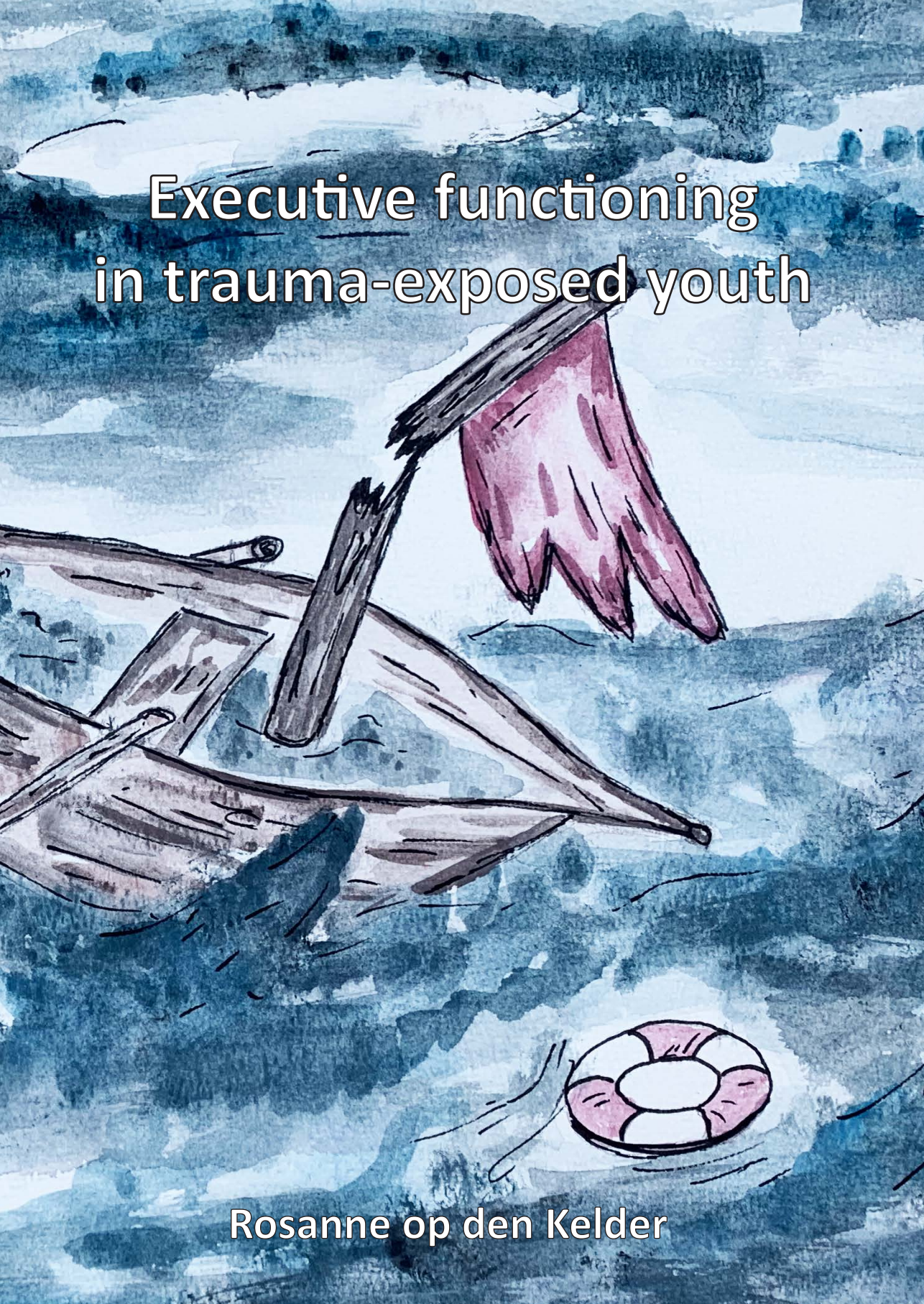
Executive functioning in trauma-exposed youth

op den Kelder, R.

Publication date
2023
Document Version
Final published version

Executive functioning in trauma-exposed youth



Rosanne op den Kelder

Executive functioning in trauma-exposed youth

Rosanne op den Kelder

Colofon

Executive functioning in trauma-exposed youth
Rosanne op den Kelder

Cover design: Daphne Bos | www.expo-enzo.nl
Lay-out: Publiss | www.publiss.nl
Print: Ridderprint | www.ridderprint.nl

Executive functioning in trauma-exposed youth

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor

aan de Universiteit van Amsterdam

op gezag van de Rector Magnificus

prof. dr. ir. P.P.C.C. Verbeek

ten overstaan van een door het College voor Promoties ingestelde commissie,

in het openbaar te verdedigen in de Agnietenkapel

op donderdag 16 februari 2023, te 10.00 uur

door Rosanne op den Kelder

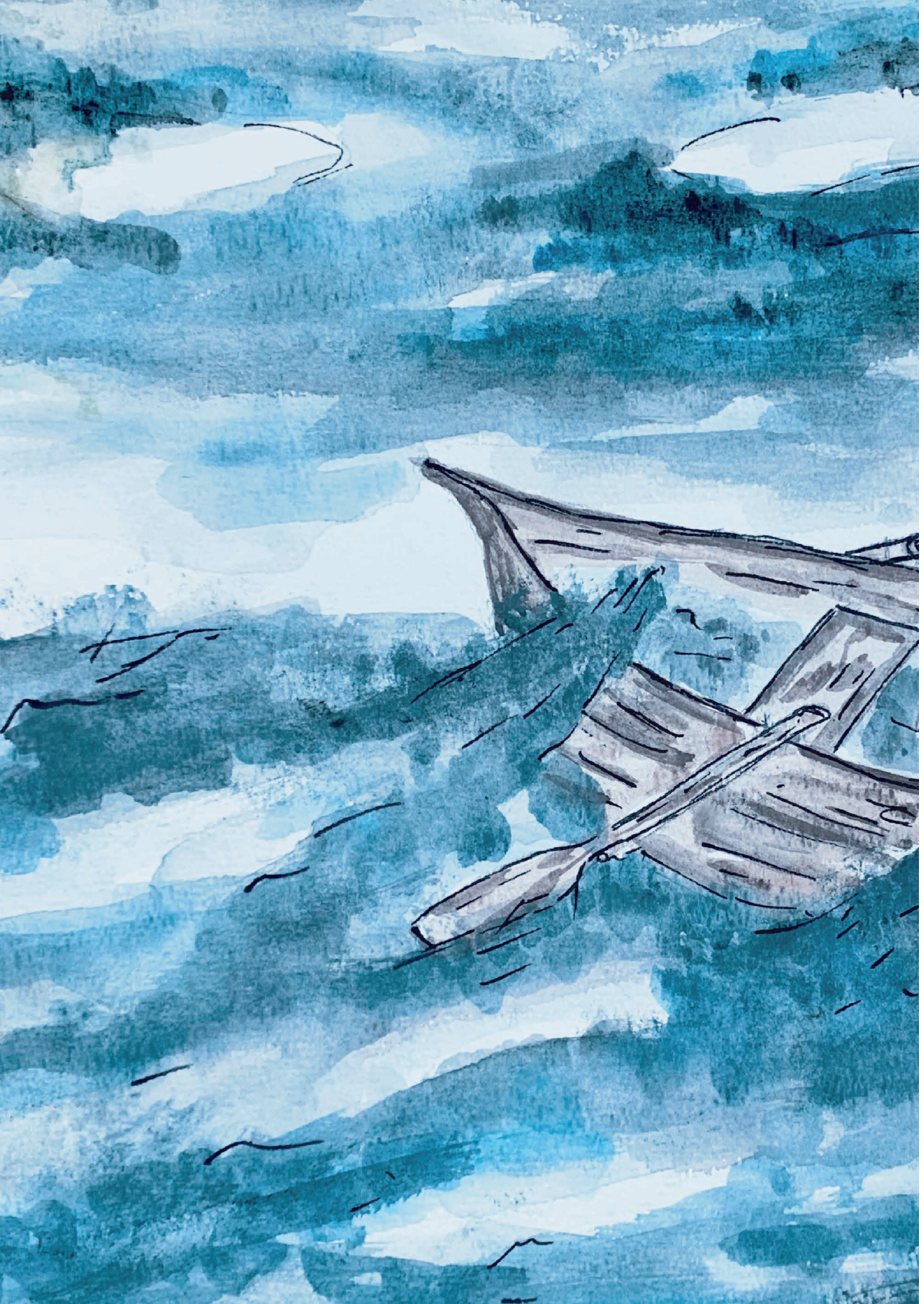
geboren te Hoorn

Promotiecommissie

Promotores:	prof. dr. G.J. Overbeek	Universiteit van Amsterdam
	prof. dr. R.J.L. Lindauer	Universiteit van Amsterdam
Copromotores:	dr. A.L. van den Akker	Universiteit van Amsterdam
	prof. dr. H.M. Geurts	Universiteit van Amsterdam
Overige leden:	prof. dr. B. Orobio de Castro	Universiteit van Amsterdam
	prof. dr. E.M.W.J. Utens	Universiteit van Amsterdam
	prof. dr. H.M. Huizenga	Universiteit van Amsterdam
	prof. dr. A. Popma	Vrije Universiteit Amsterdam
	dr. C.J.A.M. de Roos	Levvel

Faculteit der Maatschappij- en Gedragswetenschappen

Table of Contents



General Introduction

Introduction

Tom, a 15-year-old boy, and his mom Sandra enter our therapy room. Tom tended to cry a lot when he was a little baby and had a lot of tantrums as a toddler, which made parenting challenging for his parents. Approximately 8 years ago, Tom's father started to abuse Tom and Sandra both physically and emotionally. Tom heard his father yelling at his mother frequently and witnessed his father kicking and beating up his pregnant mother. Tom's father did not call him by his name; he used to call him a loser. When Tom made too much noise while playing around, dropped something on the floor, or even out of the blue, his father used severe corporal punishments. Tom's mother found the courage to leave her husband after she met with a child-protection worker. Now, Tom and his mom live together in a rental place and are rebuilding their lives. Sandra is worried about Tom. He has problems sleeping and concentrating and has a lot of nightmares. His school results are decreasing and he spends almost all of his time in his bedroom. He often has headaches and stomach pain.

Trauma exposure

We see a lot of children that have had a similar childhood as Tom in our academic center for specialized mental health care, Levvel. Unfortunately, many children that seek treatment for mental health problems in the child mental health care system (Jeugdhulp in Dutch) are exposed to one - or more - traumatic events in their lives. Trauma exposure is defined as an event in which the child experiences (directly or indirectly) a life threat, physical harm, or sexual violence (American Psychiatric Association, 2013). Examples are: rape, incest, severe car accidents, robbery, and domestic violence. For many children and adolescents, adverse childhood events co-occur (e.g. Brown, Rienks, McCrae, & Watamura, 2019; Bussemakers, Kraaykamp, & Tolsma, 2019; McLaughlin et al., 2012). Earlier research in the United States of America showed that 44.6% of children who are diagnosed with a mental disorder in childhood have been exposed to a childhood adversity (Green et al., 2010). However, trauma-exposure is not only present in clinical samples. For example, a longitudinal study of a representative community sample in the United States among 1420 children showed that up to two-thirds of children are exposed to at least one traumatic event in their life before they reach the age of 16 (Copeland, Keeler, Angold, & Costello, 2007). Another study among 403 16-19 year old adolescents in Iraq found a prevalence rate of trauma exposure of more than 80% (Al-Hadethe, Hunt, Thomas, & Al-Qaysi, 2014). Population-based studies that examined trauma-exposure prevalence are mostly conducted in samples of older adolescents and adults, using retrospective assessments. As far as we know, three prevalence studies examined trauma exposure in children and younger adolescents. In the beforementioned longitudinal study among 1420 American children, they found a prevalence of 54% at age

9-13 using interviews with children, parents and/or guardians (Costello, Erkanli, Fairbank, & Angold, 2002). In another American birth cohort among more than a thousand children between 24 and 48 months old, a prevalence rate of 26.3% was found when parents filled in a questionnaire (Briggs-Gowan, Ford, Fraleigh, McCarthy K., & Carter, 2010). In a Dutch population-based study among 1770 children aged 7-13 years, 14% of the children reported on a questionnaire that they had been exposed to one or more traumatic events (Alisic, van der Schoot, van Ginkel, & Kleber, 2008). It is thus clear that these rates vary greatly, likely because of different assessment types, but also age of children in the samples.

Trauma exposure often has long term consequences. One of the most studied consequences of trauma exposure is the development of posttraumatic stress disorder (PTSD) (Alisic, Jongmans, van Wesel, & Kleber, 2011). But other consequences have also been found: a recent study of 27,834 adults showed that participants who had experienced adverse childhood events had a higher chance of high-school dropout, unemployment, and poverty than participants who did not experience adverse events (Metzler, Merrick, Klevens, Ports, & Ford, 2017). The results of a previous systematic review and meta-analysis among 124 studies suggested that child maltreatment is also related to later drug use, suicidal thoughts and attempts, and a range of mental disorders (such as depressive, anxiety, conduct, and behavioral disorders) (Norman et al., 2012).

The impact of trauma exposure on so many aspects of life may partly be due to its impact on executive functions. Based on earlier research (e.g. Aupperle, Melrose, Stein, & Paulus, 2012; Malarbi, Abu-rayya, Muscara, & Stargatt, 2017), we can expect that there is an association between trauma exposure and executive functioning in children and adolescents. However, it is not yet clear which factors moderate the link between trauma exposure and executive functioning. There is also little information about the possible bidirectional relationship between trauma exposure and executive functioning. Third, we do not yet know how executive functioning might play a role in the development of PTSD after trauma exposure. Fourth, relatively little information is available about the question of whether children's executive functioning impacts the effectiveness of evidence-based PTSD treatments.

Executive functioning in trauma-exposed youth

Besides the problems sleeping and concentrating, 15-year-old Tom is unable to independently take a shower. He often refuses or he forgets his pajamas, underwear or a clean towel. Actually, almost all daily tasks are a struggle. Tom does not remember to finish chores or start homework, is not able to wait for his turn, does not keep his bedroom tidy, gets irritated in unpredictable situations, and has problems getting ready for his basketball practice. Tom and Sandra are getting frustrated and are entering a vicious cycle of negative interactions.

As illustrated by Tom's case report, trauma-exposed youth show a variety of problems in everyday tasks. Based on a (neuro)biological theory of PTSD, trauma exposure affects individuals due to neurobiological changes which in turn leads to problems in cognitive functions, fear conditioning, and higher responsiveness to stress (e.g. Herringa, 2017; Van der Kolk, 2003; Zantvoord, Diehle, & Lindauer, 2013). Results of a meta-analysis of 16 neuroimaging studies with a total of 1868 participants, showed a smaller hippocampus and amygdala in adults with PTSD (Logue et al., 2018). Another meta-analysis of 89 neuroimaging studies showed smaller volumes of the hippocampus, anterior cingulate, and insula, and reductions in the medial prefrontal cortex in individuals with PTSD (Bromis, Calem, Reinders, Williams, & Kempton, 2018). Yet another systematic review indicated that child abuse is associated with deficits in fronto-limbic brain areas and mediating networks for emotional and behavioral control (Hart & Rubia, 2012). Previous studies and reviews mostly linked the prefrontal cortex to executive functioning (e.g. Diamond, 2013; Fiske & Holmboe, 2019; Otero & Barker, 2014). Thus, childhood trauma exposure, especially child abuse, may predict subsequent executive functioning problems in children and adolescents.

Executive functioning refers to a set of skills needed for everyday goal-directed behavior. It is an umbrella term and covers three core executive functions: working memory, inhibition, and cognitive flexibility (Diamond, 2013). Previous research found that the three core executive functions are closely related, but also distinct processes (Huizinga, Dolan, & van der Molen, 2006; Lehto, Juujärvi, Kooistra, & Pulkkinen, 2003; Miyake & Friedman, 2012; Miyake et al., 2000). This is called the unity-diversity framework as these functions are both separable and unidimensional. Working memory is the capacity to store information temporarily and to adapt or manipulate it. Inhibition is the ability to stop automatic responses, actions, and thoughts when we have already started. When people have a high cognitive flexibility, they are capable of changing perspectives on tasks, activities, and rules (Miyake et al., 2000). Working memory, inhibition, and flexibility are basic skills necessary for more complex executive functions such as reasoning, organizing, task initiating, emotion regulation, and problem solving. Although there is still an ongoing scientific debate about the structure of executive functioning, results from factor analyses mostly support a structure distinguishing these three core executive functions (e.g. Rose, Feldman, & Jankowski, 2011; Wu et al., 2011). Although some studies observed a two-factor model in which inhibition and working memory are distinguished (e.g. Schoemaker, Mulder, Deković, & Matthys, 2013; Usai, Viterbori, Traverso, & De Franchis, 2014), a three-factor model also fits with the observation that specific clinical groups have differences among a wider range of executive functions than just inhibition and working memory (e.g. Kofler et al., 2019; Morein-Zamir et al., 2014; Verté, Geurts, Roeyers, Oosterlaan, & Sergeant, 2006).

Deficits in executive functions can have an enormous impact on daily life (Diamond et al., 2013). For example, children with impaired executive functioning have more difficulties at school as they could lack the ability to inhibit their automatic response and cannot wait for their turn. It is also difficult for them to both initiate and finish a task as they have to retain the various steps in their working memory. During the day, they may have difficulty to adapt flexibly to changing activities or routines. Furthermore, deficits in executive functioning are also associated with various problems at the personal, familial, and societal level later in life. For example, a birth cohort that followed 1000 participants from birth to 32 years-old, found that lower self-control (i.e., lower inhibition) predicted later physical illness, substance use, financial problems, and higher crime rates (Moffitt et al., 2011). A previous longitudinal study among 1824 children also found that preschool working memory was related to high school dropout (Fitzpatrick, Archambault, Janosz, & Pagani, 2015). A review of student samples (aged 8-24) found that self-control was related to academic achievement (Duckworth, Taxer, Eskreis-Winkler, Galla, & Gross, 2019). In sum, impeded executive functioning can have a long-term negative impact on both personal, familial, and societal level.

As childhood trauma exposure is associated with abnormalities in neurological structures associated with executive functions (e.g. Hart & Rubia, 2012; Teicher & Samson, 2016), various studies examined the link between them. Prior studies, however, have examined executive functioning with varying levels of precision and across different age ranges, often leading to contradicting results. Therefore, the first aim of the present dissertation is to conduct a meta-analysis of the current literature to gain insights into the link between executive functioning and trauma exposure in children.

Bidirectionality

Most empirical evidence regarding the impact of trauma exposure on executive functioning in children uses a theoretical framework that focuses on how neurobiological pathways are affected by psychological trauma. However, it is also possible that executive functioning deficits place children at increased risk for later trauma exposure (Kloosterman et al., 2014; Ter-Stepanian, 2014). For instance, as children with impeded executive functions have more behavioral problems, it could be that they are at increased risk for victimization. Another possibility is that executive functioning deficits make children more vulnerable to the exposure to a traumatic event as they are less capable of regulating emotions and cognitions. To disentangle the direction of relation between executive functioning and trauma exposure, it is important to investigate these potentially bidirectional associations. Although longitudinal research is necessary to investigate this possibility, most studies examining executive

functioning and trauma employed a cross-sectional research design. Additionally, available longitudinal research has not controlled for early executive functioning. This is problematic as this does not rule out the possibility that executive functioning problems were already present in children before trauma exposure. Therefore, we investigated possible bidirectional relations between executive functions and trauma exposure in chapter **three**.

The role of executive functioning in the association between trauma and development of PTSD

Besides his sleep problems, difficulty focusing, and daily nightmares, Tom does not trust new people. He does not feel like undertaking activities and avoids going near his old house. We diagnosed Tom with posttraumatic stress disorder and explained it to him as follows: "due to the traumatic experiences in your life, you are confronted with intrusive feelings and memories of the past. This makes you still feel stressed in your mind and body, you cannot sleep anymore and are easily agitated. As you don't want to feel this, you avoid triggers such as places and situations. However, this dysregulates your life in such a way that it holds you back you in your development."

It could be that executive functions play a role in the development of posttraumatic stress after exposure to a traumatic event. As executive functions are regulatory processes in the brain, it could be that children with lower levels of executive functioning have more difficulties with processing a traumatic event. More specifically, as they will have more difficulties in inhibiting fear responses and intrusive thoughts because of lower inhibition capacities, they might have more problems in coping with fear responses. This could in turn lead to the development of an avoidant coping strategy and changes in cognitions and mood.

Altogether, these problems constitute some of the core symptoms of PTSD. This has not yet been investigated in children and therefore we will investigate whether executive functioning might mediate the development of posttraumatic stress symptoms after trauma exposure in chapter **four.**

The role of executive functioning in trauma treatment for youth

We offered Tom trauma treatment. Although Tom was very motivated, he forgot the first appointment and arrived late every session. After a few sessions, we concluded that he needed more maternal control to attend the therapy sessions. During the sessions, Tom had problems inhibiting his automatic responses which made it more difficult to tackle his avoidant coping strategies in dealing with traumatic reminders. Tom had no overview of his traumatic events but also lacked in overview of his current activities.

Although there are two evidence-based treatments for PTSD in children, not all children benefit from therapy or even manage to finish therapy. Two currently available treatments are Eye-Movement and Desensitization and Reprocessing (EMDR) and Trauma-Focused Cognitive Behavioral Therapy (TF-CBT) (Kenniscentrum KJP, 2021). During EMDR, the child is asked to recall the traumatic event while distracting it with eye-movements, tapping on the knees, alternating sounds (left/right), and/or using buzzers with alternating left-right vibrations. TF-CBT consists of eight different modules: psycho-education, relaxation, affect-modulation, cognitions, trauma-narrative, in-vivo exposure, combination sessions with the parent and child, and evaluation. A meta-analysis has shown moderate effect sizes for both EMDR and TF-CBT (Hedge's g = 0.83) compared to a waiting list (Hedge's g = 0.41) (Morina, Koerssen, & Pollet, 2016). However, as previous noted, not all children benefit from these evidence-based therapies as they might dropout (approximately 25%) (Ormhaug & Jensen, 2018; Yasinski et al., 2018) or still suffer from (sub)clinical PTSD symptoms after treatment (Larsen et al., 2019). The level of executive functioning might affect treatment responsiveness as it is more difficult to learn alternative coping strategies for trauma-reminders with an impeded working memory, inhibition or cognitive flexibility. However, because of high dropout rates and the fact that not all children respond to trauma treatment, we will investigate whether executive functioning deficits indeed play a role in the completion and responsiveness of PTSD treatment.

Societal and scientific relevance for gaining insight into executive functioning of trauma-exposed youth

As executive functioning deficits result in many daily life problems, and at the same time might also affect the development of psychopathology and the way children respond to therapy, it is of importance to gain more knowledge about the role of executive functioning in trauma-exposed youth. Trauma-exposed children are already a vulnerable group as they are at risk for re-traumatization (Jaffe, DiLillo, Gratz, & Messman-Moore, 2019) and have more mental health and physical problems (Gilbert et al., 2009; Metzler et al., 2017; Monnat & Chandler, 2015). These consequences are visible at the individual level because trauma-exposed people have more difficulty keeping their job, have more illnesses, have more problems in relationships, and use more drugs. A better understanding of executive functioning in trauma-exposed youth could add to the improvement of both assessment and treatment for trauma-exposed youth.

Outline of the current dissertation

In this dissertation, we aimed to gain more knowledge of executive functioning of trauma-exposed children. First, we aimed to investigate whether trauma-exposed youth had more

problems in executive functioning and whether trauma exposure precedes lower levels of executive functioning or the other way around. Our second aim was to investigate the possible mediating role of executive functioning in posttraumatic stress and the influence of executive functioning on trauma treatment in terms of completion and responsiveness. This knowledge may help in improving mental health care for trauma-exposed children.

Chapter two presents a multi-level meta-analysis that investigated whether trauma-exposed children showed lower levels of executive functioning. We also performed moderator analyses to investigate how specific trauma-specific (onset, duration, type), participant characteristics (age, sex, ethnicity, socio-economic status) and measurement quality affected the link between trauma exposure and executive functioning. **Chapter three** features a study that used structural equation modeling to examine bidirectional longitudinal associations of trauma exposure and executive functioning in a community sample of 1006 children aged 5-12 year old. **Chapter four** examined the possible mediating role of executive functioning in the relationship between trauma-exposure and PTSD of 119 children aged 8-18 years-old. **Chapter five** examined whether executive functioning predicts trauma-treatment dropout and responsiveness in a sample of 94 treatment-seeking trauma-exposed children aged 8-18 years-old. **Chapter six** features a general discussion that integrates the findings of all chapters and presents recommendations for future research and clinical practice.

References

Al-Hadethe, A., Hunt, N., Thomas, S., & Al-Qaysi, A. (2014). Prevalence of traumatic events and PTSD symptoms among secondary school students in Baghdad. *European Journal of Psychotraumatology*, *5*(1), 23928. https://doi.org/10.3402/ejpt.v5.23928

Alisic, E., Jongmans, M. J., van Wesel, F., & Kleber, R. J. (2011). Building child trauma theory from longitudinal studies: A meta-analysis. *Clinical Psychology Review*, *31*(5), 736–747. https://doi.org/10.1016/j.cpr.2011.03.001

Alisic, E., van der Schoot, T. A. W., van Ginkel, J. R., & Kleber, R. J. (2008). Trauma Exposure in Primary School Children: Who Is at Risk? *Journal of Child & Adolescent Trauma*, *1*(3), 263–269. https://doi.org/10.1080/19361520802279075

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders, 5* (5th ed.). Washington DC: American Psychiatric Publishing.

Aupperle, R. L., Melrose, A. J., Stein, M. B., & Paulus, M. P. (2012). Executive function and PTSD: Disengaging from trauma. *Neuropharmacology*, *62*(2), 686–694. https://doi.org/10.1016/j.neuropharm.2011.02.008

Briggs-Gowan, M.J., Ford, J.D., Fraleigh, L., McCarthy K., Carter, A. S. (2010). Prevalence of exposure to potentially traumatic events in a healthy birth cohort of very young children in the northeastern United States. *Journal of Traumatic Stress*, *23*, 725–733. https://doi.org/10.1002/jts.20593

Bromis, K., Calem, M., Reinders, A. A. T. S., Williams, S. C. R., & Kempton, M. J. (2018). Meta-Analysis of 89 Structural MRI studies in posttraumatic stress disorder and comparison with major depressive disorder. *American Journal of Psychiatry*, *175*(10), 989–998. https://doi.org/10.1176/appi.ajp.2018.17111199

Brown, S. M., Rienks, S., McCrae, J. S., & Watamura, S. E. (2019). The co-occurrence of adverse childhood experiences among children investigated for child maltreatment: A latent class analysis. *Child Abuse and Neglect*, *87*(November 2017), 18–27. https://doi.org/10.1016/j.chiabu.2017.11.010

Bussemakers, C., Kraaykamp, G., & Tolsma, J. (2019). Co-occurrence of adverse childhood experiences and its association with family characteristics. A latent class analysis with Dutch population data. *Child Abuse and Neglect*, *98*(April), 104185. https://doi.org/10.1016/j.chiabu.2019.104185

Copeland, W. E., Keeler, G., Angold, A., & Costello, E. J. (2007). Traumatic events and posttraumatic stress in childhood. *Archives of General Psychiatry*, *64*(5), 577–584. https://doi.org/10.1016/S0084-3970(08)79296-X

Costello, E. J., Erkanli, A., Fairbank, J. A., & Angold, A. (2002). The prevalence of potentially traumatic events in childhood and adolescence. *Journal of Traumatic Stress*, *15*(2), 99–112. https://doi.org/10.1023/A:1014851823163

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Duckworth, A. L., Taxer, J. L., Eskreis-Winkler, L., Galla, B. M., & Gross, J. J. (2019). Self-Control and Academic Achievement. *Annual Review of Psychology*, *70*, 373–399. https://doi.org/10.1146/annurev-psych-010418-103230

Fiske, A., & Holmboe, K. (2019). Neural substrates of early executive function development. *Developmental Review*, *52*, 42–62. https://doi.org/10.1016/j.dr.2019.100866

Fitzpatrick, C., Archambault, I., Janosz, M., & Pagani, L. S. (2015). Early childhood working memory forecasts high school dropout risk. *Intelligence*, *53*, 160–165. https://doi.org/10.1016/j.intell.2015.10.002

Gilbert, R., Widom, C. S., Browne, K., Fergusson, D., Webb, E., & Janson, S. (2009). Burden and consequences of child maltreatment in high-income countries. *The Lancet*, *373*(9657), 68–81. https://doi.org/10.1016/S0140-6736(08)61706-7

Green, J. G., McLaughlin, K. A., Berglund, P. A., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2010). Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication I: Associations with first onset of DSM-IV disorders. *Archives of General Psychiatry*, *67*(2), 113–123. https://doi.org/10.1001/archgenpsychiatry.2009.186

Hart, H., & Rubia, K. (2012). Neuroimaging of child abuse: A critical review. *Frontiers in Human Neuroscience*, *6*, 1–24. https://doi.org/10.3389/fnhum.2012.00052

Herringa, R. J. (2017). Trauma, PTSD, and the Developing Brain. *Current Psychiatry Reports*, *19*(10), 1–9. https://doi.org/10.1007/s11920-017-0825-3

Huizinga, M., Dolan, C. V., & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia*, *44*(11), 2017–2036. https://doi.org/10.1016/j.neuropsychologia.2006.01.010

Jaffe, A. E., DiLillo, D., Gratz, K. L., & Messman-Moore, T. L. (2019). Risk for revictimization following interpersonal and noninterpersonal trauma: Clarifying the role of posttraumatic stress symptoms and trauma-related cognitions. *Journal of Traumatic Stress*, *32*(1), 42–55. https://doi.org/10.1002/jts.22372

Kloosterman, P.H., Kelley, E.A., Parker, J.D.A., & Craig, W.M.. (2014). Executive functioning as a predictor of peer victimization in adolescents with and without an Autism Spectrum Disorder. *Research in Autism Spectrum Disorder, 8,* 244-254.

Kenniscentrum (2021). *Trauma en Kindermishandeling bij Kinderen en Adolescenten*. https://www.kenniscentrum-kjp.nl/professionals/trauma-kindermishandeling/

Kofler, M. J., Irwin, L. N., Soto, E. F., Groves, N. B., Harmon, S. L., & Sarver, D. E. (2019). Executive functioning heterogeneity in pediatric ADHD. *Journal of Abnormal Child Psychology*, *47*(2), 273–286. https://doi.org/10.1007/s10802-018-0438-2

Larsen, S. E., Bellmore, A., Gobin, R. L., Holens, P., Lawrence, K. A., & Pacella-LaBarbara, M. L. (2019). An initial review of residual symptoms after empirically supported trauma-focused cognitive behavioral psychological treatment. *Journal of Anxiety Disorders*, *63*, 26–35. https://doi.org/10.1016/j.janxdis.2019.01.008

Lehto, J. E., Juujärvi, P., Kooistra, L., & Pulkkinen, L. (2003). Dimensions of executive functioning: Evidence from children. *British Journal of Developmental Psychology*, *21*, 59–80. https://doi.org/10.1348/026151003321164627

Logue, M. W., van Rooij, S. J. H., Dennis, E. L., Davis, S. L., Hayes, J. P., Stevens, J. S., … Morey, R. A. (2018). Smaller hippocampal volume in Posttraumatic Stress Disorder: A multisite ENIGMA-PGC Study: Subcortical volumetry results from osttraumatic Stress Disorder consortia. *Biological Psychiatry*, *83*(3), 244–253. https://doi.org/10.1016/j.biopsych.2017.09.006

Malarbi, S., Abu-rayya, H. M., Muscara, F., & Stargatt, R. (2017). Neuropsychological functioning of childhood trauma and post-traumatic stress disorder: A meta-analysis. *Neuroscience and Biobehavioral Reviews*, *72*, 68–86. https://doi.org/10.1016/j.neubiorev.2016.11.004

McLaughlin, K. A., Green, J. G., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2012). Childhood adversities and first onset of psychiatric disorders in a national sample of US adolescents. *Archives of General Psychiatry*, *69*(11), 1151–1160. https://doi.org/10.1001/archgenpsychiatry.2011.2277

Metzler, M., Merrick, M. T., Klevens, J., Ports, K. A., & Ford, D. C. (2017). Adverse childhood experiences and life opportunities: Shifting the narrative. *Children and Youth Services Review*, *72*, 141–149. https://doi.org/10.1016/j.childyouth.2016.10.021

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science*, *21*(1), 8–14. https://doi.org/10.1177/0963721411429458

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A.H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. https://doi.org/10.1006/cogp.1999.0734

Monnat, S. M., & Chandler, R. F. (2015). Long-term physical health consequences of adverse childhood experiences. *Sociological Quarterly*, *56*(4), 723–752. https://doi.org/10.1111/tsq.12107

Morein-Zamir, S., Papmeyer, M., Pertusa, A., Chamberlain, S. R., Fineberg, N. A., Sahakian, B. J., … Robbins, T. W. (2014). The profile of executive function in OCD hoarders and hoarding disorder. *Psychiatry Research*, *215*(3), 659–667. https://doi.org/10.1016/j.psychres.2013.12.026

Morina, N., Koerssen, R., & Pollet, T. V. (2016). Interventions for children and adolescents with posttraumatic stress disorder: A meta-analysis of comparative outcome studies. *Clinical Psychology Review*, *47*, 41–54. https://doi.org/10.1016/j.cpr.2016.05.006

Norman, R. E., Byambaa, M., De, R., Butchart, A., Scott, J., & Vos, T. (2012). The long-term health consequences of child physical abuse, emotional abuse, and neglect: A systematic review and meta-analysis. *PLoS Medicine*, *9*(11). https://doi.org/10.1371/journal.pmed.1001349

Ormhaug, S. M., & Jensen, T. K. (2018). Investigating treatment characteristics and first-session relationship variables as predictors of dropout in the treatment of traumatized youth. *Psychotherapy Research*, *28*(2), 235–249. https://doi.org/10.1080/10503307.2016.1189617

Otero, T. M., & Barker, L. A. (2014). The frontal lobes and executive functioning. In S. Goldstein & J. A. Naglieri (Eds.), *Handbook of Executive Functioning* (pp. 29–44). New York: Springer.

Rose, S. A., Feldman, J. F., & Jankowski, J. J. (2011). Modeling a cascade of effects: The role of speed and executive functioning in preterm/full-term differences in academic achievement. *Developmental Science*, *14*(5), 1161–1175. https://doi.org/10.1111/j.1467-7687.2011.01068.x

Schoemaker, K., Mulder, H., Deković, M., & Matthys, W. (2013). Executive functions in preschool children with externalizing behavior problems: A meta-analysis. *Journal of Abnormal Child Psychology*, *41*(3), 457–471. https://doi.org/10.1007/s10802-012-9684-x

Teicher, M. H., & Samson, J. A. (2016). Annual Research Review: Enduring neurobiological effects of childhood abuse and neglect. *Journal of Child Psychology and Psychiatry*, *57*(3), 241–266. https://doi.org/10.1111/jcpp.12507

Usai, M. C., Viterbori, P., Traverso, L., & De Franchis, V. (2014). Latent structure of executive function in five- and six-year-old children: A longitudinal study. *European Journal of Developmental Psychology*. Taylor & Francis. https://doi.org/10.1080/17405629.2013.840578

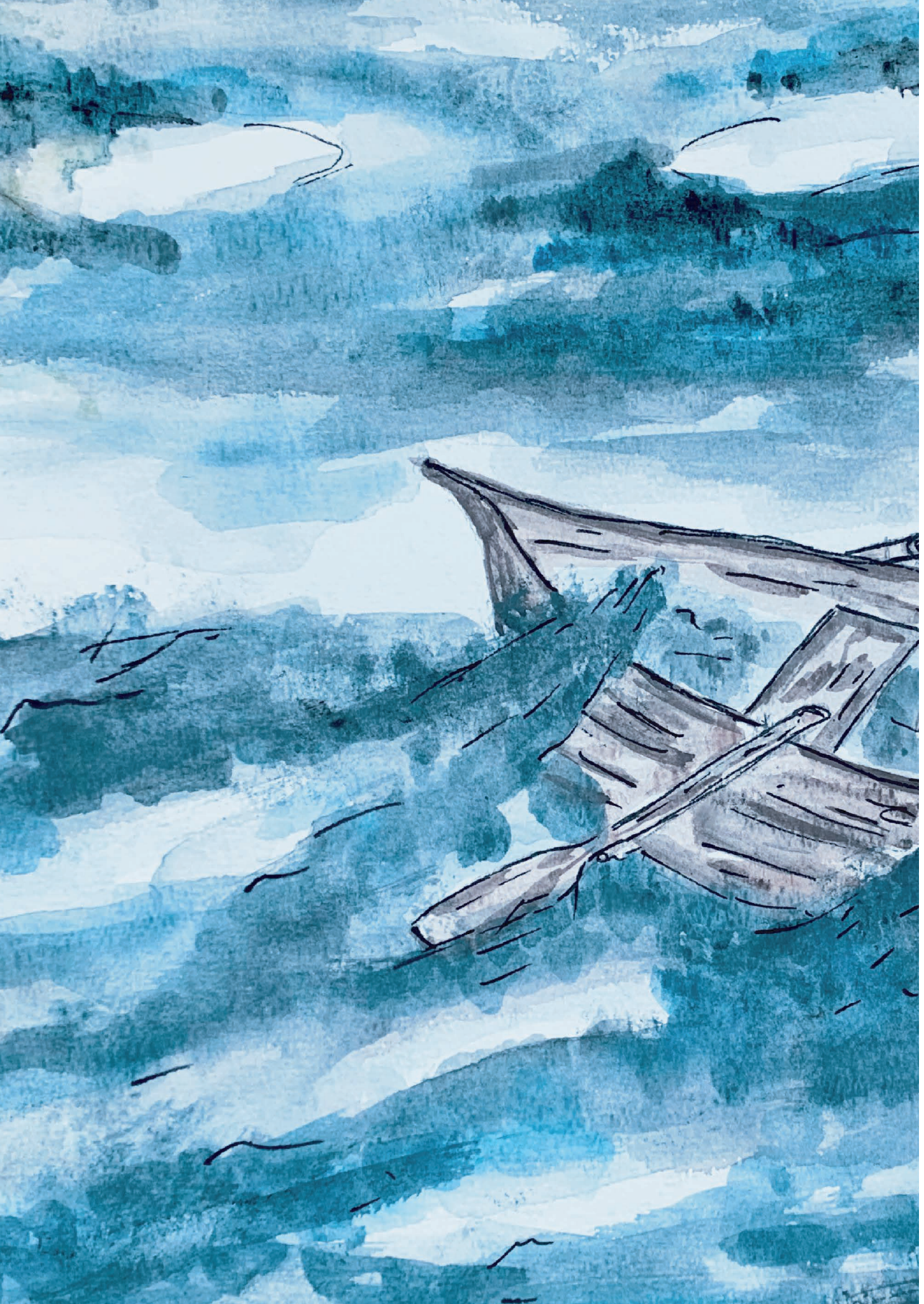
Van der Kolk, B. A. (2003). The neurobiology of childhood trauma and abuse. *Child and Adolescent Psychiatric Clinics of North America*, *12*(2), 293–317. https://doi.org/10.1016/S1056-4993(03)00003-8

Verté, S., Geurts, H. M., Roeyers, H., Oosterlaan, J., & Sergeant, J.A. (2006). Executive functioning in children with an autism spectrum disorder: Can we differentiate within the spectrum? *Journal of Autism and Developmental Disorders*, *36*(3), 351–372. https://doi.org/10.1007/s10803-006-0074-5

Wu, K. K., Chan, S. K., Leung, P. W. L., Liu, W. S., Leung, F. L. T., & Ng, R. (2011). Components and developmental differences of executive functioning for school-aged children. *Developmental Neuropsychology*, *36*(3), 319–337. https://doi.org/10.1080/87565641.2010.549979

Yasinski, C., Hayes, A. M., Alpert, E., McCauley, T., Ready, C. B., Webb, C., & Deblinger, E. (2018). Treatment processes and demographic variables as predictors of dropout from trauma-focused cognitive behavioral therapy (TF-CBT) for youth. *Behaviour Research and Therapy*, *107*, 10–18. https://doi.org/10.1016/j.brat.2018.05.008

Zantvoord, J. B., Diehle, J., & Lindauer, R. J. L. (2013). Using neurobiological measures to predict and assess treatment outcome of psychotherapy in posttraumatic stress disorder: Systematic review. *Psychotherapy and Psychosomatics*, *82*(3), 142–151. https://doi.org/10.1159/000343258



Executive functions in trauma-exposed youth: A meta-analysis

Rosanne op den Kelder
Alithe L. Van den Akker
Hilde M. Geurts
Ramón J. L. Lindauer
Geertjan Overbeek

European Journal of Psychotraumatology, 2018, 9, 1-25

Abstract

An earlier meta-analysis and review indicated that trauma exposure may be related to lower levels of executive functioning in youth. Since different developmental trajectories were found for three core executive functions, the present study focused on working memory, inhibition, and cognitive flexibility specifically. We conducted a multi-level meta-analysis on 55 studies and 322 effect sizes published between 2001 and 2017 that were retrieved from MEDLINE, Embase, and PsycINFO. The 8070 participants in selected studies were aged 2–25 years. We investigated whether the association between constructs would be moderated by trauma-specific moderators (onset, duration, and type), and study (age, gender, ethnicity, and socio-economic status) and measurement (quality) characteristics. We found small to medium effect sizes for working memory ($d = -0.49$), inhibition ($d = -0.46$), and cognitive flexibility ($d = -0.44$). Moderator analyses showed that, for working memory, when studies used low-quality measurements the effect size was significantly stronger than when studies used high-quality measurements. Compared to single trauma-exposed youth, violence-exposed/abused and foster care/adopted youth showed more problems in inhibition, and foster care/adopted youth showed more problems in cognitive flexibility. Our findings imply that trauma-exposed youth have lower levels of executive functions. Clinical practice should incorporate problems in executive functioning, especially working memory, inhibition, and cognitive flexibility, in assessment and treatment guidelines.

Introduction

Many children and adolescents, approximately between 25% and 66%, are exposed to traumatic events during childhood (Copeland, Keeler, Angold, & Costello, 2007; Costello, Erkanli, Fairbank, & Angold, 2002). Trauma- exposed youth have a wide array of emotional and physical health problems. Previous meta-analyses showed that trauma exposure is associated with post-traumatic stress complaints, internalizing and externalizing problems (Fowler, Tompsett, Braciszewski, Jacques-Tiura, & Baltes, 2009), depression, suicide attempts, drug use, sexually transmitted diseases (Norman et al., 2012), and various physical health problems such as neurological, musculoskeletal, respiratory, cardiovascular, and metabolic problems (Wegman & Stetler, 2009). Besides these emotional and physical consequences of trauma exposure, results of previous reviews showed that cognitive functioning, more specifically executive functioning, is also affected by early life stress and trauma exposure in youth (Kavanaugh, Dupont-frechette, Jerskey, & Karen, 2017; Malarbi, Abu-Rayya, Muscara, & Stargatt, 2017). Whereas earlier research focused on the impact of trauma and maltreatment on overall executive skills in youth, we distinguish three core executive functions: working memory, inhibition, and cognitive flexibility.

Trauma exposure and executive functions

Executive functions cover multiple skills, such as inhibition, organization, cognitive flexibility, self-monitoring, regulation of emotions, working memory, and attention. These are essential in preparing and executing goal-directed behaviour (Diamond, 2013; Goldstein, Naglieri, Princiotta, & Otero, 2014). Most studies indicate that executive function processes in youth are distinct, albeit moderately associated with each other (Best, Miller, & Jones, 2009; Miyake et al., 2000). Some debate exists on whether separate executive functions can be subsumed in a single, central executive function. However, impairment in global executive functioning is rare. Different regions of the prefrontal cortex are activated in different executive function tasks, and distinct developmental pathways have been identified for different executive processes (Anderson, 2002; Best et al., 2009). Most empirical neuropsychological research differentiates between three core executive functions: inhibition, working memory, and cognitive flexibility. These three domains are considered core executive functions from which higher order functions such as reasoning, problem solving, and planning arise (e.g. Diamond, 2013; Miyake et al., 2000). Therefore, in this study we focus on working memory, inhibition, and cognitive flexibility.

The first core executive function, working memory, is a cognitive process of temporarily storing and manipulating information. Working memory is distinct from short-term

memory, because short-term memory only stores information, without manipulating it (Baddeley, 2012; Goldstein et al., 2014). Verbal working memory (which 'works' with words, numbers, and letters) and visuospatial working memory (which 'works' with figures and spatial information) are commonly distinguished. Inhibition or inhibitory control, the second core executive function, refers to the ability to control attention, thoughts, and emotions, thereby suppressing dominant, automatic, or prepotent responses when necessary (Diamond, 2013; Miyake et al., 2000). Prepotent response inhibition and interference control are commonly distinguished aspects of inhibition (Friedman & Miyake, 2004; Miyake & Friedman, 2012). Prepotent response inhibition enables us to suppress a dominant motor response (Aron, 2011; Miyake et al., 2000), whereas interference control is the ability to ignore irrelevant information by resisting distractor interference (Friedman & Miyake, 2004; Nigg, 2000). The third core executive function, cognitive flexibility, refers to the ability to switch between tasks, demands, priorities, rules, and perspectives. It helps in thinking 'out- side the box' and forming creative solutions (Best et al., 2009; Diamond, 2013). Being cognitively flexible enables learning from mistakes and generating alternative solutions. Inflexible individuals fail to adapt to new situations or demands; they continue making the same mistakes, showing rigid and ritualistic behaviour (Anderson, 2002).

A previous meta-analysis and a review showed that trauma-exposed and maltreated youth performed worse on executive functions than controls (Kavanaugh et al., 2017; Malarbi et al., 2017). Trauma exposure is thought to influence executive functions by impacting underlying neurobiological mechanisms. As brain development continues into adulthood, trauma exposure may impact the development of executive functions in youth. Empirical research in humans showed that early life stress such as maltreatment affects the hypothalamic–pituitary–adrenocortical axis, but also structures of the corticolimbic networks (De Bellis, 2001; De Bellis et al., 1999; Gunnar & Quevedo, 2007). Most affected brain regions in maltreated youth are the prefrontal cortex, orbitofrontal cortex, anterior cingulate cortex, and amygdala (Cowell, Cicchetti, Rogosch, & Toth, 2015; De Bellis & Thomas, 2003; Teicher & Samson, 2016). Atypicalities in structural connectivity between the anterior cingulate cortex and dorsolateral, orbitofrontal, and ventromedial prefrontal cortices are shown by brain imaging studies (Hart & Rubia, 2012). These brain networks are activated during response inhibition, working memory, and emotion processing tasks, which suggest that the neural networks for executive functioning are affected by trauma exposure in youth (Teicher & Samson, 2016). Development of executive functions continues until young adulthood, with the most rapid development taking place during preschool and the early school years (Best & Miller, 2010; Friedman et al., 2015; Miyake & Friedman, 2012). However, the separate executive functions show slightly different developmental

trajectories (Best & Miller, 2010; Huizinga, Dolan, & van der Molen, 2006). Working memory seems to follow a linear development from preschool to adolescence. Inhibition, on the other hand, improves most rapidly during the preschool years, followed by a modest linear improvement through adolescence. For cognitive flexibility, preschoolers are able to handle shifts of simple tasks and this increases during childhood to more unexpected shifts between complex tasks. Switching of complex tasks seems to mature by middle adolescence. All executive function skills show a developmental pattern of 'rises and falls', which is related to brain development (Best & Miller, 2010; Johnson & De Haan, 2011). These different developmental trajectories may suggest different effects of both timing and the duration of trauma exposure (Teicher & Samson, 2016) on executive functions.

Moderators

By performing moderator analyses, we can examine the influence of trauma-specific moderators, sample characteristics, and executive function task characteristics on the strength of the association between trauma exposure and executive functions. First, we tested whether trauma characteristics (i.e. type, onset, duration, and post-traumatic stress complaints) influenced the strength of the association between exposure and executive functions. Specifically, interpersonal, repeated trauma has more severe effects on the brain than single trauma. The earlier and the more prolonged the trauma exposure has been, the stronger the impact of trauma exposure is (e.g. Cook et al., 2005; Bruce et al., 2014; Cowell et al., 2015; Teicher & Samson, 2016). Consequently, we tested whether earlier onset and longer duration of trauma, trauma subtype (single trauma, violence/abuse, adoption/foster care), and post-traumatic stress disorder (PTSD) would be associated with significantly lower executive functions.

Sample characteristics (age, socio-economic status, gender, and ethnicity) could influence the strength of the association between trauma expo sure and executive function in youth. Differential effects of trauma exposure have been established for gender (Alisic et al., 2014), age (e.g. Lupien, McEwen, Gunnar, & Heim, 2009; Weems et al., 2010), and ethnicity (López et al., 2017), with stronger effects of trauma exposure for girls, younger children, and Hispanic and black adolescents.

The strength of the association between trauma exposure and executive functions could also be influenced by the quality of the executive function measure. Working memory, inhibition, and cognitive flexibility are moderately associated (Best et al., 2009; Miyake & Friedman, 2012), complicating the clear assessment of executive functions (Diamond, 2013). For example, tasks such as the Digit Span, go/no-go tasks, and the Wisconsin Card

Sorting Task have various outcome measures. These outcome measures vary in how purely they assess the different executive functions (Huizinga et al., 2006). Therefore, we tested whether the quality of the outcome measurement influences the strength of the association of trauma exposure with executive functions in youth.

In sum, we investigated whether trauma-specific characteristics (onset, duration, type, and PTSD complaints), sample characteristics (gender, age, and ethnicity), and executive function task characteristics (executive function measure) influenced the relationship between trauma exposure and executive functions in youth.

The present study

As our understanding of the mental health consequences of trauma exposure in youth has increased considerably (e.g. Alisic, Jongmans, van Wesel, & Kleber, 2011; Jonkman, Verlinden, Bolle, Boer, & Lindauer, 2013; Lamers-Winkelman, Willemen, & Visser, 2012), treatments for youth have been developed to treat these (Morina, Koerssen, & Pollet, 2016). However, the link between executive functions and trauma exposure in youth is less well understood. Only the Attachment, Regulation, and Competence model includes executive functions in its guidelines (Blaustein & Kinniburgh, 2015). Our aim is to inform clinical practice to allow for integration of executive functions in therapy protocols for traumatized youth. Therefore, we investigated the extent to which youth exposed to trauma suffer from problems with their executive functions. In addition, we investigated whether different moderators influence the strength of the relationship between trauma exposure and executive functions. To answer these questions, we conducted what is, to our knowledge, the first multi-level meta-analysis to investigate working memory, inhibition, and cognitive flexibility in trauma-exposed children and adolescents.

Methods

Selection of studies

This analysis included: (1) studies comparing working memory, inhibition, and/or cognitive flexibility between trauma exposed and non-exposed individuals, and studies that reported a correlation coefficient to assess the relationship between trauma exposure and these executive functions; (2) studies reported in English; and (4) studies with samples aged between 0 and 25 years old. We focused on this specific age range because of strong indications that the development of the prefrontal cortex is largely accomplished by around the age of 25 years (e.g. Arain et al., 2013). Exclusion criteria were: studies

including participants with traumatic brain injury and current drug abuse, as these factors are known to influence executive functioning (Fernández-Serrano, Pérez-García, Schmidt Río-Valle, & Verdejo-García, 2010; Gioia, Isquith, Kenworthy, & Barton, 2002); studies that examined foster care or adopted youth but had no control group, as traumatic exposure varies widely in these samples and drawing conclusions is problematic without a reference group. Primary outcome measures pertained to working memory, cognitive flexibility, and inhibitory control. Trauma exposure was defined as exposure to events that, according to the Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5) (American Psychiatric Association, 2013), are considered potentially traumatic. For example, a traffic accident, witnessing domestic violence or a shooting, living in a war environment, and neglect are considered traumatic events (American Psychiatric Association, 2013).

Information sources

The search covered PsycINFO, Embase, and MEDLINE (until August 2017), and was based on the Meta-Analysis Reporting Standards. Appendix 2.1 shows the full electronic search strategy.

Study selection

The eligibility assessment is displayed in Figure 2.1, and was performed by two independent reviewers in a standardized manner (see Appendix 2.2). In the title and abstract screening phase, 1000 of the 10,605 papers were screened by two reviewers (first author and screener 1), and disagreements were resolved by consensus. In the second screening phase, full text screening, 1162 papers were screened by two reviewers (screeners 1 and 2). Disagreements were resolved by consultation with the first author. Finally, we included 32, 32, and 30 papers on working memory, inhibition, and cognitive flexibility, respectively.

Data collection process

We developed a data-extraction sheet (Appendix 2.3). The first author coded all studies, and the second author coded 15%, and disagreements were resolved by discussion. Interrater agreement was 1.00 for Cohen's kappa and intraclass correlation ranged between 0.96 and 1.00. Of 64 authors contacted for further information, 15 responded and 12 provided data that were requested. We could not retrieve the full text for 262 papers. After further enquiries with authors we retrieved an additional 13 full text papers. However, none of these papers was eligible for inclusion. References for the included papers are listed in Appendix 2.5.

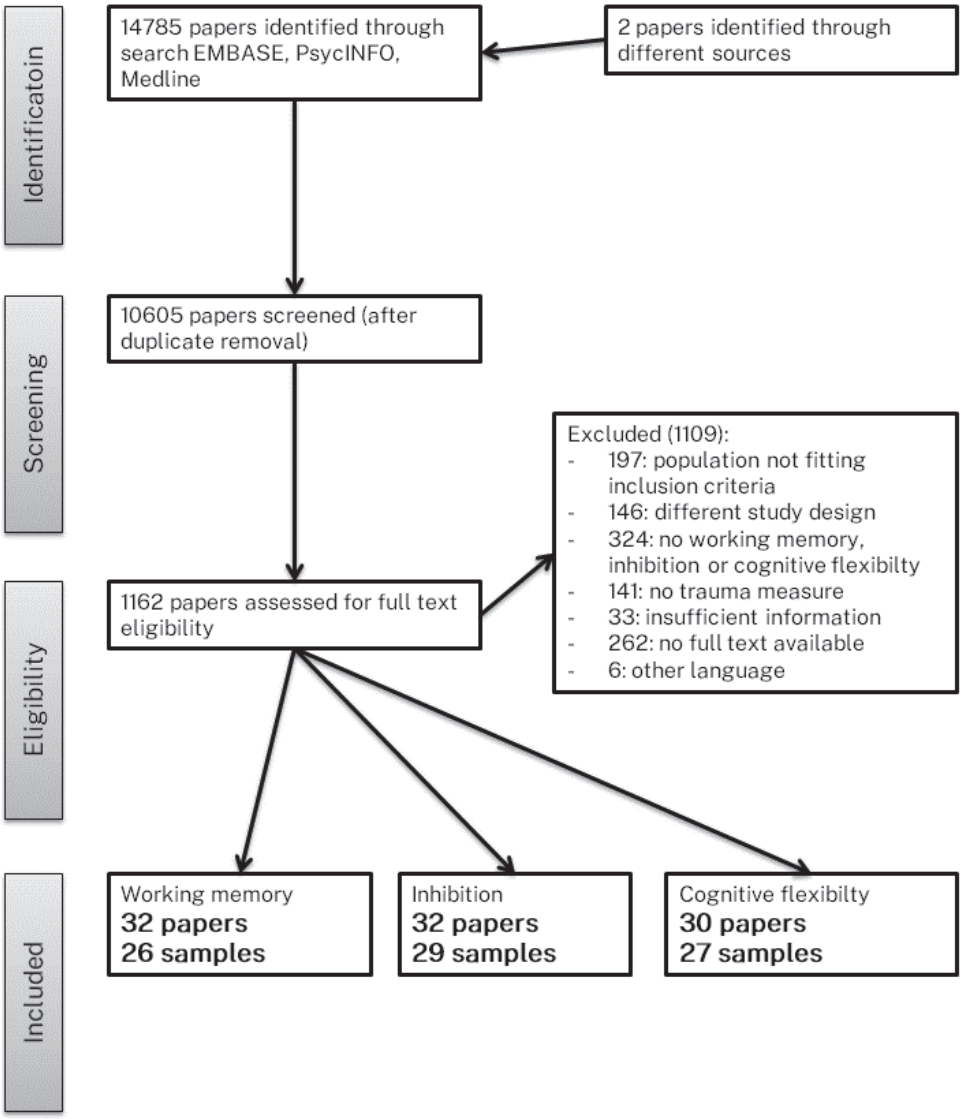


Figure 2.1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) overview for eligibility assessment.

Data items

Information was extracted from each included study on: (1) characteristics of participants (i.e. age, gender, socio-economic status, years of schooling, ethnicity); (2) study characteristics (i.e. research design, publication status, and overall study quality); (3) type of trauma exposure (i.e. trauma type, onset, and duration); (4) post-traumatic stress (post-

traumatic stress complaints, PTSD diagnosis); and (5) type of outcome measure (e.g. Wechsler Intelligence Scale for Children Digit Span backwards, Trail Making Test-B).

For the participant characteristics, overall study quality (at study level) was assessed by two independent research assistants. We used the Quality Assessment Tool for Quantitative Studies of the Effective Public Health Practice Project (Thomas, Ciliska, Dobbins, & Micucci, 2004). This is an assessment tool for the quality of both randomized and case–control studies. A global quality rating of weak, moderate, or strong was assigned by both reviewers. There was 97.8% consensus between the two reviewers. Furthermore, discrepancies were at subscale level, not at the global rating level.

For trauma characteristics, type of trauma exposure was divided into three categories: single trauma exposure; exposure to violence, abuse, or neglect; and adopted or foster care youth. Onset and duration of trauma exposure were measured using reported information about the mean age of the start of trauma exposure and the mean duration (in years). See Appendix 2.3 for more detailed information about data extraction. For studies reporting on working memory, inhibition, and/or cognitive flexibility, we coded type of outcome measure for each effect size in all data sets. With regard to the outcome measure used, we coded quality of the measurement instrument, based on the extent to which measurement of cognitive flexibility, inhibition, and working memory were confounded with the assessment of speed or other executive function elements and the level of cognitive load of the measures. These decision rules were based on the executive function research expertise of the third author and conform to recent literature specifications about quality of outcome measures of executive function (e.g. Tamminga, Reneman, Huizenga, & Geurts, 2016). The codes are described in Appendix 2.4.

Strategy of analysis

In 65.5%, 68.8%, and 73.% of the papers about respectively working memory, inhibition, and cognitive flexibility, more than one relevant effect size was reported. Papers reported on multiple effect sizes for the following reasons: (1) different outcome measures were used to assess executive functions; (2) different aspects of executive functions were measured (e.g. verbal versus non-verbal working memory); (3) various assessments of the association between trauma exposure and executive functions in time were included; and (4) different groups were investigated to assess the association between trauma exposure and executive functions (e.g. comparisons between maltreated children with PTSD and a control group, and comparisons between maltreated children without PTSD and a control group). Cohen's d was calculated using reported means and standard deviations,

and reported correlations were transformed to Cohen's d. The SPSS syntax for effect size calculation was double-checked by the second author.

We used a three-level meta-analytic random effects model as it increases power (Assink & Wibbelink, 2016). It gives us more information because effect sizes are not eliminated or averaged (Assink & Wibbelink, 2016; Cheung, 2014). We modelled three levels of variance: (1) variance in effect sizes due to random sampling; (2) variance in effect size due to differences within studies; and (3) variance in effect sizes between studies (Borenstein, Hedges, Higgins, & Rothstein, 2010). This multi-level approach allows dependency of effect sizes within studies. As a result, we can include multiple effect sizes per study and test whether there are between- or within-study differences in effect sizes when heterogeneity is assumed (Assink & Wibbelink, 2016). Moderator analyses can explain within- or between-study differences in effect sizes when there is heterogeneity (Borenstein et al., 2010). We used an expert tutorial (Assink & Wibbelink, 2016) for the software R to perform statistical analyses for our three-level meta-analyses with a random model using the Metafor package (Viechtbauer, 2006).

Publication bias

Publication selection bias is a common issue in meta-analyses (Borenstein et al., 2010). We used the PET-PEESE approach to investigate publication selection bias, as this approach has been shown to outperform the Fail Safe N analysis and Trim & Fill strategy (Stanley & Doucouliagos, 2014). The PET-PEESE approach consists of two steps. The first step, the precision-effect-test (PET), is based on results on the Egger test, an analysis in which the standard error is used as a moderator. When the intercept in this model is not significantly different from zero, a significant moderator implicates possible publication bias. When the intercept is significantly different from zero, we take the next step: PEESE (precision-effect estimate with standard error). However, instead of the standard error, the variance is included as a moderator. When the effect size varies significantly with the standard error, the analysis gives an implication for publication bias. However, it should be noted that all publication bias analyses have a low power to detect bias (Borenstein et al., 2010; Stanley & Doucouliagos, 2014). Furthermore, we used the PET-PEESE approach in a random model but, as in all other publication bias assessments, it is designed for a fixed effects model.

Results

Associations between trauma exposure and executive functions

We performed three separate multi-level meta-analyses. Overall effect sizes are displayed in Table 2.1. For working memory, we examined 26 samples and 102 effect sizes, reporting

data on 5172 participants aged between 3 and 24 years. Figure 2.2 displays a forest plot showing the effect sizes and their confidence intervals. The analysis yielded a significant, small to medium effect size of d = −0.49 in a random model. This indicated that trauma-exposed youth perform worse on working memory than non-exposed youth. For inhibition, we examined 29 samples with 119 effect sizes, reporting data on 3391 participants aged between 5 and 20 years. In Figure 2.3, effect sizes and their confidence intervals are displayed. The analysis yielded a significant, small to medium effect size of d = −0.46 in a random model. Thus, trauma-exposed youth also perform worse on inhibition tasks than non-exposed youth. For cognitive flexibility, we examined 27 samples with 101 effect sizes, reporting data on 2959 participants aged between 2 and 24 years. In Figure 2.4, the forest plot displays the effect sizes and confidence intervals. This analysis yielded also a significant, small to medium effect size of d = −0.44 in a random model. When investigating outliers for the variables of interest, we found four outliers in the effect sizes: working memory (one outlier), inhibition (two outliers), and cognitive flexibility (one outlier). After trimming these outliers to the value of the highest/lowest effect size plus/minus one unit, we found that the mean effect size, although still significant, decreased to −0.37 for inhibition, but remained the same for working memory and cognitive flexibility.

Table 2.1 Effect sizes (ES) and confidence intervals (CI) for meta-analyses on the association between trauma exposure and working memory, inhibition, and cognitive flexibility.

	K	*ES*	*n*	*d*	*95%*	*p*
Working memory	26	102	5172	-0.49	-0.67; −0.31	< 0.001
Inhibition	29	119	3391	-0.46	-0.66; −0.26	< 0.001
Cognitive flexibility	27	101	2959	-0.44	-0.63; −0.26	< 0.001

K = number of samples.

Variation in effect sizes

To investigate whether moderator analyses were necessary, we analysed whether variation in effect sizes could be attributed to random sampling error, within-study variance (level 2), or between-study variance (level 3). For working memory, effect sizes were heterogeneous as both within-study variance (σ^2_v = 0.05), x^2 (1) = 105.64, p < 0.001), and between-study variance were significant (σ^2_v = 0.16, x^2 (1) = 69.00, p < 0.001). Of the total variance, 20.4% was attributable to within study differences and 72.0% to between-study differences. For inhibition, both within-study variance (σ^2_v = 0.04), x^2 (1) = 17.11, p < 0.001) and between study variance were significant (σ^2_v = 0.23, x^2 (1) = 45.32, p < 0.001). Of the total variance, 13.3% was attributable to within-study differences and 76.4% to between-study differences.

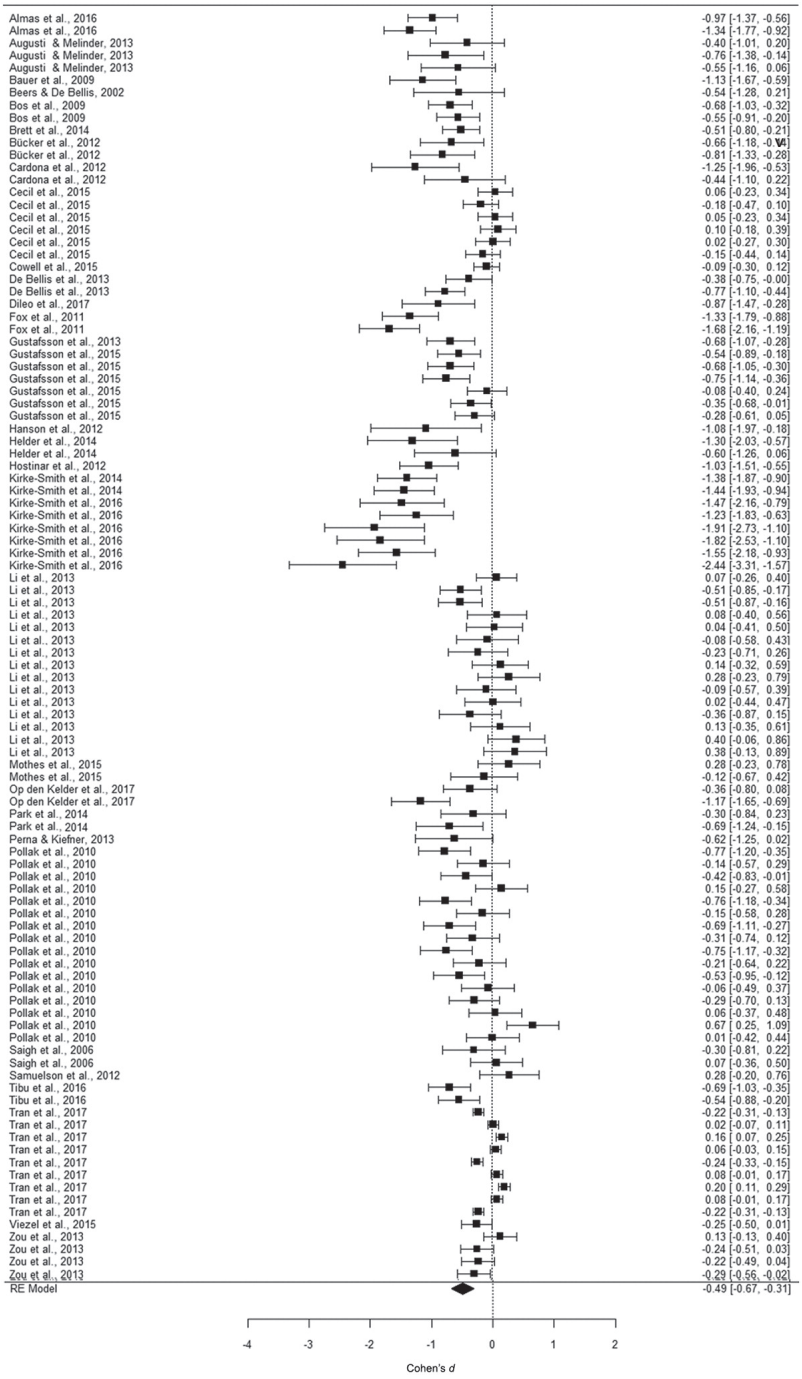


Figure 2.2. Forest plot of the meta-analysis on the association between trauma exposure and working memory. RE, random effects.

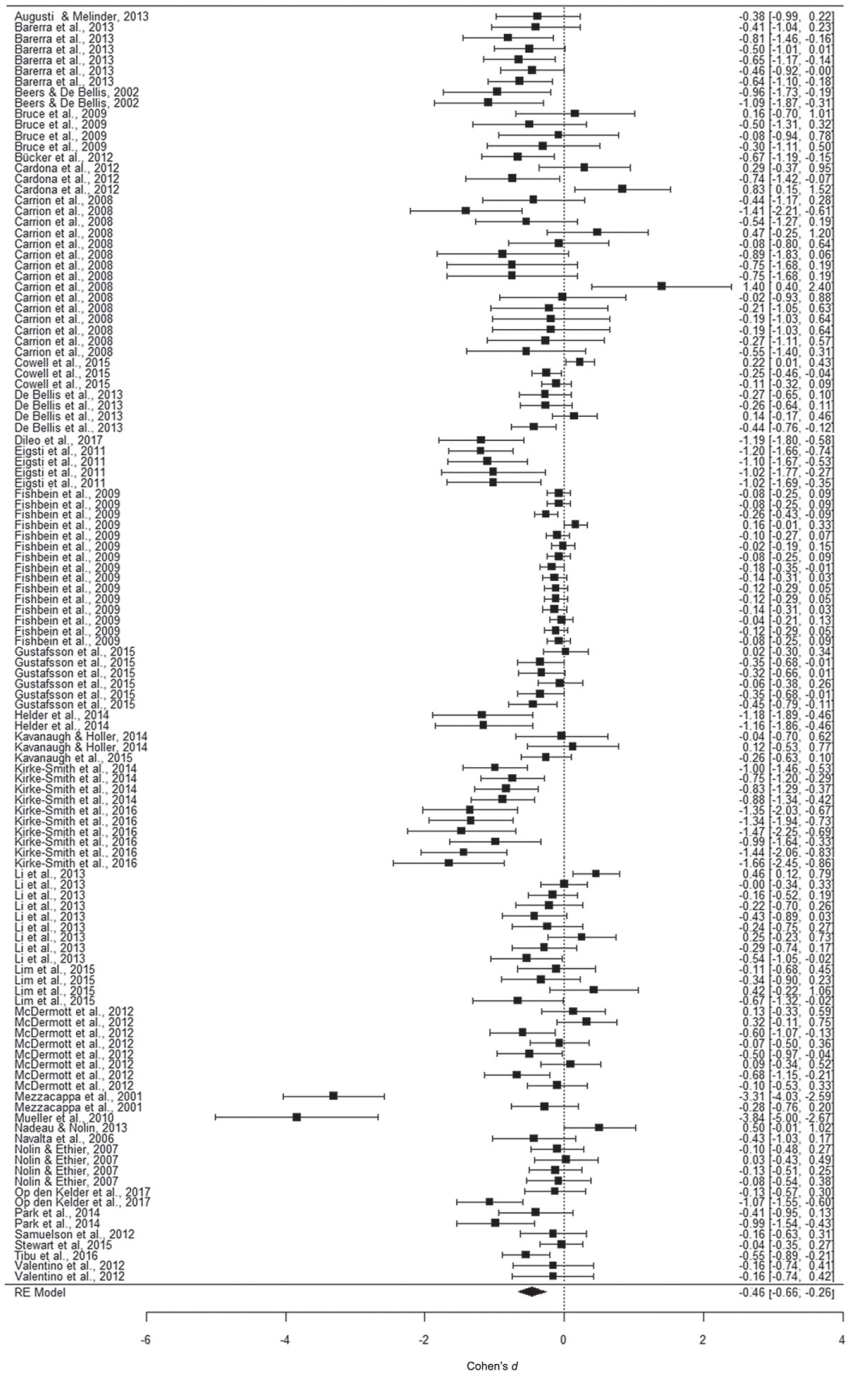


Figure 2.3. Forest plot of the meta-analysis on the association between trauma exposure and inhibition. RE, random effects.

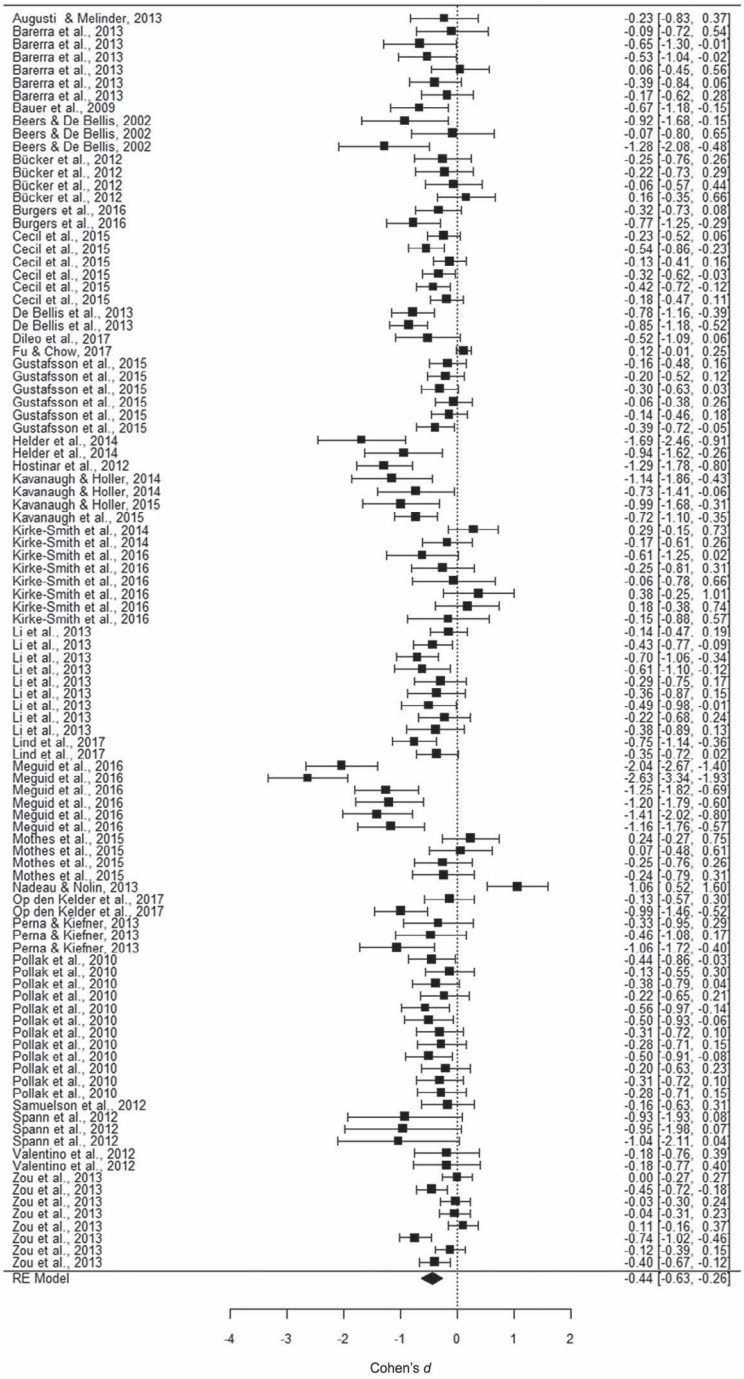


Figure 2.4. Forest plot of the meta-analysis on the association between trauma exposure and cognitive flexibility. RE, random effects.

When we analysed the heterogeneity of effect sizes for cognitive flexibility, we found significant within-study variance (σ^2_v = 0.02), x^2 (1) = 7.20, p = 0.007) and between-study variance (σ^2_v = 0.19, x^2 (1) = 54.02, p < 0.001). Of the total variance, 7.2% was attributable to within-study differences and 75.6% to between-study differences. In sum, significant heterogeneity was found between and within studies for working memory, inhibition, and cognitive flexibility. To explain the variation in effect sizes on the second and third levels, we added moderators to the random effects model.

Moderator analyses

We examined the extent to which moderators influenced the association between trauma exposure and executive functions by adding moderators as covariates (separately) to the random effect models. Table 2.2 displays the results of these analyses for working memory. We found that the quality of the measurement instrument (F (2,99) = 6.50, p = 0.002) influenced the association between trauma exposure and working memory significantly. The mean effect size for low-quality measurements was significantly stronger than the effect size that was found for high-quality measurements. We found that study quality was not an overall significant moderator (F (2,99) = 2.43, p = 0.093). However, we found that studies with a weak quality had a mean effect size that was significantly stronger than studies with a strong quality.

For inhibition, only type of trauma exposure was a significant moderator (F (2,116) = 5.21, p = 0.007). The mean effect size for single trauma exposure did not differ significantly from zero. No significant differences were found between violence-exposed/ abused and adopted/ foster care youth, but the average effect sizes for these groups differed significantly from zero and from single trauma- exposed youth. Study quality was, overall, not a significant moderator (F (2,116) = 2.42, p = 0.092). However, studies with a moderate quality had a significantly stronger effect size than weak-quality studies. Results of moderator analyses are displayed in Table 2.3.

For cognitive flexibility, although the overall moderator of trauma type was not significant (F (2,101) = 2.62, p = 0.078), we found that the average effect size for single trauma exposure did not differ significantly from zero, but the mean effect sizes for violence-exposed/ abused and adopted/foster care youth did, such that adopted/ foster care youth performed significantly lower on cognitive flexibility than children who experienced single traumatic events, but not compared to abused youth. Results of moderator analyses for cognitive flexibility are displayed in Table 2.4.

Table 2.2. Moderator analyses for the association between trauma exposure and working memory.

Variable	*K*	ES	β_0 (SE)	t_0	β_1 (SE)	t_1	*F* (df1,df2)
Study characteristics							
Age (mean centred)	24	94	−0.47 (0.82)	−5.74***	0.04 (0.02)	1.85	3.42 (1,92)
Gender (% female, mean centred)	25	90	−0.45 (0.09)	−5.23***	−0.00 (0.00)	0.74	0.55 (1,88)
Ethnicity (% minority, mean centred)	11	53	−0.32 (0.09)	−3.41**	0.00 (0.00)	1.02	1.03 (1,51)
Socio-economic status (SES)	26	102					0.05 (1,100)
Not controlled for SES (RC)	15	65	−0.51 (0.12)	−4.18***			
Controlled for SES	11	37			0.04 (0.19)	0.218	
Study quality	26	102					2.43 (2,99)
Strong (RC)	9	25	$-0.34\ (0.14)_a$	−2.49*			
Moderate	14	47	$-0.52\ (0.12)_{ab}$	−4.38***	−0.18 (0.16)	−1.15	
Weak	7	30	$-0.67\ (0.14)_b$	−4.98***	−0.34 (0.15)	−2.20*	
Trauma characteristics							
Onset	6	11	−0.72 (0.29)	−2.48*	−0.01 (0.07)	0.17	0.03 (1,9)
Duration	6	17	−0.74 (0.27)	−2.78*	−0.01 (0.08)	−0.17	0.03 (1,15)
Type	25	101					1.73 (2,98)
Single (RC)	4	10	$-0.28\ (0.16)_a$	−1.71			
Violence/abuse	16	59	$-0.41\ (0.11)_a$	−3.79***	−0.14 (0.14)	−0.95	
Adoption/foster care	7	32	$-0.71\ (0.17)_a$	−4.11***	−0.44 (0.24)	−1.86	
PTSD diagnoses	7	26					3.47 (1,24)
No diagnoses in sample (RC)	4	13	−0.38 (0.18)	−2.10*			
Diagnoses in sample	7	13			−0.24 (0.13)	−1.86	
Measurement characteristics							
Quality	26	102					6.50 (2,99)*
High (RC)	8	28	$-0.27\ (0.12)_a$	−2.32*			
Medium	11	43	$-0.44\ (0.12)_{ab}$	−3.75***	−0.17 (0.11)	−1.62	
Low	14	31	$-0.65\ (0.12)_b$	−5.64***	−0.38 (0.11)	−3.54***	

K = number of samples; ES = number of effect sizes; β_0 = mean effects size (Cohen's *d*); t_0 = test statistic for difference mean effect with zero; β_1 = regression coefficient; t_1 = test statistic of difference of mean effect size with the reference category (RC); *F* (df_1,df_2) = test statistic for testing significance of moderator; violence/abuse includes physical and emotional abuse, neglect, sexual abuse, and violence exposure; values with the same subscripts do not differ significantly from each other at $p < 0.05$.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 2.3. Moderator analyses for the association between trauma exposure and inhibition.

Variable	*K*	ES	β_0 (SE)	t_0	β_1 (SE)	t_1	*F* (df1,df2)
Study characteristics							
Age (mean centred)	27	85	−0.49 (0.11)	−4.66***	0.02 (0.03)	−0.62	0.38 (1,83)
Gender (% female, mean centred)	28	109	−0.46 (0.10)	−4.47***	0.00 (0.00)	0.43	0.19 (1,107)
Ethnicity (% minority, mean centred)	14	48	−0.25 (0.08)	−3.20***	0.00 (0.00)	0.27	0.07 (1,46)
Socio-economic status (SES)	29	119					0.14 (1,117)
Not controlled for SES (RC)	17	83	−0.43 (0.13)	−3.26**			
Controlled for SES	12	36			−0.08 (0.21)	−0.37	
Study quality	29	119					2.43 (2,116)
Strong (RC)	11	37	$-0.42\ (0.15)_{ab}$	−2.85**			
Moderate	11	41	$-0.64\ (0.14)_{a}$	−4.48***	−0.22 (0.20)	−1.10	
Weak	10	41	$-0.29\ (0.14)_{b}$	−2.07*	0.14 (0.17)	0.83	
Trauma characteristics							
Onset	10	27	−1.02 (0.51)	−2.01	−0.09 (0.12)	−0.79	0.62 (1,25)
Duration	9	23	−1.13 (0.46)	−2.45*	−0.11 (0.10)	1.051	1.11 (1,21)
Type	29	119					5.21 (2,116)**
Single (RC)	3	6	$0.04\ (0.19)_{a}$	0.21			
Violence/abuse	22	90	$-0.43\ (0.12)_{b}$	−3.58***	−0.47 (0.16)	−2.85**	
Adoption/foster care	6	23	$-0.79\ (0.24)_{b}$	−3.31***	−0.83 (0.31)	−2.72**	
PTSD diagnoses	14	55					0.47 (1,53)
No diagnoses in sample (RC)	6	13	−0.48 (0.18)	−2.63*			
Diagnoses in sample	13	42			−0.09 (0.13)	−0.69	
Measurement characteristics							
Quality	29	119					0.04 (2,116)
High (RC)	15	43	$-0.45\ (0.11)_{a}$	−4.04***			
Medium	14	38	$-0.46\ (0.12)_{a}$	−4.03***	0.01 (0.09)	−0.14	
Low	11	38	$-0.48\ (0.12)_{a}$	−3.87***	0.03 (0.11)	−0.27	

K = number of samples; ES = number of effect sizes; β_0 = mean effects size (Cohen's *d*); t_0 = test statistic for difference mean effect with zero; β_1 = regression coefficient; t_1 = test statistic of difference of mean effect size with the reference category (RC); *F* (df_1,df_2) = test statistic for testing significance of moderator; violence/abuse includes physical and emotional abuse, neglect, sexual abuse, and violence exposure; values with the samesubscripts do not differ significantly from each other at $p < 0.05$.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 2.4. Moderator analyses for the association between trauma exposure and cognitive flexibility.

Variable	*K*	ES	*β*0 (SE)	*t*0	*β*1 (SE)	*t*1	*F* (df1,df2)
Study characteristics							
Age (mean centred)	26	89	−0.38 (0.08)	−4.68***	0.02 (0.02)	0.91	0.84 (1,87)
Gender (% female, mean centred)	25	85	−0.41 (0.08)	−4.88***	−0.00 (0.00)	−0.61	0.37 (1,83)
Ethnicity (% minority, mean centred)	14	43	−0.36 (0.12)	−3.10**	0.00 (0.00)	−1.65	2.73 (1,41)
Socio-economic status (SES)	27	101					0.00 (1,99)
Not controlled for SES (RC)	16	55	−0.45 (0.12)	−3.64***			
Controlled for SES	11	46			0.01 (0.19)	0.05	
Study quality	27	101					0.87 (2,98)
Strong (RC)	6	21	$-0.33\ (0.13)_a$	−2.49*			
Moderate	11	45	$-0.57\ (0.13)_a$	−4.33***	−0.23 (0.18)	−1.28	
Weak	12	35	$-0.42\ (0.15)_a$	−2.81**	−0.09 (0.18)	−0.48	
Trauma characteristics							
Onset	2	6	−0.15 (0.28)	0.54	−0.06 (0.09)	−0.71	0.50 (1,4)
Duration	4	13	−0.87 (0.85)	−1.02	−0.21 (0.36)	0.58	0.33 (1,11)
Type	27	101					2.62 (2,98)
Single (RC)	3	5	$-0.17\ (0.17)_a$	−1.01			
Violence/abuse	21	78	$-0.39\ (0.10)_{ab}$	−3.97***	−0.22 (0.15)	−1.49	
Adoption/foster care	5	18	$-0.78\ (0.21)_b$	−3.67***	−0.61 (0.27)	−2.25*	
PTSD diagnoses	8	32					1.14 (1,30)
No diagnoses in sample (RC)	4	10	−0.32 (0.15)	−2.13*			
Diagnoses in sample	8	22			−0.11 (0.11)	−1.06	
Measurement characteristics							
Quality	27	101					0.57 (2,98)
High (RC)	11	30	$-0.41\ (0.11)_a$	−3.57***			
Medium	14	50	$-0.40\ (0.11)_a$	−3.89***	−0.00 (0.09)	−0.04	
Low	13	21	$-0.52\ (0.12)_b$	−4.52***	−0.11 (0.12)	−0.92	

K = number of samples; ES = number of effect sizes; β_0 = mean effects size (Cohen's *d*); t_0 = test statistic for difference mean effect with zero; β_1 = regression coefficient; t_1 = test statistic of difference of mean effect size with the reference category (RC); $F\ (df_1,df_2)$ = test statistic for testing significance of moderator; violence/abuse includes physical and emotional abuse, neglect, sexual abuse, and violence exposure; values with the same subscripts do not differ significantly from each other at $p < 0.05$.

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Publication bias

We applied the PET-PEESE approach to examine publication bias in our meta-analyses. For all analyses, the PET was sufficient for assessment. The effect sizes varied significantly with the standard error for working memory ($p < 0.001$), inhibition ($p < 0.001$), and cognitive flexibility ($p = 0.001$), which makes publication selection bias likely. After assessment of the funnel plots, it seemed that there were few 'small' studies that reported positive effects sizes and relatively few 'large' studies that reported negative effect sizes. This indicates the presence of a file-drawer problem in research on trauma exposure and executive functioning in youth (Franco, Malhotra, & Simonovits, 2014).

Discussion

In the present study, we analysed the association between trauma exposure and executive functions in youth using multi-level meta-analyses. The results demonstrate small to moderate effect sizes for the association between trauma exposure and working memory ($d = -0.49$), inhibition ($d = -0.46$), and cognitive flexibility ($d = -0.44$). These small to medium effect sizes indicate that approximately 68% of trauma-exposed youth will have a lower score on executive function tasks than youth in the control group. It is important to keep in mind, however, that we cannot draw strong conclusions about the clinical significance of the effect sizes. This is because not all outcome measures used standardized scores, and because the level of daily life impairments cannot readily be inferred from their executive functions. Executive functions work in complex ways to ultimately influence behaviour in daily life, with many factors (e.g. individual motivation, environmental support, compensatory strategies) potentially affecting this link. At the same time, because executive functions play a role in so many aspects of daily life, small to medium effect sizes can be expected to represent clinically relevant problems in trauma- exposed youth. Thus, our findings support the hypothesis that trauma exposure affects executive functions in youth.

We found that studies that used low-quality measurements showed a significantly larger effect size for the association between trauma-exposure and working memory than studies that used high-quality measurements. Researchers should be aware of the role of possible confounds when drawing conclusions based on low-quality outcome measures. Furthermore, we found that violence-exposed/abused and adopted/ foster care youth demonstrated lower levels of inhibition and adopted/foster care youth showed lower levels of cognitive flexibility. Based on knowledge about early brain development and developmental trajectories of executive functions, we expected that early and pro- longed

exposure to traumatic events would result in problems in executive functioning compared to single trauma exposure. It is probable that adopted/foster care youth have spent these early years in an atypical, mostly emotionally unsafe environment (Merz, Harlé, Noble, & McCall, 2016), which explains why they experience more difficulties in inhibition and cognitive flexibility than single trauma-exposed youth.

Although our results suggest that trauma types influence the impact on inhibition and cognitive flexibility, we did not find that onset and duration of trauma exposure influence this relationship, and this gives us no direct indications for critical periods in the development of executive functions. This unexpected finding may be explained by the high amount of missing data (between 75% and 90%) on these moderator variables. As moderator analyses already have a lower power than the main effects analyses, this could have led to a failure to detect a meaningful difference in effect sizes across subgroups. In light of the debate about the existence of critical periods, it is interesting to note that age at testing was not a significant moderator. This goes against the widely held notion that the moderating effect of age would be stronger for younger children, as it is assumed that earlier trauma exposure has a more severe impact on cognitive function. Although at first sight perhaps counterintuitive, our findings could be explained by the fact that we did not have enough information about onset, duration, and time between cessation of trauma exposure and executive function assessment. An important suggestion for future research is, then, to clearly assess (and report) these aspects of trauma exposure to allow for further investigation of how they determine the degree of executive functioning impairments. In sum, our findings, that were based on a small amount of effect sizes should be interpreted very carefully. Based on our moderator variable for trauma type and previous neuroimaging studies, we still expect that timing and duration of trauma exposure may affect the impact of trauma expo- sure on executive functions (Teicher & Samson, 2016).

Strengths and limitations

Our study was the first meta-analysis to examine the relationship between trauma exposure and executive functions in youth with a three-level meta-analysis approach. Therefore, we could take into account the dependency among effect sizes. Our results give a systematic overview of available empirical research on this topic, and our focus on the three core executive functions (working memory, inhibition, and cognitive flexibility) added scientific and clinical value. Despite these strengths, our meta-analysis has several limitations. First, although we specifically attempted to decrease the presence of publication bias by searching for unpublished papers and dissertations, our contact attempts were mostly not

answered. As our analyses indicated the presence of publication bias, our results should be interpreted carefully and 'real' effects may be smaller than the effects we found. Secondly, our meta-analysis was limited by missing data on theoretically important moderators such as trauma onset and duration. As there are strong indications from neuroimaging studies that the timing and duration of trauma exposure impact youth, we suggest that future research addresses these factors whenever possible. Thirdly, as both a strength and a limitation, we used various instruments that measured executive functions. This makes drawing conclusions on executive functioning in trauma-exposed youth more difficult. We handled this limitation by using a quality code on the measurement instrument, which makes us more confident about reliable outcomes. As we found that studies that used low-quality measurements showed a significantly larger effect size than studies that used high-quality measurements, future research that focuses on working memory should take this into account. As determining the quality of a task is difficult and can lead to discussion, one could, for example, combine a series of valid and reliable working memory measures in order to draw reliable conclusions instead of focusing on a sole outcome measure. Fourthly, 30–40% of studies were coded as low quality, which signals the importance for researchers to further increase the quality of their research by systematically reporting selection bias, study design, confounders, blinding, data collection methods, and withdrawal and dropouts. Fifthly, it should be noted that, as described in the introduction section, there are different types of working memory (verbal versus non-verbal) and inhibition (response inhibition and interference control). Although we aimed to investigate these differences, this was not possible because many studies used tasks that did not adequately distinguish between these different forms of working memory or inhibition. For example, many non-verbal working memory tasks do not exclude verbal working memory strategies, and there is little consensus about the categorization of Stroop-like tasks in response inhibition or interference control (e.g. Geurts, Van den Bergh, & Ruzzano, 2014). Finally, it is also important to note that we could not test causal pathways or investigate under- lying neurobiological mechanisms in our meta-analysis. While exposure to trauma may impact executive functioning, it could also be that deficits in executive functions may make individuals more at risk for exposure to traumatic events (Aupperle, Melrose, Stein, & Paulus, 2012). Therefore, future research should investigate this possibility to prevent trauma exposure and, in turn, its severe consequences such as PTSD, and internalizing and externalizing problems.

Future research

The dissociative subtype of PTSD was recently added to DSM-5 (American Psychiatric Association, 2013). Furthermore, empirical evidence indicates a link between dissociative

symptoms and executive functions (McKinnon et al., 2016; Parlar, Frewen, Oremus, Lanius, & McKinnon, 2016). The overlap between dissociation and cognitive problems such as attention and inhibition is not yet clearly established, however. This makes it highly (clinically) relevant to assess dissociative symptoms when investigating the link between trauma exposure and executive functioning. However, there were only three studies that assessed dissociative symptoms in participants and therefore we could not include this variable. As a result, we would like to point out this important limitation of existing work and therefore strongly suggest that future research addresses dissociation when investigating the link between trauma exposure and executive functioning.

In recent literature, 'hot' executive functions have gained increasing attention. These functions are used for motivationally or emotionally salient goal-directed behaviour (Prencipe et al., 2011; Zelazo & Carlson, 2012). Although this was beyond the scope of our meta-analysis, which focused on the three core executive functions, it would be very interesting for future studies to look at emotionally valent tasks as specifically trauma-exposed youth may suffer from chronic activation of the stress response in the brain and attention bias towards threatening stimuli (e.g. Gunnar & Quevedo, 2007; Pine et al., 2005).

The clear linkages between trauma exposure and executive functions indicate that it is pivotal for future intervention research to address executive functions as a possible moderator of intervention effects. For example, as working memory is assumed to be fully loaded in Eye Movement Desensitization and Reprocessing (EMDR), it could be that youth with lower working memory capacities may not be able to perform two tasks simultaneously and therefore would benefit less from treatment. Another possibility could be that techniques in trauma-focused cognitive behaviour therapy make an appeal to the basic capacity to inhibit emotions, thoughts, and action to regulate intrusive thoughts.

Conclusions

The results of our meta-analyses highlight the relationship between trauma exposure and working memory, inhibition, and cognitive flexibility in youth, especially for adopted and foster care youth. Future research on executive function in trauma-exposed youth should take into account the differential developmental pathways of executive functions and should investigate the onset and duration of trauma exposure. To draw reliable conclusions about the impact of trauma exposure in youth, researchers should use high-quality measurements. Our findings imply that clinical practice should use transdiagnostic models to incorporate problems with executive functions in their assessment and treatment guidelines for traumatized youth. Care in which trauma-exposed youth could

benefit more from treatments that also focus on a broader spectrum of problems, such as executive functions, should be the next step in both research and clinical practice.

References

Alisic, E., Jongmans, M. J., van Wesel, F., & Kleber, R. J. (2011). Building child trauma theory from longitudinal studies: A meta-analysis. *Clinical Psychology Review, 31,* 736–747. doi:10.1016/j.cpr.2011.03.001

Alisic, E., Zalta, A. K., Van Wesel, F., Larsen, S. E., Hafstad, G. S., Hassanpour, K., & Smid, G. E. (2014). Rates of post-traumatic stress disorder in trauma-exposed children and adolescents: Meta-analysis. *British Journal of Psychiatry, 204,* 335–340. doi:10.1192/bjp.bp.113.131227

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author.

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology, 8,* 71–82. doi:10.1076/chin.8.2.71.8724

Arain, M., Haque, M., Johal, L., Mathur, P., Nel, W., Rais, A., . . . Sharma, S. (2013). Maturation of the adolescent Brain. *Neuropsychiatric Disease and Treatment, 9*, 449–461. doi:10.2147/NDT.S39776

Aron, A. R. (2011). From reactive to proactive and selective control: Developing a richer model for stopping inappropriate responses. *Biological Psychiatry, 69,* 55–68. doi:10.1016/j.biopsych.2010.07.024

Assink, M., & Wibbelink, C. (2016). Fitting three-level meta-analytic models in R: A step-by-step tutorial. *The Quantitative Methods for Psychology, 12,* 154–174 doi:10.20982/tqmp.12.3.p154.

Aupperle, R. L., Melrose, A. J., Stein, M. B., & Paulus, M. P.(2012). Executive function and PTSD: Disengaging from trauma. *Neuropharmacology, 62,* 686–694. doi:10.1016/j.neuropharm.2011.02.008

Baddeley, A. (2012). Working memory: Theories, models, and controversies. *Annual Review of Psychology, 63,* 1–29. doi:10.1146/annurev-psych-120710-100422

Best, J. R., & Miller, P. H. (2010). A developmental perspective on executive function. *Child Development, 81,* 1641–1660. doi:10.1111/j.1467-8624.2010.01499.x

Best, J. R., Miller, P.H., & Jones, L. L. (2009). Executive functions after age 5: Changes and correlates. *Developmental Review, 29,* 180–200. doi:10.1016/j.dr.2009.05.002

Blaustein, M. E., & Kinniburgh, K. M. (2015). Het behandelen van trauma bij kinderen en jongeren: Hoe veerkracht door hechting, zelfregulatie en competenties versterkt kan worden. Amsterdam: Uitgevery SWP.

Borenstein, M., Hedges, L. V., Higgins, J. P. T., & Rothstein, H.R. (2010). A basic introduction to fixed-effect and random-effects models for meta-analysis. *Research Synthesis Methods, 1,* 97–111. doi:10.1002/jrsm.12

Bruce, J., Fisher, P. A., Graham, A. M.,Moore, W. M., III, Peak, S. J.,&Mannering, A.M. (2014). Patterns of brain activation in foster children and non-maltreated children during an inhibitory control task. *Developmental Psychopathology, 25*, 1–24. doi:10.1017/S095457941300028X

Cheung, M. W. L. (2014). Modeling dependent effect sizes with three-level meta-analyses: A structural equation modeling approach. *Psychological Methods, 19,* 211. doi:10.1037/a0032968

Cook, A., Spinazzola, J., Ford, J., Lanktree, C., Blaustein, M., Cloitre, M., . . . van der Kolk, B.A. (2005). Complex trauma in children and adolescents. *Psychiatric Annals, 35,* 390–398. doi:10.3928/00485713-20050501-05

Copeland, W. E., Keeler, G., Angold, A., & Costello, E. J. (2007). Traumatic events and posttraumatic stress in childhood. *Archives of General Psychiatry, 64,* 577–584. doi:10.1016/S0084-3970(08)79296-X

Costello, E. J., Erkanli, A., Fairbank, J. A., & Angold, A.(2002). The prevalence of potentially traumatic events in childhood and adolescence. *Journal of Traumatic Stress, 15,* 99–112. doi:10.1023/A:1014851823163

Cowell, R. A., Cicchetti, D., Rogosch, F. A., & Toth, S. L. (2015). Childhood maltreatment and its effect on neurocognitive functioning: Timing and chronicity matter. *Development and Psychopathology, 27,* 521–533. doi:10.1017/S0954579415000139

De Bellis, M. (2001). Developmental traumatology: The psychobiological development of maltreated children and its implications for research, treatment, and policy. *Development and Psychopathology, 13,* 539–564. doi:10.1017/S0954579401003078

De Bellis, M., Baum, A. S., Birmaher, B., Keshavan, M. S., Eccard, C. H., Boring, A. M., . . . Ryan, N. D. (1999). Developmental traumatology part I: Biological stress systems. *Biological Psychiatry, 45,* 1259–1270. doi:10.1016/S0006-3223(99)00044-X

De Bellis, M., & Thomas, L. (2003). Biologic findings of post-traumatic stress disorder and child maltreatment. *Current Psychiatry Reports, 5*, 108–117. doi:10.1007/s11920-003-0027-z

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64,* 135–168. doi:10.1146/annurev-psych-113011-143750

Fernández-Serrano, M. J., Pérez-García,M., Schmidt Río-Valle, J., & Verdejo-García, A. (2010). Neuropsychological consequences of alcohol and drug abuse on different components of executivefunctions.*JournalofPsychopharmacology,24,*1317–1332.doi:10.1177/0269881109349841

Fowler, P. J., Tompsett, C. J., Braciszewski, J. M., Jacques-Tiura, A. J., & Baltes, B. B. (2009). Community violence: A meta-analysis on the effect of exposure and mental health outcomes of children and adolescents. *Development and Psychopathology, 21,* 227–259.doi:10.1017/S0954579409000145

Franco, A., Malhotra, N., & Simonovits, G. (2014). Publication bias in the social sciences: Unlocking the file drawer. *Science, 345,* 1502–1505. doi:10.1126/science.1255484

Friedman, N. P., Miyake, A., Altamirano, L. J., Corley, R. P., Young, S. E., Rhea, S. A., & Hewitt, J. K. (2015). Stability and change in executive function abilities from study stability and change in executive function abilities from late adolescence to early adulthood: A longitudinal twin study. *Developmental Psychology, 52,* 326–340. doi:10.1037/dev0000075

Friedman, N. P., & Miyake, A. (2004). The relations among inhibition and interference control functions: A latent variable analysis. *Journal of Experimental Psychology: General, 133,* 101–135. doi:10.1037/0096-3445.133.1.101

Geurts, H. M., Van den Bergh, S. F. W. M., & Ruzzano, L. (2014). Prepotent response inhibition and interference control in autism spectrum disorders: Two meta-analyses. *Autism Research, 7,* 407–420. doi:10.1002/aur.1369

Gioia, G. A, Isquith, P. K., Kenworthy, L., & Barton, R. M. (2002). Profiles of everyday executive function in acquired and developmental disorders. *Child Neuropsychology, 8,* 121–137. doi:10.1076/chin.8.2.121.8727

Goldstein, S., Naglieri, J. A., Princiotta, D., & Otero, T. M. (2014*). Introduction: A history of executive functioning as a theoretical and clinical construct. In J. A. Goldstein & S. Naglieri (Eds.), Handbook of executive functioning.* Springer, New York, NY, 3–12.

Gunnar, M., & Quevedo, K. (2007). The neurobiology of stress and development. *Annual Review of Psychology, 58,* 145–173. doi:10.1146/annurev.psych.58.110405.085605

Hart, H, & Rubia, K. (2012). Neuroimaging of child abuse: a critical review. *Frontiers in Human Neuroscience, 6,* 1–24. doi:10.3389/fnhum.2012.00052

Huizinga, M., Dolan, C. V., & van der Molen, M. W. (2006). Age-related change in executive function: Developmental trends and a latent variable analysis. *Neuropsychologia, 44,* 2017–2036. doi:10.1016/j.neuropsychologia.2006.01.010

Johnson, M. H., & De Haan, M. (2011). *Developmental neuroscience: An introduction*. Malden, MA: Wiley-Blackwell.

Jonkman, C. S., Verlinden, E., Bolle, E. A., Boer, F., & Lindauer, R. J. L. (2013). Traumatic stress symptomatology after child maltreatment and single traumatic events: Different profiles. *Journal of Traumatic Stress, 26,* 225–232. doi:10.1002/jts.21792

Kavanaugh, B. C., Dupont-Frechette, J. A., Jerskey, B. A., & Holler, A. (2017). Neurocognitive deficits in children and adolescents following maltreatment: Neurodevelopmental consequences and neuropsychological implications of traumatic stress. *Applied Neuropsychology: Child, 6,* 64–78. doi:10.1080/21622965.2015.1079712

Lamers-Winkelman, F., Willemen, A.M., & Visser, M. (2012). Adverse childhood experiences of referred children exposed to intimate partner violence: Consequences for their wellbeing. *Child Abuse and Neglect, 36,* 166–179. doi:10.1016/j.chiabu.2011.07.006

López, C. M., Andrews, A. R., Chisolm, A. M., De Arellano, M.A., Saunders, B., & Kilpatrick, D.G. (2017). Racial/ethnic differences in trauma exposure and mental health disorders in adolescents. *Cultural Diversity and Ethnic Minority Psychology, 23,* 382–387. doi:10.1037/cdp0000126

Lupien, S. J., McEwen, B. S., Gunnar, M. R., & Heim, C. (2009). Effects of stress throughout the lifespan on the brain, behaviour and cognition. *Nature Reviews Neuroscience, 10,* 434–445. doi:10.1038/nrn2639

Malarbi, S., Abu-Rayya, H. M., Muscara, F., & Stargatt, R. (2017). Neuropsychological functioning of childhood trauma and post-traumatic stress disorder: A meta-analysis. *Neuroscience and Biobehavioral Reviews, 72,* 68–86. doi:10.1016/j.neubiorev.2016.11.004

McKinnon, M. C., Boyd, J. E., Frewen, P. A., Lanius, U. F., Jetly, R., Richardson, J. D., & L Lanius, R. A. (2016). A review of the relation between dissociation, memory, executive functioning and social cognition in military members and civilians with neuropsychiatric conditions. *Neuropsychologia, 90,* 210–234. doi:10.1016/j.neuropsychologia.2016.07.017

Merz, E. C., Harlé, K. M., Noble, K. G., & McCall, R. B. (2016). Executive function in previously institutionalized children. *Child Development Perspectives, 10,* 105–110. doi:10.1111/cdep.12170

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: Four general conclusions. *Current Directions in Psychological Science, 21,* 8–14. doi:10.1177/0963721411429458

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A.,&Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "Frontal Lobe" tasks: A latent variable analysis. *Cognitive Psychology, 41,* 49–100. doi:10.1006/cogp.1999.0734

Morina, N., Koerssen, R., & Pollet, T. V. (2016). Interventions for children and adolescents with posttraumatic stress disorder: A meta-analysis of comparative outcome studies. *Clinical Psychology Review, 47,* 41–4. doi:10.1016/j.cpr.2016.05.006

Nigg, J. T. (2000). On inhibition/disinhibition in developmental psychopathology: Views from cognitive and personality psychology and a working inhibition taxonomy. *Psychological Bulletin, 126,* 220–246. doi:10.1037/0033- 2909.126.2.220

Norman, R. E., Byambaa, M., De, R., Butchart, A., Scott, J., & Vos, T. (2012). The long-term health consequences of child physical abuse, emotional abuse, and neglect: A systematic review and meta-analysis. *PLoS Medicine, 9.* doi:10.1371/journal.pmed.1001349 9 e1001349

Parlar, M., Frewen, P. A., Oremus, C., Lanius, R. A., & McKinnon, M. C. (2016). Dissociative symptoms are associated with reduced neuropsychological performance in patients with recurrent depression and a history of trauma exposure. *European Journal of Psychotraumatology, 7,* 1–19. doi:10.3402/ejpt.v7.29061

Pine, D. D. S., Mogg, K., Bradley, B. P., Montgomery, L., Christopher Monk, M. S., McClure, E., . . . Kaufman, J. (2005). Attention bias to threat in maltreated children: Implications for vulnerability to stress-related psychopathology. *American Journal of Psychiatry, 162,* 291–296. doi:10.1176/appi.ajp.162.2.291

Prencipe, A., Kesek, A., Cohen, J., Lamm, C., Lewis, M. D., & Zelazo, P. D. (2011). Development of hot and cool executive function during the transition to adolescence. *Journal of Experimental Child Psychology, 108,* 621–637. doi:10.1016/j.jecp.2010.09.008

Stanley, T. D., & Doucouliagos, H. (2014). Meta-regression approximations to reduce publication selection bias. *Research Synthesis Methods, 5,* 60–78. doi:10.1002/jrsm.1095

Tamminga, H. G. H., Reneman, L., Huizenga, H. M., & Geurts, H. M. (2016). Effects of methylphenidate on executive functioning in attention-deficit/hyperactivity disorder across the lifespan: A meta-regression analysis. *Psychological Medicine, 46,* 1791–1807. doi:10.1017/S0033291716000350

Teicher, M. H., & Samson, J. A. (2016). Annual Research Review: Enduring neurobiological effects of childhood abuse and neglect. *Journal of Child Psychology and Psychiatry, 57,* 241–266. doi:10.1111/jcpp.12507

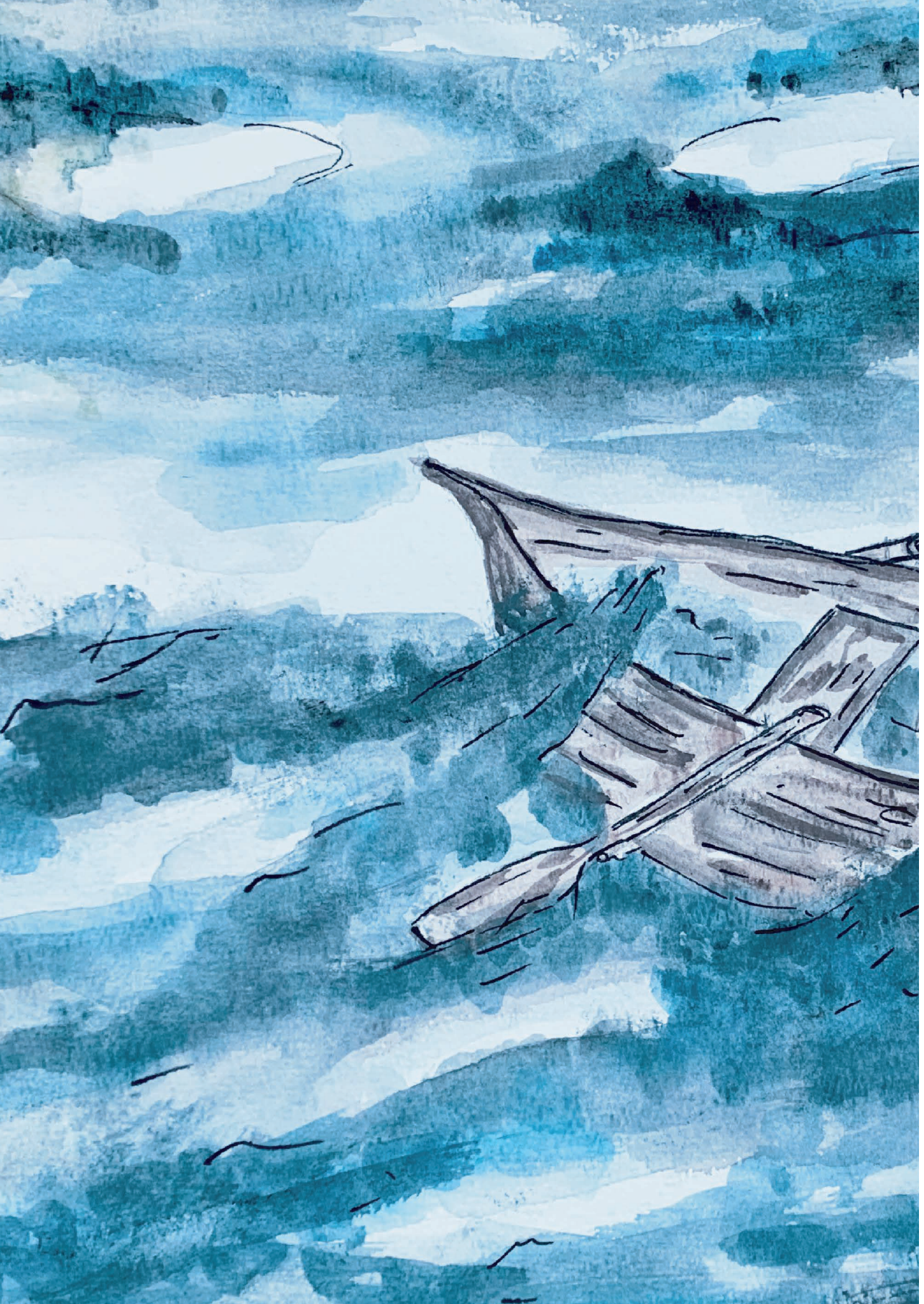
Thomas, B. H., Ciliska, D., Dobbins, M., & Micucci, S. (2004). A process for systematically reviewing the literature: Providing the research evidence for public health nursing interventions. *World Views on Evidence-Based Nursing, 1,* 176–184. doi:10.1111/j.1524-475X.2004.04006.x

Viechtbauer. (2006). Conducting meta-analyses in R with the Metafor package. Journal of Statistical Software, 17, 1–11. doi:10.18637/jss.v069.i12

Weems, C. F., Taylor, L. K., Cannon, M. F., Marino, R.C., Romano, D. M., Scott, B.G., ... Triplett, V. (2010). Posttraumatic stress, context, and the lingering effects of the Hurricane Katrina disaster among ethnic minority youth. *Journal of Abnormal Child Psychology, 38,* 49–56. doi:10.1007/s10802-009-9352-y

Wegman, H. L., & Stetler, C. (2009). A meta-analytic review of the effects of childhood abuse on medical outcomes in adulthood. *Psychosomatic Medicine, 71,* 805–812. doi:10.1097/PSY.0b013e3181bb2b46

Zelazo, P. D., & Carlson, S.M. (2012). Hot and cool executive function in childhood and adolescence: Development and plasticity. *Child Development Perspectives, 6,* 354–360. doi:10.1111/j.1750-8606.2012.00246.x



Longitudinal associations between trauma exposure and executive functions in children: Findings from a Dutch birth cohort study

Rosanne op den Kelder,
Alithe L. van den Akker
Judith B. M. Ensink
Hilde M. Geurts
Geertjan Overbeek
Susanne R. de Rooij
Tanja G. M. Vrijkotte
Ramón J. L. Lindauer

Research on Child and Adolescent Psychopathology, 2022, 50, 295-308.

Abstract

This study is the first to distinguish two possible predictive directions between trauma exposure and executive functioning in children in a community sample. The sample consists of 1006 children from two time points with a seven years' time interval of a longitudinal Dutch birth cohort study, the ABCD-study (Van Eijsden et al., 2011). We analyzed the longitudinal associations between trauma exposure and executive functioning using structural equation modeling. The results demonstrated that (after controlling for prenatal substance exposure and mothers' educational level) trauma exposure before age 5 is predictive of poorer executive functioning at age 12 and trauma exposure between age 6 and 12. However, the association between executive functioning at age 5 and trauma exposure between age 6 and 12 was not statistically significant. Our results indicate that early life trauma exposure has a long term impact on later executive functioning and not the other way around. On top of that, trauma exposure seems to accumulate across childhood when children are exposed to a traumatic event before the age of 5. When looking at the potential moderating role of parenting behavior we found no evidence for such a moderating effect of parenting behavior. Our findings showed that children exposed to trauma early in life may experience problems in executive functioning later in life and they seem at higher risk for cumulative trauma exposure. Clinical practice should take this into account in both the way they provide (early) mental health care and in prevention and recognition of early trauma exposure.

Keywords Trauma exposure, Children, Executive functioning, Structural equation modeling, Parenting behavior

Introduction

Approximately two-thirds of youth across the globe are exposed to traumatic events before they are sixteen (Copeland et al., 2007; McLaughlin et al., 2013). According to the Diagnostic and Statistical Manual of Mental Disorders 5, trauma exposure is defined as exposure to an actual or threatened death, serious injury or sexual violation (American Psychiatric Association, 2000, 2013). A person is exposed to a traumatic event when the person directly experiences the traumatic event, witnesses the event in person or learns that the event occurred to a close family member or close friend. Examples of possible traumatic events are child sexual abuse, traffic accidents, physical abuse, natural disasters, and war-related experiences. Trauma-exposed youth are at heightened risk for the development of various emotional, behavioral, and physical health problems in both the short and long term (Fowler et al., 2009; Norman et al., 2012; Wegman & Stetler, 2009). As there are serious consequences of trauma exposure in childhood on both the individual and societal level, it is important to both prevent trauma exposure and the development of problems after trauma exposure.

A substantial body of research has shown that trauma-exposed youth do not only experience emotional and behavioral adjustment difficulties, but that they also experience problems with basic cognitive functions. A frequently reported finding in the cognition research field is that trauma-exposed youth show problems in executive functioning (Malarbi et al., 2017; Op den Kelder et al., 2018). Executive functions are a set of cognitive skills that are needed for goal-directed behavior. These functions play a crucial role in an individuals' daily functioning (Diamond, 2013; Goldstein et al., 2014). Children with executive functioning problems experience difficulties with (1) dealing flexibly with and adapting to new situations, rules, and perspectives, (2) inhibiting automatic responses, thoughts, feelings, and (3) simultaneously storing and manipulating incoming information (Diamond, 2013; Miyake et al., 2000). Poor executive functioning can have serious impact on the quality of life (Brown & Landgraf, 2010), increases the risk for obesity (Miller, Lee, & Lumeng 2014) and substance abuse (Kim-Spoon et al., 2017), and is associated with lower academic achievements and more difficulties in finding and maintaining a job (Diamond, 2013).

Trauma exposure may not only impact the development of executive functions in children, problems in executive functions could predate and increase the risk for subsequent trauma exposure. There could be different explanations for this direction from early executive functioning to later trauma exposure. First, children with lower executive functions have more

behavioral problems which increases the risk for interpersonal trauma such as child abuse or community violence as they are more difficult to handle at home or at school. Weaker executive functioning in pre-school children has been associated with more behavioral problems according to a meta-analysis based on 22 studies (Schoemaker et al., 2013). A prospective study among 69 five year-old children found that early inhibitory control predicted behavioral problems at six years old (Quistberg & Mueller, 2020). Another study among elementary school children with oppositional/conduct problems showed that these children were at increased risk for peer victimization (Ter-Stepanian et al., 2019). Another potential pathway through which problems in executive functioning could lead to trauma exposure is that children with lower executive functioning are more vulnerable and therefore at higher risk of victimization or exploitation by adults. For example, a study among 92 adolescents found that children with lower executive functioning had a higher risk of being victimized by their peers (Kloosterman et al., 2014). Another study among 1377 children showed that inhibition at age 4 was associated with a higher risk of being a victim of bullying (Verlinden et al., 2014), which can also be considered traumatic in cases of physical threat or harm.

Although several longitudinal studies investigated the associations between early trauma and later executive functioning (Bos et al., 2009; McDermott et al., 2012, 2013), these studies did not make any attempt to control for early executive functioning making it impossible to draw conclusions about the direction of effects between trauma expo- sure and executive functioning. However, two longitudinal studies on trauma exposure in relation to intelligence and academic skills (which is closely related to executive functioning) (van Aken et al., 2016), did take early cognitive functioning into account. A longitudinal study among 206 children found that children exposed to interpersonal trauma exposure between birth and 64 months had lower scores on cognitive outcomes such as memory learning, problem solving, abstract thinking, and mathematical concept formation at 24 months (Bayley Mental Development Scale). These children also had lower scores on cognitive outcomes on subtests of the Wechsler's preschool intelligence scale (Block Design, Vocabulary, and Animal House) at 64 months (Enlow et al., 2012). Another longitudinal birth cohort study among 8928 participants showed long term effects of childhood neglect on reading, mathematics, and general ability tests at age 7, 11, 16, and 50 year old when taking into account the earlier cognitive scores using multivariate response modeling (Geoffroy et al., 2016). Based on earlier research, we assume that trauma exposure is predictive of executive functioning, but to date, there is no longitudinal research confirming this link with executive functions specifically. Additionally, to date, there is no longitudinal research examining the possible predictive relationship of early executive functioning to later trauma exposure. This knowledge gap highlights the importance to investigate whether

early trauma exposure predicts problems in executive functions and/or whether problems in executive functions predicts later trauma exposure.

Parenting behavior

Especially in childhood it is important to take the child's context in consideration. The relationship between trauma exposure and executive functioning could be influenced by the child's family environment. Specifically, parenting behaviors could function as putative moderators (i.e., buffers or exacerbators). Three parenting styles are mostly distinguished: authoritative, authoritarian, and permissive parenting (Baumrind, 1971). Parenting styles are about attitudes, values, beliefs about children's nature, and specific parenting practices. The authoritative parenting style reflects high responsiveness and control, while the authoritarian parenting style reflects high control, but low responsiveness, and permissive parenting style reflects highly responsiveness but little control (Baumrind, 1971; Darling & Steinberg, 1993; Steinberg et al., 1992). It is possible that these variations in the degree of responsiveness and parental control moderates in the association between trauma exposure and executive functioning.

First, high levels of responsiveness and control in parenting behavior are known to be associated with adaptive coping styles and resilience in children (e.g. Afifi & MacMillan, 2011; Lind et al., 2018). Children who grow up in a parenting context that is more sensitive and supportive, might be better equipped to cope with trauma expo- sure as their parents might be more aware of the potential impact of trauma exposure, which in turn may lead parents to give more support and help their children when needed. As far as we know, to date, there is no research investigating parenting in the context of early trauma exposure and later executive functioning. Based on the resilience framework, the assumption is that parents who are more regulating and responsive are better in enhancing resilience for adverse life events. Resilience is defined as a good adaptation in a dynamic system after disturbances that are a threat to the system, its viability or development (Masten, 2014). Although not specifically focused on executive functioning, previous studies have shown that parenting behaviors might influence how much children are impacted by a traumatic event more generally. For instance, a large cross-sectional study among 5765 adolescents showed that an authoritarian parenting style had a significant negative effect on children's resilience, indicating that they are more impacted by a traumatic event (Zhai et al., 2015). Another cross-sectional study among 358 school-aged children showed that children from parents who provided relatively little care to their children had a relatively high risk of developing internalizing problems after experiencing mass trauma (Sriskandarajah et al., 2015). More specifically, in a sample of 74 children that grew up in a household with intimate partner violence, positive parenting practices of the mother were related to a higher level of executive functioning (Samuelson et al., 2012). In sum, authoritative

parenting behavior might buffer the impact of trauma exposure, and in turn, protect children from developing executive functioning problems. In contrast, authoritarian or permissive parenting behaviors could strengthen the negative relationship between trauma exposure and later executive functioning.

Parenting behavior could also moderate the relationship between early executive functioning and later trauma exposure. For example, responsive parents may be more likely to recognize that their child has problems with executive functioning and consequently may be more inclined to help children to regulate and structure their environment to a greater extent, which diminishes the risk for trauma exposure for their children. In a related vein, permissive parents will not likely regulate and control the child's environment, sometimes children who are low in executive functioning need more. In other words, when children have lower executive functioning and parents are not able to guide their child in a responsive way, the relationship between executive functioning and later trauma exposure could be stronger. Previous research among 169 children aged 9 to 13 years has shown that parenting with high involvement and responsibility was associated with better performances on executive functioning tasks (Sosic-Vasic et al., 2017). Another study among 82 children and adolescents with ADHD or ASD showed that authoritarian and permissive parenting styles were associated with poorer executive functioning (Hutchison et al., 2016).There is no previous research that investigated parenting in the light of early executive functioning and later trauma exposure or broader risks for children. Therefore, we are in need of longitudinal research for more stringent and temporally informative tests about the possible moderating role of parenting on the relationship between trauma exposure and executive functions as well as the other way around.

Besides parenting behaviors, other factors may impact the bidirectional relationship between trauma exposure and executive functioning. First of all, a review has shown that children who have been exposed to both prenatal maternal alcohol use and a traumatic event are more likely to show deficits in attention, memory, intelligence and increased behavioral problems (Price et al., 2017). Second, prenatal exposure to cannabis or cigarettes is also related with problems in executive functioning in both young and older children (Fried & Smith, 2001; Micalizzi & Knopik, 2018; Noland et al., 2003; Richardson et al., 2002). Third, previous research suggested that parents' educational level is negatively associated with executive functioning (Ardila et al., 2010) and that a low educational level is a risk factor for trauma exposure (Brattström et al., 2015). Furthermore, a systematic review showed that prenatal exposure to drugs, alcohol or tobacco and educational level influences the relationship between parenting practices and executive functioning in childhood (Fay-Stammbach et al., 2014). Therefore, each of these factors were included

in our analytic model to control for them in the bidirectional associations between trauma exposure and executive functioning.

In our study, our aim was to investigate the longitudinal and bidirectional associations between trauma exposure and executive functioning as depicted in Fig. 3.1 We hypothesized that there would be a longitudinal relationship between early trauma exposure and later executive functioning and between early executive functioning and later trauma exposure. We also hypothesized that authoritarian and permissive parenting would strengthen these longitudinal associations, and that an authoritative parenting behavior would decrease the strength of these longitudinal associations.

Method

Study population

The present study is part of the Amsterdam Born Children and their Development (ABCD) study (Van Eijsden et al., 2011). The ABCD study is an ongoing prospective birth cohort study among 8000 children, followed since pregnancy. The medical ethical committee of the Academic Medical Center of Amsterdam approved the ABCD cohort study (NL53940.018.15, study number: 2015_154).

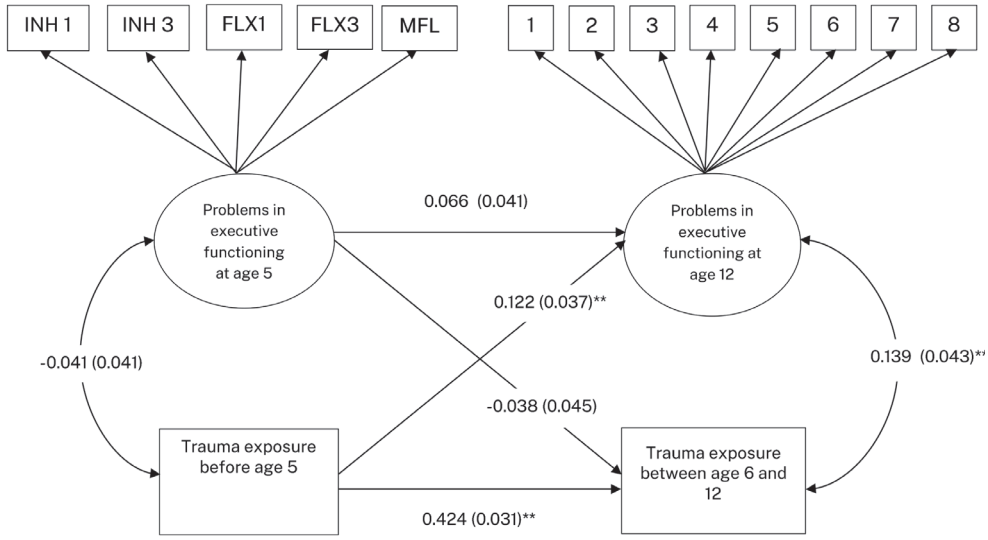


Fig. 3.1 Model of the longitudinal and bidirectional associations between trauma exposure and executive functioning
Path coefficients are standardized. Variables: INH1 = inhibition 1, INH3 = inhibition 3, FLX1 = flexibility 1, FLX3 = Flexibility 3, MFL = motor flexibility. Observed variables for factor of executive functioning at age 12 represent the sumscore of three items of each subscale of the Behavior Rating Inventory of Executive Functioning (BRIEF) **p < 0.001*

From January 2003 until March 2004, all pregnant women in Amsterdam were asked to participate in the ABCD study during their first prenatal care visit. In total, 8266 pregnant women filled out the questionnaire and 6735 (81%) gave permission for follow-up. After 5 years (wave 3), 6161 mothers were retrieved and 4488 mothers reported on their children's health. At age 11–12 (wave 4), 2997 mothers reported about their children's health and 1006 children participated in physical examinations and interviews. We used information of these 1006 children that participated in both wave 3 and 4. We will further address these measurement waves as time point 1 (T1 = wave 3) and time point 2 (T2 = wave 4). The other waves primarily focused on physical health of the pregnant mother and the newborn child and thus could not be used for our study purposes.

The 1006 children who participated at T1 and T2 had a mean age of 5.1 (SD 0.23; range 5.0–7.2) at T1 and a mean age of 11.8 at T2 (SD 0.37; range 10.5—12.9). Of these participants, 49.0% were girls. Ethnicity was defined by the country of birth of the mother (Menting et al., 2018; Van Eijsden et al., 2011) and was divided into Dutch (82%) or non-Dutch (18%). Non-Dutch included the following ethnicities: Surinam (2.9%), Antilleans (1.0%), Turkish (1.2%), Moroccan (1.9%), Ghanese (1.0%), western (5.7%), non-western (4.4%)."

Mothers educational level was distributed as follows: 7.3% low (only primary school), 17.7% mid (high school or vocational training), and 75.1% high (university; in Dutch HBO and university). The mid educational level-group was overrepresented by non-Dutch participants, while the high educational level group was overrepresented by Dutch participants, and the low educational group was almost equally divided. When we compared our study sample to the larger population in the Amsterdam municipality in 2004, approximately 29.2% of the citizens were not born in the Netherlands. Approximately 20.6% of Amsterdam citizens followed higher education (van Zee et al., 2004). Although this comparison is not totally reliable because the total Amsterdam population also includes inhabitants that were not parents, this showed that our study was a relatively highly educated, ethnically more homogeneous sample. Our study sample did not differ significantly from the total group of participants at T2 (all participants at T2, including those who did not participate in the lab assessment) on educational level (x^2 (4) = 6.34, p = 0.18), but did differ significantly on ethnicity (x^2 (1) = 5.50, p = 0.02), with fewer non-Dutch children in our sample compared to the total sample (30%). Missing data from the individual variables ranged from 1.99% (trauma exposure) to 17.71% (inhibition 3).

Procedure

All caregivers and participants older than 11 years (in some cases the participant just turned 12) gave informed consent. The information folders, letters and questionnaires were available in Dutch, English, and Turkish. Caregivers were asked to fill out questionnaires at home.

At T1, children completed four neuropsychological tasks individually on a laptop with a duration between 20 to 26 min. Trained instructors invited the children to perform the tasks individually in a quiet room at school. Instructors gave a verbal task instruction and demonstrated an example of the task. Then, the child performed a practice trial before starting the test trial of each single tasks (Guxens et al., 2016; Menting et al., 2018).

At T2, a total of 1006 children and their caregivers visited the research location and participated in both physical and mental health assessments. For the mental health assessments, children were interviewed face-to-face by trained psychologists and filled in questionnaires individually. The questionnaire that included items on executive functioning was send out by mail before the assessment day and caregivers filled this in at home. For more details on all measurement instruments and an overview of published research, see: https://www.amc.nl/web/abcd-studie-2.htm.

Measures

Childhood trauma exposure

Trained psychologists interviewed children with the life-events checklist (LEC) during T2. This semi-structured checklist is part of the Clinician Administered PTSD Scale for Children and Adolescents (CAPS-CA) (van Meijel et al. 2019; Pynoos et al., 2015). The checklist consists of 25 possible traumatic items, with five answer options; '*Happened to me*', '*Witnessed it*', '*Learned about it*', '*Not sure*' and '*Doesn't apply*'. The LEC has good psychometric properties with a test–retest reliability of r = 0.82 and convergence validity with a mean kappa for all items of 0.61 (Gray et al., 2004). Besides questioning exposure to events, we also asked the child's age during these events. After data collection and data entry, we rated the traumatic events based on the DSM–IV criteria. All events were rated by at least 2 out of 3 independent coders (RodK; JE; HB) and discrepancies were resolved by discussion with a third coder or expert panel.

We decided to include events that concerned participants themselves, their first degree relatives, or best friends only. Exceptions for this decision were cases of extreme violence such as victims of the attack on flight MH17 (in that case also teachers and friends were included). As a traumatic event is defined as one involving an actual or threatened death, serious injury or sexual violation, we decided that only severe accidents where an ambulance or hospital stay was needed, were included. For domestic emotional abuse we only included events that were extreme or caused structural safety issues for a longer period of time. As emotional abuse is mostly vaguely described by children (e.g. by mother yelled at me/called me names), we only included this as a traumatic event when the children reported that this happened more than once over a longer period of time. This

was done by a "blind" expert panel of five experts in the field. In cases of discrepancies, consensus was reached by discussion Approximately one-third of the children had been exposed to a traumatic event. Most traumatic events were severe accidents (27.5%) and victim of community violence (22.5%). Other events were disaster (1.6%), victim of domestic violence (7.8%), witness of domestic violence (7.5%), witness of community violence (5.9%), sexual assault (2.2%), dead or injury of a loved one (6.7%), serious medical condition (14.9%), and other events (3.5%). Based on the interviews, we constructed two variables: traumatic events untilthe age of 5 (no / ≥ 1 event), and traumatic events between 6 and 12 years old (no, 1 event, ≥ 2 events). Twenty children (2.0%) did not participate in the interview.

Executive Functions

Based on earlier research and theories, our approach was to focus on the conceptual unity underlying different aspects of executive functioning (Miyake & Friedman, 2000; Diamond, 2013). At T1, executive functioning was measured using subtests of the widely-used Amsterdam Neuropsychological Tasks (ANT) (Sonneville, 1999). The ANT is a computerized test battery that was performed in an individual setting at school in which the children performed the tasks pursuit, tracking, and response organization objects (ROO). The tasks have been shown to be sensitive to detection of neuropsychological problems in various samples and have good reliability and validity (De Sonneville et al., 2002; Rowbotham et al., 2009).The ROO task measures inhibitory control and cognitive flexibility and consists of three parts that increase in complexity. In part 1, children had to click the left mouse button when a green ball appeared on the left side of the screen and vice versa. In part 2, the tasks requires a click on the right mouse button when a red ball appeared on the left side of the screen and vice versa. In part 3, children had to follow these instructions based on the color of the ball that randomly alternated. A valid response was considered when a child clicked the correct button between 200 to 6000 ms after the stimulus was presented on the screen. Both the pursuit and tracking task measure visuomotor coordination. In the pursuit task, the child had to follow a mouse cursor on the screen that made a random trajectory with a constant speed of 10 mm/s, using their non-preferred hand and in the second part with their preferred hand. The tracking task is similar to the pursuit task, but in this task the mouse cursor follows a familiar and planned trajectory, which requires less executive demands.

The following outcome measures of these tasks were used to assess executive functions at age 5 (1) flexibility 1: mean reaction time compatible part 3 minus mean reaction time compatible part 1 in milliseconds, (2) flexibility 2: number of errors compatible part 3 minus mean reaction time compatible part 1, (3) flexibility 3: standard deviation right plus left hand compatible part 3 minus standard deviation right plus left hand compatible part 1 in

milliseconds, (4) inhibition 1: mean reaction time incompatible part 2 minus mean reaction time compatible part 1 in milliseconds, (5) inhibition 2: number of errors incompatible part 2 minus number of errors number of errors compatible part 1, (6) inhibition 3: standard deviation right plus left hand compatible part 2 minus standard deviation right plus left hand compatible part 1 in milliseconds, and (7) motor flexibility: mean deviation overall pursuit – mean deviation overall tracking. The variables included were those that were most often reported focusing on inhibition and flexibility (Guxens et al., 2016; Menting et al., 2018). There was some missing data for these variables, as 15.51% of the children did not participate in the tasks. Furthermore, as the outcome is assumed to be unreliable when children outperform the difficult trials compared to the control trials of the tasks, negative contrast scores (in 0% to 14.5% of the cases) were recoded as invalid. To improve model convergence, we divided the values by constants to obtain variances with values between 1 and 10. A higher score on a variable corresponds with worse executive functioning.

We examined whether these variables could be modeled to load on one latent factor for executive functioning using the maximum likelihood with robust standard errors (MLR) estimator. Step 1 was to load the seven variables on one latent variable. This model had a poor model fit (x^2 (14) = 462.69, p = 0.00, CFI = 0.69. RMSEA = 0.19). Modification indices showed – step by step – that the errors of inhibition 3 and flexibility 1, inhibition 1 and 3 should covary to improve the model. However, after adding the last error covariance, this model did not converge due to negative residual variance of inhibition 1. As this residual variance was non-significant, we could constrain the residual variance to zero and did not add the error covariance. We continued with adding step by step error covariances based on the modification indices between inhibition 3 and flexibility 3, flexibility 1 and 2, inhibition 2 with flexibility 2, inhibition 2 with flexibility 1, and inhibition 2 and 3. Inspection of the factor loadings indicated that inhibition 2 (0.11, p = 0.39) and flexibility 2 (0.17, p = 0.17) both had non-significant factor loadings on the latent variable. We excluded these variables (and their added error covariances) from the model. Therefore, the final measurement model included flexibility 1, flexibility 3, inhibition 1, inhibition 3, and motor flexibility as shown in Fig. 3.1. This model had excellent fit (x^2 (4) = 0.38, p = 0.99, CFI = 1.00. RMSEA = 0.00), with standardized factor loadings ranging between 0.21 for motor flexibility to 0.76 for flexibility 3.

To measure executive functions at T2, 24 items (of a total of 75 items) of the Dutch parent version of the Behavior Rating Inventory for Executive Functioning (BRIEF) were used (Gioia et al., 2001; Huizinga & Smidts, 2009). The selected items cover eight subscales with three items each which were rated by caregivers. The questionnaire has eight subscales (inhibit, shift, emotional control, initiate, working memory, plan/organize, organization of

materials and monitor) that are covered by the two indices Behavior Regulation Index (BRI) and Metacognition Index (MI). Statements such as "he/she struggles with finishing tasks" and "he/she gets upset in new situations" are scored on a three-point scale (1 = never, 2 = sometimes, 3 = often). This means that a higher score on the subscales indicate poorer executive functioning. The questionnaire showed good psychometric properties in a sample of parents of 847 children with Cronbach's alpha's ranging from 0.78 to 0.96 (Huizinga & Smidts, 2009). Due to the long battery of questionnaires and to decrease the burden of participating in the research, we selected 24 items. In our study, the 24 items version of the BRIEF had an excellent reliability on item-level, as indicated by a Cronbach's alpha of 0.91. Of the 1006 participants, 55 participants (5.5%) did not fill out the questionnaire. It is important to note that a higher score on these items corresponds with worse executive functioning.

We also examined whether these subscales could be modeled to load on one latent variable for executive functioning at age 12 using the MLR estimator. A model with all eight subscales of the BRIEF loading on one latent factor with error variances allowed to covary based on step-by-step modification indices, had an excellent model fit (x^2 (7) = 8.79, p = 0.27, CFI = 0.99, RMSEA = 0.016). Error variances that covaried were: planning with initiate; emotion regulation with flexibility; inhibition with behavior evaluation, emotion regulation, and flexibility; behavior regulation with emotion regulation and flexibility; initiate with flexibility; organizing with working memory, flexibility and initiate. All standardized factor loadings were significant and in the expected direction and ranged from 0.31 for flexibility to 0.89 for working memory.

Parenting behavior

Parents reported on their parenting behavior by filling out the shortened version (32 items) of the Parental Styles and Dimensions Questionnaire (PSDQ) at T1. This scale was developed to investigate parenting styles using specific parenting practices that occur within the authoritative, authoritarian, and permissive parenting style. Due to the long battery of questionnaires and to decrease the burden of participating in the research, we used the shortened version of the questionnaire. This version consists of 15 items in the authoritative scale, 12 in the authoritarian scale, and 5 in the permissive parenting scale. In our study, items were rated on a four-point Likert type scale (*1 = (almost) never; 2 = once in a while; 3 = often; 4 = always*) for readability of the overall test battery. Parents responded on questions such as "I encourage my child to talk about its troubles", "*I punish by taking privileges away from my child with little if any explanation*", and "*I spoil my child*". Scales were calculated by taking the sum score of the items within that scale. Psychometric properties of the 32-PSDQ have been investigated across various studies. Cronbach's alphas ranged

between 0.82 and 0.91 for authoritative, 0.67 and 0.86 for authoritarian, and 0.58 and 0.79 for permissive parenting. Good concurrent and predictive validity was also reported (Olivari et al., 2013). Although validity research on the shortened version is scarce, one study found its concurrent validity in relation to three other questionnaires to be sufficient (Topham et al., 2011). In our sample, we found Cronbach alpha's of 0.82 for authoritative parenting, 0.71 for authoritarian parenting, and 0.59 for permissive parenting. As we found the reliability of the permissive parenting scale to be insufficient, we did not include these in our analyses. To assess the moderating role of parenting behavior, we used multi-group analyses. Therefore, the sample was split across the median for each of the parenting dimensions to create equal groups (authoritative parenting: 16; authoritarian parenting: 8).

Prenatal exposure

During their pregnancy, mothers reported on their cigarette, alcohol, and drugs intake. We combined these variables into one dichotomous variable. There was 0.4% missing data on this variable and 34.1% of the mothers reported on prenatal exposure of cigarettes, alcohol or drugs.

Statistical analyses

To answer our research questions, we performed structural equation modeling (SEM) using Mplus 7 (Muthén & Muthén, 2012) for analyses. Little's Missing Completely at Random (MCAR) test was significant (x^2 (292) = 541.30, p = 0.000), therefore we assumed that data were not missing completely at random. As missingness was not predictable from the dependent variables, we assumed that the data was Missing At Random (MAR) (Tabachnick & Fidell, 2013). We investigated whether cases with or without any missing data were significantly different from each other on all included variables using independent T-tests. Independent T-tests did not show significant differences between participants with missing data on T1 on measures of executive functioning at T2 nor the other way around. However, we found significant differences for all outcome measures of the ROO task and for authoritarian parenting behavior. This means, that on these variables, the mean scores were different for participants that had no missing data compared to participants that had missing information on one of the variables of interest. For prenatal substance abuse, we found significant differences between our sample and the total sample at birth (x^2 (1) = 29.23, p = 0.00) as more mothers reported on prenatal substance use in our sample. For trauma exposure and executive functioning at age 12, we were not able to check whether our sample differed from the total sample of the birth cohort (starting at birth) as we only included participants that reported on trauma exposure at age 12. We checked normality of the data by investigating skewness and kurtosis and divided these statistics by their standard error. For all executive

functioning variables, we found extreme positive skewness and kurtosis, which improved after dealing with univariate outliers. We modified the values to the closest observed value plus or minus one unit when z-scores exceeded ± 3.29, which resulted in an improved — but non-normal — distribution. We did not transform variables, as this would make interpretation merely impossible. We ran all models also with censored variables, and differences in models are reported when this was the case. We used the weighted least squares means and variance adjusted (WLSMV) estimator for the model analyses.

We constructed a longitudinal model as depicted in Fig. 3.1. After running our hypothesized model, we used multi-group analyses to investigate whether the link between trauma exposure and executive functioning was different across relatively low and high parenting behavior along the dimensions of authoritarian, authoritative, and permissive parenting. Model fit was assessed using comparative fit index (CFI; good model fit > 0.90) and Root Mean Square Error of Approximation (RMSEA; good model fit < 0.08) (Kline, 2005).

Results

Longitudinal associations of trauma and executive functioning

Means and standard deviations of independent, dependent and moderator variables are displayed in Table 3.1. To test our hypotheses, we ran the hypothesized model, which showed good model fit (x^2 (72) = 136.54, p < 0.001, CFI = 0.98, RMSEA = 0.03), its coefficients are displayed in Fig. 3.1. With regard to concurrent associations, we found that trauma exposure was not associated with poorer executive functioning at age 5, but that this association was significant at age 12 (small effect). As expected for the longitudinal associations, trauma exposure was predictive of later poorer executive functioning (small effect) and later trauma exposure (small to moderate effect). However, the longitudinal association between executive functioning at age 5 and trauma exposure between age 6 and 12 was not significant.

To control for educational level and prenatal exposure factors we included these factors in the model by regressing the variables at age 12 on the control variables and covary them with the variables at age 5. This model also had an excellent model fit (x^2 (105) = 195.75, p < 0.001, CFI = 0.97, RMSEA = 0.03). After inclusion of these variables, the pattern of significant associations did not change, but educational level was significantly correlated with executive functioning at age 5. More specifically, a high maternal educational level was negatively associated with poorer executive functioning at age 5. This means that children of mothers with a high educational level had better executive functioning compared to children of mothers with a low or mid educational level. Coefficients, standard errors, and p-values are displayed in Table 3.2.

Moderating role of parenting behavior

To investigate the moderating effects of parenting behavior, we performed three separate multi-group analyses on the final model that controlled for prenatal exposures and maternal educational level. First, we tested a model with all parameters constrained across groups against a model with the hypothesized associations freed across groups using the DIFFTEST option in Mplus. For authoritative (Δx^2 = 8.94, Δ df = 6, p = 0.18) and authoritarian parenting (Δx^2 = 3.25, Δ df = 6, p = 0.78) no significant group differences were found. This means that paths in the model were not different for parents with a relatively high or low score on the subscales of authoritative and authoritarian parenting.

Table 3.1 Means, standard deviations and percentages of independent, dependent, and moderator variables.

Variables	Time 1		Time 2		
	n	***%***		***n***	***%***
Trauma exposure					
No events	901	91.4	No events	671	68.1
1 event	78	7.9	1 event	233	23.6
≥ 2 events*	7	0.7	≥ 2 events	82	8.3
	Mean	***SD***		***Mean***	***SD***
Executive Functioning**					
Inhibition 1	369.67	209.04	Shift	4.27	1.38
Inhibition 2	2.21	3.51	Working memory	5.04	1.85
Inhibition 3	621.98	466.15	Initiate	5.18	1.53
Flexibility 1	772.18	326.24	Emotional control	4.10	1.32
Flexibility 2	2.87	4.14	Organization of materials	5.41	1.60
Flexibility 3	386.89	352.73	Monitor/evaluation	4.75	1.69
Motor flexibility	14.76	7.18	Plan/organize	5.37	1.69
Permissive parenting***			Inhibit	4.05	1.23
Low	6.97	0.88			
High	9.85	1.14			
Authoritarian parenting					
Low	15.33	1.29			
High	19.96	2.41			
Authoritative parenting					
Low	42.41	3.09			
High	50.71	3.04			

*Trauma exposure before age 5 was used as a dichotomous variable in the analyses.

**Executive functioning at T1 is measured using the Response Objects Organization, Tracking and Pursuit tasks. Executive functioning at T2 is measured using the sum of three items of each subscale of the Behavior Rating Inventory of Executive Functioning (BRIEF).

***Parenting styles were split at the median for analyses into respectively low and high groups and was measured using a subset of the *PSDQ* Parental Styles and Dimensions Questionnaire

Table 3.2 Coefficients, standardized coefficients, standard errors and p-values of model with control variables

	B	β	S.E	*p*-value
Executive functioning age 5 → executive functioning age 12	0.044	0.060[a]	0.041	0.148
Trauma exposure before age 5 → executive functioning age 12	0.188	0.121	0.036	0.002
Executive functioning age 5 → trauma exposure between age 6 and 12	-0.070	-0.042	0.045	0.347
Trauma exposure before age 5 → trauma exposure between age 6 and 12	1.515	0.425	0.031	0.000
Executive functioning age 5 ↔ trauma exposure before age 5	-0.007	-0.041	0.041	0.325
Executive functioning age 12 ↔ trauma exposure between age 6 and 12	0.052	0.134	0.044	0.005
Prenatal drug exposure ↔ executive functioning at age 5	-0.010	-0.035	0.039	0.366
Prenatal drug exposure ↔ trauma exposure before age 5	-0.001	-0.007	0.032	0.828
Prenatal drug exposure → executive functioning at age 12	-0.010	-0.010	0.036	0.773
Prenatal drug exposure → trauma exposure between age 6 and 12	0.065	0.031	0.035	0.386
Mid maternal educational level ↔ executive functioning at age 5	0.015	0.065	0.037	0.074
Mid maternal educational level ↔ trauma exposure before age 5	0.006	0.059	0.030	0.054
Mid maternal educational level → executive functioning at age 12	-0.078	-0.068	0.066	0.305
Mid maternal educational level → trauma exposure between age 6 and 12	-0.268	-0.102	0.071	0.149
High maternal educational level ↔ executive functioning at age 5	-0.023	-0.088	0.036	0.014
High maternal educational level ↔ trauma exposure before age 5	-0.005	-0.040	0.032	0.217
High maternal educational level → executive functioning at age 12	-0.120	-0.119	0.066	0.079
High maternal educational level → trauma exposure between age 6 and 12	-0.304	-0.131	0.071	0.064

[a]Following guidelines, all estimated are standardized using STDYX standardization in Mplus, expect for the longitudinal association between executive functioning at age 5 and age 12, then STD standardization is used. For analyses purposes, dummy variables were made for maternal educational level in which low maternal educational level was the reference category

Discussion

In the present study, we analyzed concurrent and longitudinal associations between trauma exposure and executive functioning in a birth cohort using structural equation modeling. Our primary aim was to distinguish the direction of relationships between trauma exposure and executive functioning in children. When we gain more insights in the direction of this relationship we can offer some implications for clinical practice and further research. Our results demonstrated that after controlling for prenatal drug exposure and maternal educational level, early trauma exposure was indeed predictive of poorer executive functioning later. Although we had hypothesized that early poorer

executive functioning could also be a risk factor for later trauma exposure, we did not find such an association. Also, we did not observe evidence to suggest that maternal parenting behavior moderates the longitudinal association between trauma exposure and subsequent executive functioning. We did, however, find that, while trauma exposure before age 5 was not associated with executive functioning at age 5 it was predictive of poorer executive functioning at age 12. Specifically, we can conclude that early trauma exposure does indeed predict parent-reported executive functioning, but we are not able to draw conclusions whether this would also be the case for objective executive functioning measured by neuropsychological tasks. Moreover, executive functioning at age 5 did not seem to be associated with subsequent trauma exposure.

This study's findings are in line with earlier research that did not control for pre-existing executive functioning in trauma-exposed youth growing up in a deprived institutional setting (Bos et al., 2009; Jennifer Martin. McDermott et al., 2013). The findings are also in line with studies that did control for earlier cognitive functioning (Enlow et al., 2012; Geoffroy et al., 2016), but did not examine executive functioning specifically. The fact that we replicate these earlier findings is of importance given that we observed these associations even when the children in our sample experienced relatively "less severe" trauma exposure (mostly severe accidents rather than extreme neglect or maltreatment) and had a relatively high socio-economic status as compared to the children participating in these earlier studies.

Although not a main aim of our study, it is interesting to note that early trauma exposure was not only predictive of later poorer executive functioning, but also predictive of later trauma exposure. Longitudinal co-occurrence of adverse childhood events has previously been found (Green et al., 2010; McLaughlin et al., 2012). Based on cumulative risk theory, accumulation of trauma exposure has been found to predict more long term problems including mental health problems (McLaughlin & Sheridan, 2016). The fact that we also found this accumulation of trauma exposure across childhood, even in a relatively highly educated community sample, underscores the importance of population-wide early screening, prevention, and intervention efforts.

In our study, we did not observe a significant longitudinal association between executive functioning at age 5 and 12. Previous research indicated that, even measured at the same time, there is often a relatively weak link between executive functions measured by tasks and measured by self-report questionnaires (e.g. Kenworthy et al., 2008; Silver, 2014; Toplak et al., 2013). In our study too, the discrepant measurement strategies (T1: tasks;

T2: questionnaire) across the waves could have led to this non-significant association. An alternative explanation for the fact that we did not find a longitudinal association for executive functioning could be that we used different measures of executive functioning at T1 (core executive functions are the key components) and T2 (core executive functions and higher order executive functions are combined). Additionally, although we did find a significant covariance between trauma exposure and executive functioning at age 12, we did not find a significant covariance at age 5. Based on an earlier review and a meta-analysis, an association between trauma exposure and executive functioning was expected (Malarbi et al., 2017; Op den Kelder et al., 2018). As the concurrent link between trauma exposure and executive functioning at age 5 was not significant, this supports the finding that trauma exposure leads to later executive functioning problems and that this process takes time. Additionally, it supports our finding that earlier levels of executive functioning does not predict later trauma exposure. However, it is still possible that a concurrent link between trauma exposure and executive functioning becomes more visible later in childhood. The majority of research is based on children aged above eight years old, which results in a limited understanding of the relationship between trauma exposure and executive functioning in younger children. Our results indicate that the effect of early trauma exposure may not yet be visible on neuropsychological tasks in five year old children.

Parenting behavior as a moderator

The secondary aim was to investigate the moderating role of maternal parenting behavior in the association between trauma exposure and executive functioning. We found no moderating effect of maternal parenting behavior in the associations between trauma exposure and executive functioning. This means that overall maternal parenting behavior did not buffer or exacerbate the longitudinal relationship between trauma exposure before preschool and executive functioning and trauma exposure later in life. As our study is the first to examine this association, more research is necessary to draw firm conclusions. Possibly, trauma exposure could have such an overridingly strong effect, that maternal parenting behavior does not come out as a significant moderator in our analyses. It could be that there are other protective factors that outweigh the buffering effect of authoritative parenting behavior such as social support or secure attachment style. Alternatively, accumulation of protective factors is needed for resilience against trauma exposure in early childhood (Sattler & Font, 2018). In other words, although we did not find moderating effects of maternal parenting behavior, it does not mean that parents cannot support their children after trauma exposure and thereby diminish the consequences of trauma

exposure. It could be that some specific parenting behaviors such as providing structure, warmth and calmness, and regulatory practices (that are not specified in an overall authoritative parenting style) do help children after they have been exposed to a traumatic event.

Strengths & limitations

Our study has several strengths. First, our study was based on a relatively large community sample with a longitudinal design. This increases power and makes it possible to use sophisticated statistical methods such as structural equation modeling. Second, we used a multi-informant and multi-method approach which reduces mono-method bias. However, several limitations are also important to take into account. Although the ABCD birth cohort aimed to be as ethnically diverse as the Amsterdam community, compared to the Amsterdam community, the sample included a relatively high number of Dutch children from parents with higher educational levels. This is a limitation as our results are not directly generalizable to the Amsterdam community nor to samples with a lower socioeconomic status. However, as aforementioned, the fact we still observe the longitudinal association between trauma exposure and executive functioning seven year later in this relatively healthy community sample is a strong indicator for the strength of this relationship.

Second, we were limited by the retrospective assessment of trauma exposure at age 12. Retrospective reports may be biased due to difficulties remembering (correctly). We aimed to improve the retrospective assessment as much as possible by using face-to-face interviews with detailed questions about life events by trained developmental psychologists, which enabled us to ask specifically about facts regarding the traumatic events.

Third, it is important to realize that the use of a median split for our moderator reduced variance, which may have impacted the results. We cannot rule out that a significant moderation effect of parenting would occur at a very high or very low level of our moderator. At the same time, as there are no clinical cut-offs for our parenting measure, it is difficult to argue for a choice of a cut-off. A median split ensures comparable sample size in both groups. However, future research using different models, may be able to include a continuous moderator for parenting behavior and examine this possibility.

Fourth, as we used different assessment methods of executive functioning we can only interpret our findings on that specific assessment type (tasks or questionnaire). Therefore, we are limited in differentiating between age- and measurement-method effects in our study.

Finally, the questionnaire that was used for measuring maternal parenting behavior had a good reliability for authoritarian and authoritative parenting, but not sufficient reliability for permissive parenting (both in previous research and in our sample). This made it impossible to investigate the moderating role of maternal permissive parenting behavior. Notwithstanding our study's limitations, our study is the first to distinguish the two possible predictive relationships between trauma exposure and executive functioning, in a well-powered, large sample of families from the general population, using a sophisticated, SEM based analytical strategy. In this study, we modelled executive functioning with one latent factor because we were interested in the common component underlying executive functioning in relation to trauma exposure. However, the fact that the errors of our executive functioning indicators were correlated might indicate that executive functioning in our sample consisted of subfactors. Although there are different findings in previous research in terms of unity/diversity of executive functioning in children, based on a recent review most evidence is found for unidimensionality of executive functioning in young children and adolescents (Karr et al., 2018). As a very recent study argued that the chosen measurement model for executive functioning might impact interpretation of results (Camerota et al., 2020), future studies should investigate whether modeling a latent factor structure, subcomponents or a composite score are differentially related to trauma exposure than the common component we modeled here.

Future research

Although we found a predictive association between early trauma exposure and later executive functioning, our results do not provide insight on the mechanisms that may underlie this association. Resilience and vulnerability after trauma exposure are thought to arise from complex interactions between various systems such as genetics, structure and functioning of the brain, cognition, social environment, endocrinology, and the immune system (Ioannidis et al., 2020). It is possible that long-lasting neurobiological changes play a role in these complex interactions. At the same time it could be that trauma-exposed children suffer from posttraumatic stress symptoms which in turn leads to poorer executive functions. In this case, it could be possible that poorer executive functioning is more temporary, and trauma-focused treatment may alleviate problems in executive functioning. There is very little research on this topic, but one study among fifteen women found medium-sized improvements on cognitive flexibility and planning three months after the start of trauma focused treatment (Walter et al., 2010). Future research should therefore try to examine how trauma exposure results in executive functioning problems in children and whether these problems are alleviated after trauma treatment. Future research should also focus on a possible critical time frame and accumulation of trauma exposure in order to

investigate the neurobiological effects of trauma exposure in childhood. More knowledge on these mechanisms makes it possible to develop and implement prevention and intervention programs for trauma-exposed youth. Additionally, as we focused on the conceptual unity of executive functioning while taking into account its differentiability in our latent factor model, it would be interesting to investigate executive functioning more specifically and thereby focus on specific pathways of working memory, inhibition, and flexibility.

Conclusion

Results of our study do not support the notion that associations between trauma exposure and executive functioning can be explained by pre-existing executive functioning problems acting as a risk factor for trauma exposure. Rather, our findings indicate that trauma exposure impacts developing executive functioning of the child. These findings result in a few clinical and practical implications. First, as our study suggest that early trauma exposure predicts executive functioning and further trauma exposure over a course of seven years, youth health services for young children could play an important role in recognizing trauma exposure. Based on earlier research we know that an accumulation of trauma exposure in childhood leads to a higher risk of development of posttraumatic stress and other health issues (Green et al., 2010; McLaughlin et al., 2012). Additionally, we are also aware of the relatively high impact of problems in executive functioning in daily life (Diamond, 2013). We urge general mental and physical health practice, also because of protective reasons, to include specific questions about trauma exposure in their standard protocols in both early childhood as well as during early and late adolescence. Second, as later executive functioning is predicted by early trauma exposure, it is important to include executive functioning in the assessment of traumatized youth in clinical practice.

In conclusion, our results suggest that trauma exposure before age 5 is predictive of poorer parent-reported executive functioning and trauma exposure at age 12. This longitudinal association could not be explained by pre-existing poor executive functioning (measured by neuropsychological tasks), as executive functioning at age 5 was not associated with trauma exposure before age 5, and was also not predictive of trauma exposure up to age 12. Our findings are based on a community sample with relatively "mild" trauma exposure and a relatively high socio-economic status; which implies that even under these circumstances, these mechanisms are at work. We would like to suggest that clinical practice takes this into account in the implementation of prevention and intervention programs after trauma exposure. The scientific field should aim to replicate our findings in different samples, using multiple measurement instruments for executive functioning.

References

Afifi, T. O., & MacMillan, H. L. (2011). Resilience following child maltreatment: A review of protective factors. *Canadian Journal of Psychiatry, 56(5),* 266–272.

American Psychiatric Association. (2000). *Diagnostic and statistical manual of mental disorders (4th (text).* American Psychiatric Publishing.

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders 5 (5th ed.).* American Psychiatric Publishing: Arlington, VA.

Ardila, A., Rosselli, M., & Matute, E. (2010). The influence of the parents ' educational level on the development of executive functions. *Developmental Neuropsychology, 5641,* 37–41.

Baumrind, D. (1971). Current patterns of parental authority. *Developmental Psychology, 4,* 1–103.

Bos, K. J., Fox, N., Zeanah, C. H., & Nelson Iii, C. (2009). Effects of early psychosocial deprivation on the development of memory and executive function. *Frontiers in Behavioral Neuroscience, 3,* 1–7.

Brattström, O., Eriksson, M., Larsson, E., & Oldner, A. (2015). Socio-economic status and co-morbidity as risk factors for trauma. *European Journal of Epidemiology, 30(2),* 151–157.

Brown, T. E., & Landgraf, J. M. (2010). Improvements in executive function correlate with enhanced performance and functioning and health-related quality of life: Evidence from 2 large, doubleblind, randomized, placebo-controlled trials in ADHD. *Postgraduate Medicine, 122(5),* 42–51.

Camerota, M., Willoughby, M. T., & Blair, C. B. (2020). Measurement models for studying child executive functioning: Questioning the status quo. *Developmental Psychology, 56(12),* 2236–2245.

Copeland, W. E., Keeler, G., Angold, A., & Costello, E. J. (2007). Traumatic events and posttraumatic stress in childhood. *Archives of General Psychiatry, 64(5),* 577–584.

Darling, N., & Steinberg, L. (1993). Parenting style as context: An integrative model. *Psychological Bulletin, 113(3),* 487–496.

De Sonneville, L. M. J., Boringa, J. B., Reuling, I. E. W., Lazeron, R. H. C., Adèr, H. J., & Polman, C. H. (2002). Information processing characteristics in subtypes of multiple sclerosis. *Neuropsychologia, 40(11),* 1751–1765.

Diamond, A. (2013). Executive functions. Annual Review of Psychology, 64, 135–168.

Enlow, M. B., Egeland, B., Blood, E. A., Wright, R. O., & Wright, R. J. (2012). Interpersonal trauma exposure and cognitive development in children to age 8 years: A longitudinal study. *Journal of Epidemiology & Community Health, 66(11),* 1005–1010.

Fay-Stammbach, T., Hawes, D. J., & Meredith, P. (2014). Parenting influences on executive function in early childhood: a review. *Child Development Perspectives, 8(4),* 258–264.

Fowler, P. J., Tompsett, C. J., Braciszewski, J. M., Jacques-Tiura, A. J., & Baltes, B. B. (2009). Community violence: A meta-analysis on the effect of exposure and mental health outcomes of children and adolescents. *Development and Psychopathology, 21(01),* 227–259.

Fried, P. A., & Smith, A. M. (2001). A literature review of the consequences of prenatal marihuana exposure - An emerging theme of a deficiency in aspects of executive function. *Neurotoxicology and Teratology, 23(1),* 1–11.

Geofroy, M. C., Pinto Pereira, S., Li, L., & Power, C. (2016). Child neglect and maltreatment and childhood-to-adulthood cognition and mental health in a prospective birth cohort. *Journal of the American Academy of Child and Adolescent Psychiatry,55(1),* 33-40.

Gioia, G. A., Isquith, P. K., Guy, S. C., Kenworthy, L., & Baron, I. S. (2001). Behavior rating inventory of executive function. *Child Neuropsychology, 6(3),* 235–238.

Goldstein, S., Naglieri, J. A., Princiotta, D., & Otero, T. M. (2014). *Introduction: A history of executive functioning as a theoretical and clinical construct.* In S. Goldstein, J.A. Naglieri (Ed.), Handbook of Executive Functioning (pp. 3–12). Springer, New York.

Gray, M. J., Litz, B. T., Hsu, J. L., & Lombardo, T. W. (2004). Psychometric properties of the life events checklist. *Assessment, 11(4),* 330–341.

Green, J. G., McLaughlin, K. A., Berglund, P. A., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2010). Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication I: Associations with first onset of DSM-IV disorders. *Archives of General Psychiatry, 67(2),* 113–123.

Guxens, M., Vermeulen, R., van Eijsden, M., Beekhuizen, J., Vrijkotte, T. G. M., van Strien, R. T., et al. (2016). Outdoor and indoor sources of residential radiofrequency electromagnetic fields, personal cell phone and cordless phone use, and cognitive function in 5–6 years old children. *Environmental Research, 150,* 364–374.

Huizinga, M., & Smidts, D. (2009*). BRIEF: Vragenlijst executieve functies voor 5–18 jarigen.* Hogrefe Uitgevers.

Hutchison, L., Feder, M., Abar, B., & Winsler, A. (2016). Relations between Parenting Stress, Parenting Style, and Child Executive Functioning for Children with ADHD or Autism. *Journal of Child and Family Studies, 25(12),* 3644–3656.

Ioannidis, K., Askelund, A. D., Kievit, R. A., & Van Harmelen, A. L. (2020). The complex neurobiology of resilient functioning after childhood maltreatment. *BMC Medicine, 18(1),* 1–16.

Karr, J. E., Areshenkof, C. N., Rast, P., Hofer, S. M., Iverson, G. L., & Garcia-Barrera, M. A. (2018). The unity and diversity of executive functions: A systematic review and re-analysis of latent variable studies. *Psychological Bulletin, 144(11),* 1147–1185.

Kenworthy, L., Yerys, B. E., Anthony, L. G., & Wallace, G. L. (2008). Understanding executive control in autism spectrum disorders in the lab and in the real world. *Neuropsychology Review, 18(4),* 320–338.

Kim-Spoon, J., Kahn, R. E., Lauharatanahirun, N., Deater-Deckard, K., Bickel, W. K., Chiu, P. H., & King-Casas, B. (2017). Executive functioning and substance use in adolescence: Neurobiological and behavioral perspectives. *Neuropsychologia, 100,* 79–92.

Kline, R. B. (2005). Principles of Practice of Structural Equation Modeling. The Guilford Press.

Kloosterman, P. H., Kelley, E. A., Parker, J. D., & Craig, W. M. (2014). Executive functioning as a predictor of peer victimization in adolescents with and without an Autism Spectrum Disorder. *Research in Autism Spectrum Disorders, 8(3),* 244–254.

Lind, M. J., Brown, R. C., Sheerin, C. M., York, T. P., Myers, J. M., Kendler, K. S., & Amstadter, A. B. (2018). Does parenting influence the enduring impact of severe childhood sexual abuse on psychiatric resilience in adulthood? *Child Psychiatry and Human Development, 49(1),* 33–41.

Malarbi, S., Abu-rayya, H. M., Muscara, F., & Stargatt, R. (2017). Neuropsychological functioning of childhood trauma and post-traumatic stress disorder: A meta-analysis. *Neuroscience and Biobehavioral Reviews, 72,* 68–86.

Masten, A. S. (2014). Global perspectives on resilience in children and youth. *Child Development, 85(1),* 6–20.

McDermott, J. M., Troller-Renfree, S., Vanderwert, R., Nelson, C. A., Zeanah, C. H., & Fox, N. A. (2013). Psychosocial deprivation, executive functions and the emergence of socio-emotional behavior problems. *Frontiers in Human Neuroscience, 7,* 167.

McDermott, J. M., Westerlund, A., Zeanah, C. H., Nelson, C., & Fox, N. A. (2012). Early adversity and neural correlates of executive function: Implications for academic adjustment. *Developmental Cognitive Neuroscience, 2,* S59–S66.

McLaughlin, K. A., Green, J. G., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2012). Childhood adversities and first onset of psychiatric disorders in a national sample of US adolescents. *Archives of General Psychiatry, 69(11),* 1151–1160.

McLaughlin, K. A., Koenen, K. C., Hill, E. D. M. S. P. H., Petukhova, M., Sampson, N. A. B. A., Zaslavsky, A. M., & Kessler, R. C. (2013). Trauma exposure and posttraumatic stress disorder in a national sample of adolescents. *Journal of American Academic Child and Adolescent Psychiatry, 71(2),* 233–236.

McLaughlin, K. A., & Sheridan, M. A. (2016). Beyond cumulative risk: a dimensional approach to childhood adversity. *Current Directions in Psychological Science, 25(4),* 239–245.

Menting, M. D., van de Beek, C., de Rooij, S. R., Painter, R. C., Vrijkotte, T. G. M., & Roseboom, T. J. (2018). The association between pre-pregnancy overweight/obesity and offspring's behavioral problems and executive functioning. *Early Human Development, 122,* 32–41.

Micalizzi, L., & Knopik, V. S. (2018). Maternal smoking during pregnancy and offspring executive function: What do we know and what are the next steps? *Development and Psychopathology,30(4),* 1333–1354.

Miller, A., Lee, H., & Lumeng, J. (2015). Obesity-associated biomarkers and executive function in children. *Pediatric Research, 77,* 143–147.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: a latent variable analysis. *Cognitive Psychology, 41(1),* 49–100.

Muthén, K. L., & Muthén, B. O. (2012). Mplus User's Guide (Sevents). Muthén & Muthén.

Noland, J. S., Singer, L. T., Arendt, R. E., Minnes, S., Short, E. J., & Bearer, C. F. (2003). Executive functioning in preschool-age children prenatally exposed to alcohol, cocaine, and marijuana. *Alcoholism: Clinical and Experimental Research, 27(4),* 647–656.

Norman, R.E., Byambaa Rumna, M., De, R., Butchart, A., Scott, J., Vos, T., & Tomlinson, M. (2012). The long- term health consequences of child physical abuse emotional abuse and neglect: A systematic review and meta-analysis. *PLoS Medicine, 9(11),* e1001349.

Olivari, M. G., Tagliabue, S., & Confalonieri, E. (2013). Parenting Style and Dimensions Questionnaire: A review of reliability and validity. *Marriage and Family Review, 49(6),* 465–490.

Op den Kelder, R., Van den Akker, A. L., Geurts, H. M., Lindauer, R. J. L., & Overbeek, G. (2018). Executive functions in trauma-exposed youth: A meta-analysis. *European Journal of Psychotraumatology, 9(1),* 1450595.

Price, A., Cook, P. A., Norgate, S., & Mukherjee, R. (2017). Prenatal alcohol exposure and traumatic childhood experiences: A systematic review. *Neuroscience and Biobehavioral Reviews, 80,* 89–98.

Pynoos, R. S., Weathers, F. W., Steinberg, A. M., Marx, B. P., Layne, C. M., Kaloupek, D. G., Schnurr, P. P., Keane, T. M., Blake, D. D., Newman, E., Nader, K. O., & Kriegler, J. A. (2015). *Clinician Administered PTSD Scale for DSM-5 - Child/Adolescent Version.* Scale available from the National Center for PTSD at https://www.ptsd.va.gov

Quistberg, K.A. & Mueller, U. (2020) Prospective relations between kindergarteners' executive function skills and their externalizing and internalizing behaviors. *The Clinical Neuropsychologist, 34,* 845–862

Richardson, G. A., Ryan, C., Willford, J., Day, N. L., & Goldschmidt, L. (2002). Prenatal alcohol and marijuana exposure: Effects on neuropsychological outcomes at 10 years. *Neurotoxicology and Teratology, 24(3),* 309–320.

Rowbotham, I., ten Cate, I. M. P., Sonuga-Barke, E. J. S., & Huijbregts, S. C. J. (2009). Cognitive control in adolescents with neurofibromatosis type 1. *Neuropsychology, 23(1),* 50–60.

Samuelson, K. W., Krueger, C. E., & Wilson, C. (2012). Relationships between maternal emotion regulation, parenting, and children's executive functioning in families exposed to intimate partner violence. *Journal of Interpersonal Violence, 27(17),* 3532–3550.

Sattler, K. M. P., & Font, S. A. (2018). Resilience in young children involved with child protective services. *Child Abuse and Neglect, 75,* 104–114.

Schoemaker, K., Mulder, H., Deković, M., & Matthys, W. (2013). Executive functions in preschool children with externalizing behavior problems: A meta-analysis. *Journal of Abnormal Child Psychology, 41(3),* 457–471.

Silver, C. H. (2014). Sources of data about children's executive functioning: Review and commentary. *Child Neuropsychology, 20(1),* 1–13.

de Sonneville, L. M. J. (1999). *Amsterdam Neuropsychological Tasks: A computer aided assessment.* In & P. L. M., Den Brinker, P. J., Beek, A. N., Brand, F. J. Maarse (Ed.), Cognitive ergonomics, clinical assessment, and computer-assisted learning. Swets & Zeitlinger: Lisse

Sosic-Vasic, Z., Kröner, J., Schneider, S., Vasic, N., Spitzer, M., & Streb, J. (2017). The association between parenting behavior and executive functioning in children and young adolescents. *Frontiers in Psychology, 8,* 1–8.

Sriskandarajah, V., Neuner, F., & Catani, C. (2015). Parental care protects traumatized Sri Lankan children from internalizing behavior problems. *BMC Psychiatry, 15(1),* 1–11.

Steinberg, L., Lamborm, S. D., Dornbusch, S. M., & Darling, N. (1992). Impact of parenting practices on adolescent achievement: Authoritative parenting, school involvement, and encouragement to succeed. *Child Development, 63(5),* 1266–1281.

Tabachnick, B. G., & Fidell, L. S. (2013). Using Multivariate Statistics (6th ed.). Pearson/Allyn & Bacon.

Ter-Stepanian, M., Martin-Storey, A., Bizier-Lacroix, R., Déry, M., Lemelin, J. P., & Temchef, C. E. (2019). Trajectories of verbal and physical peer victimization among children with comorbid pppositional defiant problems, conduct problems and hyperactive-attention problems. *Child Psychiatry and Human Development, 50(6),* 1037–1048.

Topham, G. L., Hubbs-Tait, L., Rutledge, J. M., Page, M. C., Kennedy, T. S., Shriver, L. H., & Harrist, A. W. (2011). Parenting styles, parental response to child emotion, and family emotional responsiveness are related to child emotional eating. *Appetite, 56(2),* 261–264.

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner Review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry, 54(2),* 131–143.

van Aken, L., Kessels, R. P., Wingbermühle, E., van der Veld, W. M., & Egger, J. I. (2016). Fluid intelligence and executive functioning more alike than different? *Acta Neuropsychiatrica, 28(1),* 31–37.

van Eijsden, M., Vrijkotte, T. G. M., Gemke, R. J. B. J., & Van der Wal, M. F. (2011). Cohort profle: The Amsterdam born children and their development (ABCD) study. *International Journal of Epidemiology, 40(5),* 1176–1186.

van Meijel, E. P. M., Ensink, J. B., Verlinden, E., & Lindauer, R. J. L. (2019). *CAPS-CA DSM-5 Klinisch interview voor PTSS bij kinderen en adolescenten*. Bohn Stafleu van Loghum.

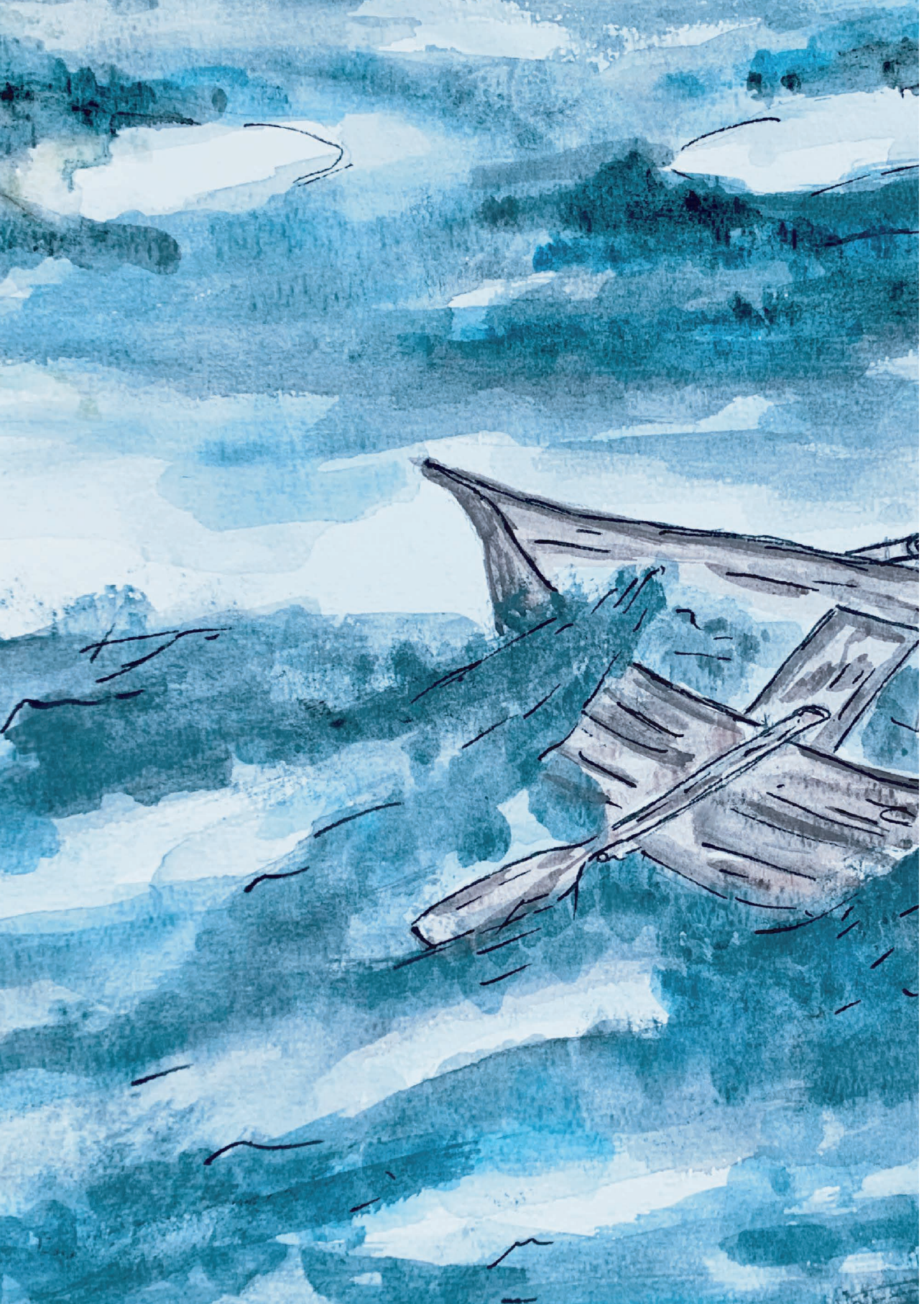
van Zee, W., Hermans, C., Hylkema, C., de Boer, E., & Slot, J. (2004). *Amsterdam in cijfers, Jaarboek 2004*. O + S Amsterdam in opdracht van Gemeente Amsterdam: Amsterdam.

Verlinden, M., Veenstra, R., Ghassabian, A., Jansen, P.W., Hofman, A., Jaddoe, V.W.V., Verhulst, F.C., & Tiemeier, H. (2014). Executive functioning and non-verbal intelligence as predictors of bullying in early elementary school. *Journal of Abnormal Child Psychology, 42(6),* 953–966.

Walter, K. H., Palmieri, P. A., & Gunstad, J. (2010). More than symptom reduction: changes in executive function over the course of PTSD treatment. *Journal of Traumatic Stress, 23,* 292–295.

Wegman, H. L., & Stetler, C. (2009). A meta-analytic review of the effects of childhood abuse on medical outcomes in adulthood. *Psychosomatic Medicine, 71(8),* 805–812.

Zhai, Y., Liu, K., Zhang, L., Gao, H., Chen, Z., Du, S., et al. (2015). The relationship between post-traumatic symptoms, parenting style, and resilience among adolescents in Liaoning, China: A cross-sectional study. *PLoS ONE, 10(10),* 1–15.



Executive function as a mediator in the link between single or complex trauma and posttraumatic stress in children and adolescents

Rosanne op den Kelder
Judith B. M. Ensink
Geertjan Overbeek
Marija Maric
Ramón J. L. Lindauer

Slightly adapted for consistency (abbreviations and reference style)
Quality of Life Research, 2017, 26, 1687-1696

Abstract

Purpose: In this study, we examined whether there is a mediating role of executive functions in the relationship between trauma exposure and posttraumatic stress in youth.

Methods: Children and adolescents exposed to trauma were recruited at an academic center for child psychiatry in The Netherlands. The total sample consisted of 119 children from 9 to 17 years old (M = 13.65, SD = 2.45). Based on retrospective life event information, the sample was divided into three groups: a single trauma group (n = 41), a complex trauma group (n = 38), and a control group that was not exposed to traumatic events (n = 40).

Results: Our findings revealed that youth exposed to complex trauma had more deficits in executive functioning compared to youth in the single trauma and control groups. Executive functioning was found to partly mediate posttraumatic stress symptoms for youth exposed to complex trauma, but not for youth exposed to single trauma. Youth exposed to complex trauma showed more deficits in executive functioning, which was in turn associated with higher levels of posttraumatic stress symptoms.

Conclusions: Our findings provide partial support for the role of executive functioning in mediating posttraumatic stress outcomes for youth exposed to complex trauma. This points to the important role of executive functioning in the etiology and treatment of complexly traumatized youth.

Keywords Trauma, Executive functions, Posttraumatic stress, PTSD, Youth

Introduction

Trauma exposure

Many youths experience a traumatic event before entering adulthood, with prevalence rates varying from 14 to 80% (Alisic, van der Schoot, van Ginkel, & Kleber, 2008; Fairbank & Fairbank, 2009). According to the Diagnostic and Statistical Manual of Mental Disorders, a traumatic event is defined as one in which somebody experiences or witnesses a threat or violation of a person's physical or psychological integrity (American Psychiatric Association, 2013). As a result of exposure to traumatic events, youth may develop Post-Traumatic Stress Disorder (PTSD). PTSD symptoms are intrusive re-experiences (e.g., intrusive thoughts and nightmares), persistent avoidance (e.g., avoidance of feelings/ thoughts related to traumatic events), negative alterations in cognitions and mood (e.g., feelings of detachment), and alterations in arousal and reactivity (e.g., sleep problems, hypervigilance) (American Psychiatric Association, 2013). Youth diagnosed with PTSD experience academic, social, emotional, and physical problems (Alisic, Jongmans, Van Wesel, & Kleber, 2011).

The role of executive functions in the development of PTSD

From a developmental perspective, exposure to traumatic events in childhood, when the brain is still developing, may impact neurological and cognitive development (De Bellis, 2001; Van der Kolk, 2005) and thereby leave youth vulnerable to develop symptoms of PTSD. Specifically, executive functions (EFs) are hypothesized to be affected by trauma exposure and to play a role in the development of PTSD after trauma exposure.

Most studies in youth define executive functioning as an umbrella term for separate, but related, cognitive processes (Anderson, 2002; & Best, Miller, & Jones, 2009). We describe executive functioning as a range of mental skills that allow individuals to pay attention, manage their feelings, think in flexible and creative ways, control their impulses, plan and start activities, monitor their own performance, and remember and manipulate key information (Goldstein, Naglieri, Princiotta, & Otero, 2014). Three core concepts of executive functioning are frequently addressed in empirical neuropsychological research in youth: inhibition, working memory, and cognitive flexibility (Miyake & Friedman, 2012; Diamond, 2013). We consider these to be core concepts of a common executive functioning factor from which higher order functions such as decision making and planning arise (Diamond, 2013). There are various outcomes associated with executive dysfunction in childhood and adolescence. For example, poor executive functioning has been associated with addictions (Goldstein & Volkow, 2011), conduct

disorders [Fairchild et al., 2009), obesity (Reinert, Po'e, Barkin, 2013), poor treatment adherence McNally, Rohan, Pendly, Delamater, & Drotar, 2010), lower quality of life (Sherman, Slick, Eyrl, 2006), and aggression (Denson, DeWall, & Finkel, 2012). In daily life, children with poor executive functioning experience various difficulties: acting without thinking, overreaction to small problems, being upset by changes in plans, forgetting to hand in homework, delays in starting any kind of effortful task, switching between many tasks without finishing any, losing or misplacing things, difficulties meeting deadlines, difficulty setting personal goals, and lacking insight in their behavior (Dawson & Quare, 2014).

Executive functioning as a mediator in the link between trauma and PTSD

Results of a systematic review of adults with PTSD have shown that adults from 18 to 65 years perform significantly worse on executive functioning measures than controls with other psychiatric disorders (Polka, Witteveen, Reitsma, & Olff, 2012). There is limited research on the association between trauma exposure and executive functioning in youth, but some study results suggest that exposure to traumatic events can affect their executive functioning. Familial trauma was related to poorer basic executive functioning performance, compared to children exposed to non-familial trauma in a community sample (DePrince, Weinzierl, & Combs, 2009). Children exposed to maltreatment during multiple developmental phases performed lower on inhibitory control and working memory tasks than non-maltreated children or children that experienced maltreatment during one developmental period (Cowell, Cicchetti, Rogosh, & Toth, 2015). Maltreated youth also performed lower on cognitive flexibility than non-maltreated individuals (De Bellis, Woolley, & Hooper, 2013).

Executive functioning could be a mediating factor in the association between trauma exposure and posttraumatic stress symptoms in children and adolescents. As trauma exposure negatively affects executive functioning in youth (Cowell et al., 2015; ;De Bellis et al., 2013; DePrince et al., 2009), in turn, this could lead to posttraumatic stress symptoms. When emotion regulation or inhibitory control is decreased, they could have more difficulties inhibiting fear responses, intrusive thoughts, and experience more hypervigilance. While lacking the ability of inhibiting fear responses to triggers of the trauma, children and adolescents might develop an avoidant coping strategy (Aupperle, Melrose, Stein, & Paulus, 2012). The problems of hyperarousal, intrusions, and avoidance are core symptoms of PTSD.

Empirical evidence available indicates that trauma experience may impact executive functioning differently in terms of timing and chronicity, which makes it important to

make a distinction between single and complex trauma. Single trauma is defined as exposure to a single traumatic event, such as a traffic accident or rape. Children exposed to complex trauma have been exposed to multiple, persistent, and traumatic events (e.g., maltreatment, child sexual abuse, and neglect). Complex trauma is more often interpersonal, has an early onset, and more often occurs in the care-giving system of the child than single trauma (Van der Kolk, 2005). Children with complex trauma histories develop more problems within various domains: attachment, neurobiological changes, affect regulation, dissociation, behavior control, and self concept (Cook et al., 2005). Moreover, results of a recent meta-analysis suggest that while approximately 16% of children exposed to trauma develop PTSD, the prevalence of PTSD in children differs greatly across single and complex trauma. Youth exposed to interpersonal trauma are 2.5 times more likely to develop PTSD than youth exposed to non-interpersonal trauma (Alisic et al., 2014). However, as previous studies have not made the distinction between single trauma and complex trauma, it remains unclear how trauma exposure impacts executive functioning differently for children exposed to single or complex trauma. The current study helps closing this knowledge gap by giving more insight in the possible differential impact of single and complex trauma on executive functioning. Clinical practice could also benefit from this study as we gain more knowledge about how exactly single and complex trauma are related to problems in executive functioning in youth.

Research questions

Drawing from the literature and theoretical framework (De Bellis, 2001), the following research question was devised: To what extent is executive functioning a mediator in the relationship between trauma exposure and posttraumatic stress in youth? First, we hypothesized that there is a negative association between trauma exposure and executive functioning in children and adolescents (Aupperle, et al., 2012; DePRince et al., 2009). Therefore, we compared youth exposed to traumatic events (both single and complex trauma) with healthy control youths that did not experience traumatic events. Considering that executive functioning develops across childhood and adolescence (Diamond, 2013), we hypothesized that executive functioning is more likely to be impacted by complex trauma than by single trauma [Cowell et al., 2015; De Bellis, et al., 1999; Rinne-Albers, Van der Wee, Lamers-Winkelman, & Vermeiren, 2013). Third, we hypothesized that executive functioning plays a mediating role in the relationship between complex trauma and posttraumatic stress in youth, but not in the relationship between single trauma and posttraumatic stress (Aupperle, et al, 2012; Leskin & White, 2007).

Method

Sample

The current study compared executive functioning between children exposed to single trauma, exposed to complex trauma, and children that did not experience trauma in a cross-sectional research design. Twelve participants were excluded from our study because of missing screening questionnaires due to language barriers of parents, excessive loads on the parental burden, and unstable home environment with changing caregivers. The total sample consisted of 119 participants (65 girls) aged 9–17 years old (M = 13.65, SD = 2.45). The control group consisted of 40 children (17 girls) aged 9–17 years old (M = 13.88, SD = 2.50), the single trauma group consisted of 41 children (24 girls) aged 10–17 years old (M = 14.00, SD = 2.04), and the complex trauma group consisted of 38 children (24 girls) aged 9–17 years old (M = 13.03, SD = 2.73).

Procedure

Our study was part of ongoing research on genetic and neurological vulnerability, including executive functioning, in the development of PTSD in youth. For this study, we obtained permission from the Medical Ethical Committee of the Academic Medical Center in Amsterdam and the Ethics Committee of the University of Amsterdam, The Netherlands.

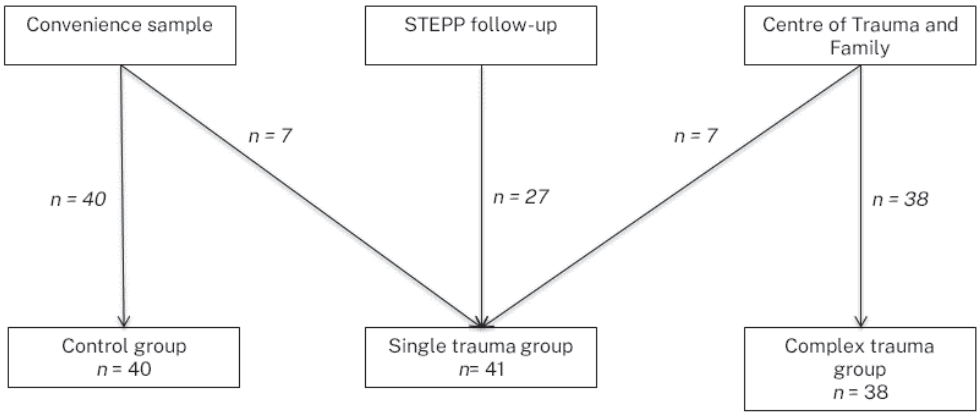


Fig. 4.1 Flow diagram of participants

Recruitment differed between traumatized participants and the control group, and there were two lines of recruitment of children exposed to traumatic events (see Fig. 4.1). First, trauma-exposed children and adolescents were recruited during a follow-up of a research project of the Academic Medical Center of the University of Amsterdam that focused on PTSD in

children who were involved in an accident (Van Meijel et al., 2015). Researchers contacted these participants and their caregivers during follow-up of this research project and asked them to participate in the current study. Second, youth exposed to traumatic events were recruited at the Center of Trauma and Family at De Bascule, Academic Center for Child and Adolescent Psychiatry in Amsterdam. Youth, aged 8–18 years, were recruited and assessed before the start of trauma treatment. Many studies that investigated complex trauma included treatment seeking individuals (e.g. Carrion, Garret, Menon, Weems, & Reiss, 2008; Cloitre et al., 2010) because in complexly traumatized individuals treatment seeking is the norm rather than the exception. Individuals in a treatment setting were a logical group to recruit and are a representative sample for complex trauma. Researchers provided information about the study, its aims, and the research procedure. While informing them about the research, we highlighted that participation was voluntary and would not affect their possible treatment program. Regular intake procedure consisted (among other aspects) of assessment of trauma exposure and trauma symptoms and a parent questionnaire about EF. Children exposed to traumatic events were then subdivided into a single trauma and complex trauma group based on their retrospective information about trauma exposure. Children who were exposed to prolonged or recurrent traumatic events were assigned to the complex trauma group. Trauma types across groups are depicted in Table 4.1 to gain more insight in types of trauma participants experienced. Age was the only exclusion criteria for the traumatized groups; children had to be aged 8–18 years. Children older than 12 years old and parents with custody had to sign informed consent forms. As the control group was recruited through convenience sampling in an informal network setting, it was compared to both single and complex trauma groups on age and gender composition. Inclusion criteria for children in the control group were no exposure to traumatic events, age between 8 and 18 years old, and a non-clinical score on the CRIES-13 (a posttraumatic stress questionnaire; see under Variables).

Table 4.1 Frequency of type of traumatic experiences across groups and means and standard deviations of age and gender

Type of trauma	**Control group (*n* = 40)**	**Single trauma Group (*n* = 41)**	**Complex trauma group (*n* = 38)**
Traffic accident		29	-
Severe bullying		4	3
Maltreatment		2	30
Sexual abuse/assault		2	5
Other		4	-
Mean age (SD)	13.88 (2.50)	14.00 (2.04)	13.13 (2.73)
Female sex (%)	17 (42.50)	24 (58.53)	24 (63.16)

Variables

Executive functions

The Global Executive Composite (GEC) of the Dutch parent version of the Behavior Ratings Inventory Executive Function (BRIEF) was used to measure everyday executive functioning in our participants [32]. The parental questionnaire consists of 75 items. The Behavior Regulation Index (BRI) covers three clinical subscales: Inhibit, Shift, and Emotional Control. The five other subscales, Initiate, Working Memory, Plan/ Organize, Organization of Materials, and Monitor, are covered by the Metacognition Index (MI). Statements such as "he/she struggles with starting homework or chores" and "he/she gets upset very quickly" are scored on a three-point scale (1 = never, 2 = sometimes, 3 = often) and were rated by caregivers. Previous study results have shown that the parent version of the BRIEF, including the GEC, is a reliable and valid instrument of measuring executive functioning in daily life for youth from 5 to 18 years old. The questionnaire shows good psychometric properties (test–retest reliability = 0.86, Cronbach's = 0.96). Construct and convergent validity of the BRIEF was examined in several large normative samples and found to be satisfactory [Sherman et al., 2006; Huizinga & Smidts, 2009; Gioia, Isquith, Guy, & Kenworthy, 2000). The instrument was also reliable in our sample with a Cronbach's alpha of 0.98.

Posttraumatic stress

The Dutch version of the Children's Revised Impact of Events Scale-13 (CRIES-13), a 13-item-questionnaire, was used to measure posttraumatic stress in participants after experiencing a traumatic event (Children and War Foundation, 1998; Verlinden et al., 2014; Verlinden & Lindauer, 2015). The CRIES-13 is a screening questionnaire for youth from 8 to 18 years that assesses the risk for PTSD in youth based on the PTSD criteria of the DSM-IV-TR (American Psychiatric Association, 2000). The questionnaire has a good construct validity and factor structure (Perrin, Meiser-Stedman, & Smith, 2005) and was found to be a valid and reliable screening instrument in a Dutch sample including youth exposed to both single and complex trauma (Verlinden et al., 2014). A score above the cut-off (>30) is associated with an increased risk of PTSD. For example, children and adolescents responded on items as "Do pictures about it pop into your mind?" and "Do you stay away from reminders of it?" Items were scored on a scale (0 = not at all, 1 = rarely, 3 = sometimes, 5 = often) and were summed for a total score (Verlinden, et al., 2015). Three subscales that correspond to the DSM-IV TR criteria of PTSD can be distinguished in this questionnaire: intrusion, avoidance, and arousal. Internal consistency and test–retest reliability of the

CRIES-13 is high: = 0.89 and trr = .85 [35]. This was also the case in our sample with a Cronbach's alpha of 0.90.

Data analysis

First, we evaluated assumptions for analysis of variance (ANOVA) and mediation analysis. Assumptions of linearity and homoscedasticity were met. The dependent variable, posttraumatic stress symptoms, was not normally distributed. However, ANOVA and mediation analyses are robust against violations of normality (Tabachnick & Fidell, 2013).

Prior to analyses to test our hypotheses, demographic variables were checked to assess whether or not the three groups differed with regard to age and gender composition. Results of the one-way ANOVA and Chi-square test showed that the three groups did not differ significantly on age (F (2,116) = 1.853, p = .161) nor gender (x^2 (2) = 3.742, p = .154). In other words, age and gender composition of the control, single trauma, and complex trauma groups were similar, and could be excluded as possible confounder variables in further analyses. Age and gender could also be excluded as possible confounder variables in the mediation analyses, because one-way ANOVA and x^2 tests showed no significant correlations between age and executive functioning (F (1,118) = 1.753, p = .094) and age and posttraumatic stress (F (1,118) = 1.156, p = .333) nor between gender and executive functioning (x^2 (39) = 40.911, p = .387) and gender and posttraumatic stress (x^2 (51) = 57.181, p = .256).

To investigate the first hypotheses, we analyzed the bivariate links between trauma exposure and executive functioning with Pearson correlations. Second, to investigate group differences in executive functioning between single trauma group, complex trauma group, and control group, a one-way ANOVA was conducted. To investigate the final hypothesis about the mediating role of executive functioning in the relationship between trauma exposure and posttraumatic stress, a mediation analysis with a multi-categorical independent variable (in our case, trauma exposure) was conducted based on the Process Macro for SPSS (Hayes, 2013) and an expert tutorial (Hayes & Preacher, 2014). Process uses ordinal least squares regression analyses for the first two steps of mediation analysis and bootstrap samples for mediator analysis. Process enables the use of multi-categorical independent variable by dummy coding the independent variable. We used an alpha level of 0.05 with bootstrap samples set to 1000 estimates. This analysis is mathematically identical to an analysis of covariance, but also reproduces group means for the mediator and dependent variable. Therefore, it is possible to obtain model, parameter estimates,

and model fit statistics that gives us information about how the single trauma group and complex trauma group differ from each other compared to a reference group, in our study participants who are not exposed to a traumatic event (Hayes & Preacher, 2014). The conceptual mediation model is depicted in Fig. 4.2. We performed a priori power analyses using G*Power for the first two steps in the mediation analysis: correlation between the independent and dependent variable and correlation between the independent and mediator. A sample of 68 was sufficient for an alpha level of 0.05, a medium effect size (F^2 = 0.15), and power of 0.80. As the PROCESS macro uses bootstrapping to 1000 estimates to construct confidence intervals, power issues are highly unlikely in the mediation analysis.

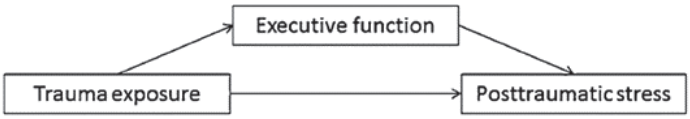


Fig. 4.2 Conceptual mediation model

Results

To investigate bivariate links between two groups (single/ complex trauma-exposed and control groups) and executive functioning, we calculated Pearson correlations (see Table 4.2). Positive significant correlations (p < .05) between trauma exposure and executive functioning measures were found. This shows that participants exposed to traumatic events reported more deficits in the global executive composite (GEC), compared to participants in the control group. Supplementary, we investigated bivariate links between the indices metacognition (MI) and behavioral regulation (BRI) and posttraumatic stress symptoms by calculating Pearson correlations (see Table 4.2). The positive correlations between all indices and subscales of executive functioning and posttraumatic stress were significant. This shows that more deficits in executive functioning were associated with higher levels of posttraumatic stress symptoms in youth.

Although results from the correlational analyses indicated a general association between trauma complexity and executive functioning, this did not indicate whether there would be a linear decrease in executive functioning between control, single trauma, and complex trauma groups. Thus, to investigate group differences in executive functioning, we conducted a one-way ANOVA. Results indicated that the groups differed significantly on the Global Executive Composite (F (2,116) = 19.290, p = .000, η^2 = 0.25). Table 4.3 displays

mean scores and standard deviations. Post hoc Bonferroni comparisons showed that while the control group did not differ significantly (p = .448) from the single trauma group in terms of executive functioning, it did differ significantly from the complex trauma group (p < .001). There was also a significant difference between the single trauma group and complex trauma group (p < .001). This indicates that participants in the complex group showed more deficits in executive functioning compared to both control group and single trauma group. Additionally, a one-way ANOVA was conducted on the level of posttraumatic stress symptoms across groups. Results indicated that the groups differed significantly on posttraumatic stress symptoms (F (2,116) = 19.255, p < .001, η^2 = 0.25). Post hoc Bonferroni comparisons showed that the control group did differ significantly from the single trauma group (p = .047), and from the complex trauma group (p < .001) in terms of posttraumatic stress levels. The difference in posttraumatic stress symptoms was also significant between the single and complex trauma groups (p = .001).

The estimated model coefficients to investigate the mediating role of executive functioning in the relationship between trauma exposure and posttraumatic stress are displayed in Table 4.4. The association between single trauma and executive functioning compared to the control group was not significant. On the other hand, the positive association between complex trauma and executive functioning was significant compared to the control group. In other words, youth in the complex trauma group scored 13.06 points higher on executive functioning (which corresponds with more deficits) compared to the control group. Furthermore, with executive functioning in the model, the positive association of complex trauma with posttraumatic stress remained significant (higher score reflects more posttraumatic stress symptoms). Executive functioning had a small, but significant, positive association with posttraumatic stress. The total indirect effect of complex trauma on posttraumatic stress through executive functioning was also significant with a coefficient (B = 6.10, boot SE = 2.02, 95% CI 2.25–10.17). This means that there is a genuine, but partial, mediating role for executive functioning in the link between complex trauma and posttraumatic stress.

Auxiliary analyses

We performed auxiliary analyses to explore the possible mediating role of three subscales of the BRIEF, namely inhibition, flexibility, and working memory. Separate mediation analyses showed the same patterns as the previous mediation model with total executive functioning as a mediator. The total indirect effects of complex trauma on posttraumatic stress through inhibition (B = 4.54, boot SE = 1.81, 95% CI 1.62–9.41), through working memory (B = 4.97, boot SE = 1.94, 95% CI 1.54–9.44), and through flexibility (B = 5.08, boot SE = 1.82, 95% CI 2.19–9.48) were significant.

Table 4.2 Correlations between trauma exposure, executive function, and posttraumatic stress

		Executive function			Posttraumatic stress		
	Trauma exposure	**GEC**	**BRI**	**MI**	**In**	**Av**	**Ar**
Executive function							
Global Executive (GEC)	.34*						
Behavior Regulation (BRI)	.29*	.91*					
Metacognition (MI)	.32*	.95*	.77*				
Posttraumatic stress							
Intrusion (In)	.24*	.37*	.37*	.31*			
Avoidance (Av)	.41*	.41*	.42*	.35*	.78*		
Arousal (Ar)	.45*	.49*	.50*	.43*	.68*	.74*	
Total	.40*	.47*	.47*	.40*	.87*	.90*	.87*

* $p < 0.05$.

Table 4.3 Means and standard deviations of executive functioning and posttraumatic stress in control, single trauma, and complex trauma groups.

	Control Group		**Single trauma Group**		**Complex trauma group**			
	Mean	***SD***	**Mean**	***SD***	**Mean**	***SD***	***F***	***p***
Executive function								
Global Executive	47.10	9.08	50.22	9.18	60.16	10.72	19.29	.000
Behavior Regulation	48.20	9.80	50.15	10.69	60.84	9.95	17.40	.000
Metacognition	47.15	8.32	49.80	8.12	58.32	10.40	16.39	.000
Posttraumatic stress								
Intrusion	4.45	4.04	5.51	6.31	9.63	6.02	9.44	.000
Avoidance	3.10	3.35	6.12	6.77	11.24	5.84	21.57	.000
Arousal	4.20	3.42	8.14	6.42	13.29	7.11	23.50	.000
Total	11.75	8.49	20.05	18.16	33.00	17.12	19.26	.000

Table 4.4 Coefficients of PROCESS mediation model

	Executive function (EF)	**Posttraumatic stress**
	***B* (SE)**	***B* (SE)**
Model excluding (EF)		
Constant	-	11.75 (1.36)*
Single trauma	-	8.30 (3.18)*
Complex trauma	-	21.25 (3.13)*
Model including (EF)		
Constant	47.10 (1.45)*	-10.26 (7.11)
Single Trauma	3.12 (2.05)	6.84 (3.05)*
Complex Trauma	13.06 (2.28)*	15.15 (3.40)*
Executive Function (EF)	-	.47 (.15)*

Note. EF = Executive Function. SE's are bootstrapped SE's. We used unstandardized B's in order to interpret regression coefficient easily in comparison with the measurement units.

* $p < .05$.

Discussion

The results of the present analyses indicate that, indeed, trauma-exposed youth experience more deficits in executive functioning compared to participants who did not experience traumatic events. More specifically, our results indicate quite clearly that children and adolescents exposed to complex trauma experienced more deficits in executive functioning than youth exposed to a single traumatic event. In addition, our results revealed that executive functioning partially mediates the relationship between complex trauma exposure and posttraumatic stress symptoms. That is, participants exposed to complex trauma had more deficits in executive functioning, and this in turn was associated with more posttraumatic stress symptoms.

In line with our first hypothesis and previous research, trauma exposure was associated with more deficits in executive functioning compared to youth that did not experience traumatic events (Aupperle, et al., 2012; DePrince, et al., 2009). Complexly traumatized youth in our sample showed more deficits in executive functioning compared to youth exposed to single trauma or non-traumatized children. We also found that complexly traumatized children and adolescents had a subclinical mean score on the executive functioning measure; their reported executive functioning difficulties should be taken into account by a (neuro) psychologist for further assessment. Additionally, we found that youth exposed to single trauma did not have more deficits in executive functioning than participants in the control group. The cumulative risk model of psychopathology (Flouri & Kallis, 2007) and the cumulative stressors model (Jaffee, Caspi, Moffit, Polo-Tomas, & Taylor, 2007) help explain these findings. Children's developing brains might be more resilient against exposure to one severe traumatic event in terms of executive functioning compared to exposure to complex trauma, and therefore to chronic stress (Van der Kolk, 2005).

Besides the model of cumulative stressors, another plausible explanation for our findings could be the nature of trauma exposure. Generally, complex trauma exposure has an interpersonal character, while single trauma exposure mostly includes events such as traffic accidents or earthquakes (Alisic, et al., 2008). It might be that emotionally charged traumas such as child sexual abuse or child maltreatment have more severe effects on the developing brain than non-interpersonal trauma such as earthquakes or traffic accidents. This could be an alternative explanation as the majority of the single trauma group was exposed to traffic accidents. Therefore, executive functioning could be more affected by complex trauma than by single trauma (Cook et al., 2005; Van der Kolk, 2005). In this case,

it is not the accumulation of traumatic events that cause executive dysfunction, and in turn posttraumatic stress, but rather the emotional character of the traumatic events.

The mediation analysis showed that executive functioning is a partial mediator in the relationship between complex trauma and posttraumatic stress symptoms. Reasonably, trauma exposure played the most important role in predicting levels of posttraumatic stress symptoms. From a neuropsychological and developmental perspective (Van der Kolk et al., 2005), it might be that youth exposed to complex trauma show more severe posttraumatic stress symptoms through their deficits in executive functioning. Due to problems with inhibition, fear responses and hypervigilance symptoms arise. Subsequently, because these children and adolescents cannot inhibit the fear response on triggering stimuli, they develop an avoidant coping strategy (Aupperle et al., 2012)

There are several limitations to our study. The most prominent limitation is our cross-sectional research design. It prohibits us from drawing causal conclusions based on the analyses. Although it is logical that posttraumatic stress follows trauma exposure as it is within the definition, it could be possible that youth with executive functioning deficits are at higher risk for traumatic exposures due to parental conflicts or interpersonal problems (Williams, Suchy, & Rau, 2009). It could also be that children with executive functioning deficits are more sensitive to develop posttraumatic stress symptoms. To the best of our knowledge, there are no prospective studies that measured the predictive relationship between executive functioning and PTSD. Therefore, as an experimental design is not feasible within this research context, the next step should be to employ longitudinal research to investigate the developmental trajectory of posttraumatic stress in relation to executive functioning in youth. In addition, prior to analysis, group composition was only tested for the variables age and gender. More demographic variables such as socio-economic status, ethnicity, and IQ should be included to exclude possible confounding variables. As timing of trauma could be an important factor in the development of PTSD, future studies should use a longitudinal approach to assess this relationship. Third, the use of questionnaires to assess posttraumatic stress and executive functioning is limited. More information from specific executive functioning tasks, related to inhibition, flexibility, and working memory, could give researchers more insight in executive functioning deficits in children exposed to traumatic events.

Future research

We suggest that the strong association between executive functioning and posttraumatic stress demonstrates that complex trauma exposure is associated with a broader range of

problems in youth. This is aligned with earlier research findings that complexly traumatized children and adolescents, compared to youth exposed to single trauma, show more developmental problems besides posttraumatic stress symptoms such as intrusion, avoidance, and arousal (Cook et al., 2005; Copeland, Keelyer, Angold, & Costello, 2007; Jonkman, Verlinden, Bolle, Boer, & Lindauer, 2013). Many propositions have been made for the concept of developmental trauma disorder after exposure to single or complex trauma (Cook et al., 2005; Van der Kolk, 2005). Although we cannot draw conclusions about the etiology of posttraumatic stress through executive functioning, our findings may give guidelines to investigate a broader range of consequences following exposure to complex trauma. Therefore, we strongly recommend research at neurological level (brain imaging research) and neuropsychological level to gain more insight in the possible mediating role of executive functioning in posttraumatic stress.

Our findings can have important implications for clinical practice. When deficits in executive functioning are acknowledged as additional consequences of complex trauma exposure or as a mediator in the development of posttraumatic stress, trauma therapy and prevention can be adjusted or expanded. For example, cognitive training programs might improve executive functioning also in traumatized youth. Training could diminish the negative consequences on children's and adolescents' academic and social development. In turn, it could prevent youth from developing posttraumatic stress and thereby reduce or alleviate adverse consequences on their development. Additionally, combining cognitive training and trauma therapy might enable them to benefit more or faster from techniques learned in psychotherapy.

In conclusion, we found strong associations between complex trauma, executive functioning, and posttraumatic stress in youth with strong indications for a partial mediating role of executive functioning on the development of posttraumatic stress. This means that complexly traumatized youth show more deficits in executive functioning, which is associated with higher levels of posttraumatic stress. Our research findings should be replicated longitudinally to give definitive answers to the question how trauma exposure, executive functioning, and posttraumatic stress are associated in children and adolescents. This may yield more effective clinical practice that is able to tackle the negative consequences of trauma exposure in children's development.

Acknowledgements

We would like to thank Lous Oudejans and Olga van Rooijen for data collection. We also would like to thank our participants.

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

All procedures performed in our study were in accordance with ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Open Access

References

Alisic, E., Jongmans, M. J., van Wesel, F., & Kleber, R. J. (2011). Building child trauma theory from longitudinal studies: A meta-analysis. *Clinical Psychology Review, 31(5)*, 736–747. doi:10.1016/j.cpr.2011.03.001.

Alisic, E., van der Schoot, T., van Ginkel, J. R., & Kleber, R. J. (2008). Looking beyond posttraumatic stress disorder in children: Posttraumatic stress reactions, posttraumatic growth, and quality of life in a general population sample. *Journal of Clinical Psychiatry, 69(9)*, 1455–1461. doi:10.4088/JCP.v69n0913.

Alisic, E., Zalta, A. K., Van Wesel, F., Larsen, S. E., Hafstad, G. S., Hassanpour, K., & Smid, G. E. (2014). Rates of posttraumatic stress disorder in trauma-exposed children and adolescents: Meta-analysis. *British Journal of Psychiatry, 204(5)*, 335–340. doi:10.1192/bjp.bp.113.131227.

Anderson, P. (2002). Assessment and development of executive function (EF) during childhood. *Child Neuropsychology, 8(2)*, 71–82. doi:10.1076/chin.8.2.71.8724.

American Psychiatric Association (2000). *Diagnostic and statistical manual of mental disorders (4th, text.*). Washington DC: American Psychiatric Association.

American Psychiatric Association (2013*). Diagnostic and statistical manual of mental disorders (5th ed.).* Washington DC: American Psychiatric Association.

Aupperle, R. L., Melrose, A. J., Stein, M. B., & Paulus, M. P. (2012). Executive function and PTSD: Disengaging from trauma. *Neuropharmacology, 62(2),* 686–694. doi:10.1016/j.neuropharm.2011.02.008.

Best, J. R., Miller, P. H., & Jones, L. L. (2009). Executive functions after age 5: Changes and correlates. *Developmental Review, 29(3),* 180–200. doi:10.1016/j.dr.2009.05.002.

Carrion, V. G., Garrett, A., Menon, V., Weems, C. F., & Reiss, A. L. (2008). Posttraumatic stress symptoms and brain function during a response-inhibition task: An fMRI study in youth. *Depression and Anxiety, 25(6),* 514–526. doi:10.1002/da.20346.

Cloitre, M., Stovall-McClough, K. C., Nooner, K., Zorbas, P., Cherry, S., Jackson, C. L., … Petkova, E (2010). Treatment for PTSD related to childhood abuse: A randomized controlled trial. *The American journal of Psychiatry, 167(8),* 915–924. doi:10.1176/appi.ajp.2010.09081247.

Cook, A., Spinazzola, J., Ford, J., Lanktree, C., Blaustein, M., Cloitre, M., … van der Kolk, B. A. (2005). Complex trauma in children and adolescents. *Psychiatric Annals, 35(5),* 390–398. Retrieved from http://www.nctsnet.org.

Copeland, W. E., Keeler, G., Angold, A., & Costello, E. J. (2007). Traumatic events and posttraumatic stress in childhood. *Archives of General Psychiatry, 64(5),* 577–584. doi:10.1016/S0084-3970(08)79296-X.

Cowell, R. A., Cicchetti, D., Rogosch, F. A., & Toth, S. L. (2015). Childhood maltreatment and its effect on neurocognitive functioning: Timing and chronicity matter. *Development and Psychopathology, 27(02),* 521–533. doi:10.1017/S0954579415000139.

De Bellis, M. (2001). Developmental traumatology: The psychobiological development of maltreated children and its implications for research, treatment, and policy. *Development and Psychopathology, 13(3),* 539–564. doi:10.1017/S0954579401003078.

De Bellis, M. D., Baum, A. S., Birmaher, B., Keshavan, M.S., Eccard, C. H., Boring, A. M., … Ryan, N. D. (1999). Developmental traumatology part I: Biological stress systems. *Biological Psychiatry, 45(10),* 1259–1270. doi:10.1016/S0006-3223(99)00044-X.

De Bellis, M. D., Woolley, D. P., & Hooper, S. R. (2013). Neuropsychological findings in pediatric maltreatment: Relationship of PTSD, dissociative symptoms, and abuse/neglect indices to neurocognitive outcomes. *Child Maltreatment, 18(3),* 171–183. doi:10.1177/1077559513497420.

Dawson, P., & Guare, R. (2014). *Interventions to promote executive development in children and adolescents.* In J. A. Goldstein, S., Naglieri (Eds.), Handbook of Executive Functioning (pp. 427–443). New York: Springer.

Diamond, A. (2013). Executive functions. *Annual Review of Psychology, 64,* 135–168. doi:10.1146/annurev-psych-113011-143750.

Denson, T. F., DeWall, C. N., & Finkel, E. J. (2012). Self-control and aggression. *Current Directions in Psychological Science, 21(1),* 20–25. doi:10.1177/0963721411429451.

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. doi:10.1016/j.chiabu.2008.08.002.

Fairbank, J. A., & Fairbank, D. W. (2009). Epidemiology of child traumatic stress. *Current Psychiatry Reports, 11(4),* 289–295. doi:10.1007/s11920-009-0042-9.

Fairchild, G., van Goozen, S. H. M., Stollery, S. J., Aitken, M.R. F., Savage, J., Moore, S. C., & Goodyer, I. M. (2009). Decision making and executive function in male adolescents with early-onset or adolescence-onset conduct disorder and control subjects. *Biological Psychiatry, 66(2),* 162–168. doi:10.1016/j.biopsych.2009.02.024.

Flouri, E., & Kallis, C. (2007). Adverse life events and psychopathology and prosocial behavior in late adolescence: Testing the timing, specificity, accumulation, gradient, and moderation of contextual risk. *Journal of the American Academy of Child and Adolescent Psychiatry, 46(12),* 1651–1659. doi:10.1097/chi.0b013e318156a81a.

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. doi:10.1076/chin.6.3.235.3152.

Goldstein, S., Naglieri, J. A., Princiotta, D., & Otero, T. M. (2014). *Introduction: A history of executive functioning as a theoretical and clinical construct.* In J. A. Goldstein, S., Naglieri (Eds.), Handbook of executive functioning. New York: Springer

Goldstein, R. Z., & Volkow, N. D. (2011). Dysfunction of the prefrontal cortex in addiction: Neuroimaging findings and clinical implications. *Nature Reviews. Neuroscience, 12(11),* 652–669. doi:10.1038/nrn3119.

Hayes, A. (2013). *Introduction to mediation, moderation, and conditional process analysis.* New York: Guilford. doi:978-1-60918-230-4.

Hayes, A. F., & Preacher, K. J. (2014). Statistical mediation analysis with a multicategorical independent variable. *British Journal of Mathematical and Statistical Psychology, 67(3),* 451–470. doi:10.1111/bmsp.12028.

Huizinga, M., & Smidts, D. (2009). *BRIEF: Vragenlijst executieve functies voor 5–18 jarigen.* Amsterdam: Hogrefe Uitgevers.

Jaffee, S. R., Caspi, A., Moffitt, T. E., Polo-Tomas, M., & Taylor, A. (2007). Individual, family, and neighborhood factors distinguish resilient from non-resilient maltreated children: A cumulative stressors model. *Child Abuse and Neglect, 31(3),* 231–253. doi:10.1016/j.chiabu.2006.03.011.

Jonkman, C. S., Verlinden, E., Bolle, E. A., Boer, F., & Lindauer, R. J. L. (2013). Traumatic stress symptomatology after child maltreatment and single traumatic events: Different profiles. *Journal of Traumatic Stress, 26,* 225–232. doi:10.1002/jts.21792.

Kenworthy, L., Yerys, B. E., Anthony, L. G., & Wallace, G. L. (2008). Understanding executive control in autism spectrum disorders in the lab and in the real world. *Neuropsychology Review, 18(4),* 320–338. doi:10.1007/s11065-008-9077-7.

McNally, K., Rohan, J., Pendley, J. S., Delamater, A., & Drotar, D. (2010). Executive functioning, treatment adherence, and glycemic control in children with type 1 diabetes. *Diabetes Care, 33(6),* 1159–1162. doi:10.2337/dc09-2116.

Miyake, A., & Friedman, N. P. (2012). The nature and organization of individual differences in executive functions: four general conclusions. *Current Directions in Psychological Science, 21(1),* 8–14. doi:10.1177/0963721411429458.

Leskin, L. P., & White, P. M. (2007). Attentional networks reveal executive function deficits in posttraumatic stress disorder. *Neuropsychology, 21(3),* 275–284. doi:10.1037/0894-4105.21.3.275.

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(04),* 487. doi:10.1017/S1352465805002419.

Polak, A. R., Witteveen, A. B., Reitsma, J. B., & Olff, M. (2012). The role of executive function in posttraumatic stress disorder: A systematic review. *Journal of Affective Disorders, 141(1),* 11–21. doi:10.1016/j.jad.2012.01.001.

Reinert, K. R. S., Po'e, E. K., & Barkin, S. L. (2013). The relationship between executive function and obesity in children and adolescents: A systematic literature review. *Journal of Obesity, 10(2).* doi:10.1155/2013/820956.

Rinne-Albers, M. A. W., Van Der Wee, N. J. A., Lamers-Winkelman, F., & Vermeiren, R. R. J. M. (2013). Neuroimaging in children, adolescents and young adults with psychological trauma. *European Child and Adolescent Psychiatry, 22(12)*, 745–755. doi:10.1007/s00787-013-0410-1.

Sherman, E. M. S., Slick, D. J., & Eyrl, K. L. (2006). Executive dysfunction is a significant predictor of poor quality of life in children with epilepsy. *Epilepsia, 47(11),* 1936–1942. doi:10.1111/j.1528-1167.2006.00816.x.

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston: Pearson/Allyn & Bacon.

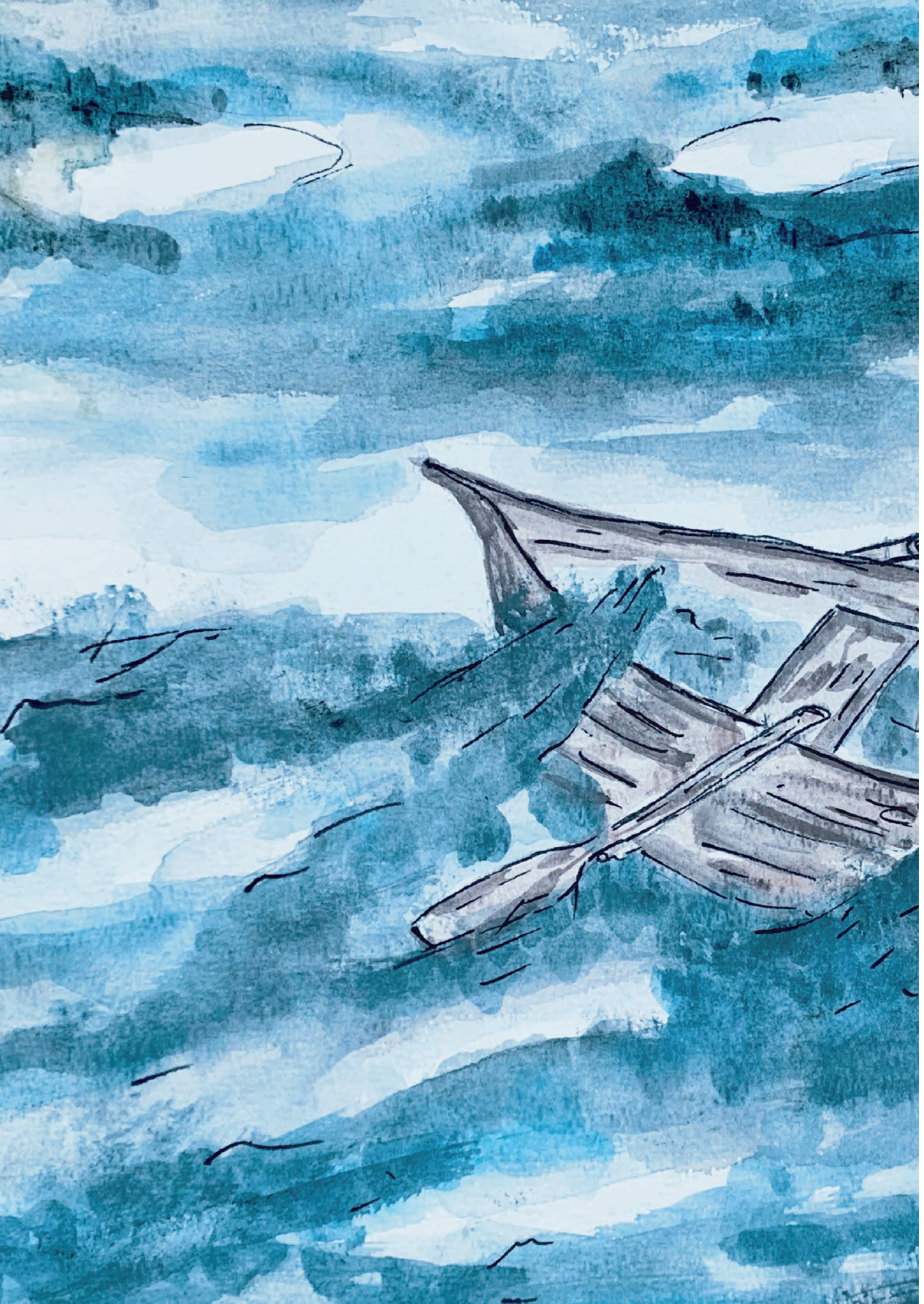
Van der Kolk, B. A. (2005). Developmental trauma disorder: Toward a rational diagnosis for children with complex trauma histories. *Psychiatric Annals, 35(5),* 401–409.

van Meijel, E. P. M., Gigengack, M. R., Verlinden, E., Opmeer, B. C., Heij, H. A., Goslings, J. C., … Lindauer, R. J. (2015). Predicting posttraumatic stress disorder in children and parents following accidental child injury: Evaluation of the screening tool for early predictors of posttraumatic stress disorder (STEPP). *BMC Psychiatry, 15(1),* 1–8. doi:10.1186/s12888-015-0492-z.

Verlinden, E., van Meijel, E .P .M., Beer, R., de Roos, C., Bicanic, I. A. E., Lamers-Winkelman, F., Olff, M., Boer, F., & Lindauer, R. J. L. (2014). Characteristics of the children's revised impact of event scale in a clinically referred Dutch sample. *Journal of Traumatic Stress, 27,* 338–344. doi:10.1002/jts.21910. 36.

Verlinden, E., Lindauer, R. L. (2015). *CRIES kindversie: Vragenlijst voor het screenen op posttraumatische stressklachten bij kinderen van 8 tot 18 jaar*. Retrieved October 14, 2016, from http://www.childrenandwar.org/measures/children%E2%80%99srevised-impact-of-event-scale-8-%E2%80%93-cries-8/ies13/.

Williams, P. G., Suchy, Y., & Rau, H. K. (2009). Individual differences in executive functioning: Implications for stress regulation. *Annals of Behavioral Medicine, 37(2),* 126–140. doi:10.1007/s12160-009-9100-0.



Executive functioning as a predictor of PTSD treatment completion and responsiveness in youth aged 8-18 years old

R. Op den Kelder
A.L. Van den Akker
J.B.M. Ensink
J.B. Zantvoord
H.M. Geurts
G. Overbeek
R.J.L. Lindauer

To be submitted

Abstract

In this study we test whether executive functioning predicts completion of and responsiveness to PTSD treatment for children aged 8-18 years old. Our sample consists of 94 treatment-seeking children (56 girls) with a mean age of 12.8 years. We used the Behavior Rating Inventory for Executive Functioning (BRIEF) and four neuropsychological tasks (Stroop task, Stop task, Gender-emotion switch task, and working memory task) to measure executive functioning. None of our executive functioning measures showed a significant association with either treatment completion or treatment responsiveness. Our results indicate that in contrast with research among adults, executive functioning may not be a robust predictor of treatment completion and responsiveness in children with PTSD.

Introduction

Trauma exposure in childhood is very common as approximately two-thirds of children have experienced a traumatic event before they have reached the age of sixteen (Copeland et al., 2007). Based on a meta-analysis, approximately 16% of trauma-exposed youth meet the criteria for Post-Traumatic Stress Disorder (PTSD) (Alisic et al., 2014). PTSD is characterized by four symptom criteria: intrusion (e.g., nightmares and flashbacks), avoidance (e.g., avoidance of trauma-related thoughts or feelings), negative alterations in cognitions and mood (e.g., increased feelings of shame, blame, and isolation), and alterations in arousal (e.g., hypervigilance and difficulty sleeping) (American Psychiatric Association, 2013). PTSD is a severe mental disorder with a high personal and societal cost due to its negative mental, physical, and academic consequences for the affected individuals and their families. Additionally, children who did not meet all PTSD criteria, and 'qualify' for partial PTSD, can experience the same level of impairment in daily life (Carrion, Weems, Ray, & Reiss, 2002; Cukor, Wyka, Jayasinghe, & Difede, 2010). Untreated PTSD is associated with long term PTSD symptoms over a course of five years (Goenjian et al., 2005). PTSD is also associated with lower quality of life (Pagotto et al., 2015) and more physical health problems (Pacella, Hruska, & Delahanty, 2013). This highlights the importance of effective treatment for children and adolescents with (partial) PTSD.

Several psychological treatments such as Eye-Movement and Desensitization (EMDR) and Trauma Focused Cognitive Behavioral Therapy (TF-CBT) have been found to be effective in treating children with PTSD according to a meta-analysis (Morina et al., 2016). This meta-analysis among 39 randomized controlled trials found that psychological interventions were effective with an effect size of Hedge's *g* of 0.83 compared to a waitlist with Hedge's *g* of 0.41. Another meta-analysis (Lewey et al., 2018) showed that EMDR and TF-CBT are both effective in treating posttraumatic stress symptoms. However, even with 'effective treatment' of PTSD, treatment response is relatively limited in terms of total remission of PTSD symptoms for some individuals. For example, a review of 51 randomized controlled trials among adults with clinical levels of PTSD found that 31% of participants experienced clinical PTSD symptoms after treatment and that 59% had subthreshold PTSD symptoms after treatment (Larsen et al., 2019). In addition, although trauma-focused treatment is effective overall and TF-CBT and EMDR are included in both ISTSS (ISTSS, 2018) and NICE (NICE, 2018) guidelines, for many children and adolescents receiving effective treatment is challenging due to the high dropout rates.

Treatment dropout and response for children with PTSD

The dropout rates in PTSD treatment for youth vary from 25% (Diehle, Opmeer, Boer, Mannarino, & Lindauer, 2015; Ormhaug & Jensen, 2018; Yasinski et al., 2018) to 76% when clinicians are asked whether their client has finished treatment (Wamser-Nanney, 2019). These dropout rates are highly problematic, as children and adolescents who drop out from treatment may not, or much less, benefit from this potentially effective treatment, leaving them at heightened risk for severe (long term) consequences of PTSD. It is important to better understand treatment dropout and limited treatment responsiveness due to the severe consequences of (persistent) PTSD symptoms at both the societal and personal level. Untreated and persistent PTSD increases the risk of developing into a chronic mental disorder (Goenjian et al., 2005), but also the risk for re-traumatization (Jaffe et al., 2019).

Executive functioning as a predictor of treatment dropout and response

At the moment, there is not much literature about factors that predict dropout and responsiveness in treatment for children with PTSD. In a study among 194 children, levels of avoidance during the first few therapy sessions, relationship difficulties between therapist and child predicted higher levels of treatment dropout in TF-CBT (Yasinski et al., 2018). Additionally, this study found that children living with their parents or relatives were more likely to dropout than children living in foster care. Another possible factor that might decrease the likelihood of dropout and that might increase treatment responsiveness is youths executive functioning. Executive functioning has consistently been found to be impaired in children with PTSD (Op den Kelder, Van den Akker, Geurts, Lindauer, & Overbeek, 2018). Executive functioning consists of three core executive functions: inhibition, working memory, and cognitive flexibility. They form the foundation for higher-order skills such as planning, problem solving, reasoning, and decision making (Diamond, 2013). Trauma-exposed children with weaker executive functioning tend to have more problems inhibiting their responses in the classroom, organizing homework, planning and executing activities such as showering, school trips or homework, and show more rigid behavior than before the traumatic event. Problems in executive functioning are, among others, associated with problems in learning (Cantin, Gnaedinger, Gallaway, Hesson-McInnis, & Hund, 2016; Magalhães, Carneiro, Limpo, & Filipe, 2020; Ropovik, 2014). As children and adolescents learn and integrate new cognitive and behavioral coping strategies in trauma-focused treatment, it could be that these problems in executive functioning impede completion of and response to treatment. With this study, we are the first to investigate separate executive functions as predictors of treatment dropout and treatment responsiveness in children with PTSD.

Several executive functions are likely relevant for treatment completion and responsiveness. First, working memory, the ability to hold and manipulate information in the short-term memory (Miyake et al., 2000b), is also essential for learning processes (Ropovik, 2014). Problems with working memory make it more difficult to focus on therapy tasks and to finish a task or treatment exercise successfully. Learning new strategies for coping with feelings, thoughts, and trauma-related stimuli and situations might therefore be compromised by an impeded working memory. Second, inhibition, the capacity to stop automatic responses, actions, and thoughts (Miyake et al., 2000b), could influence treatment completion and responsiveness. Impeded inhibitory control could make it more difficult to inhibit the habitual responses, unwanted responses and intrusive thoughts that are characteristic for PTSD. As this control is necessary to "overrule" these impulses with internal and external stimuli, a lower level of inhibitory control could make it more difficult to benefit from treatment. Third, cognitive flexibility could moderate treatment responsiveness as the greater the ability to be flexible in thoughts and categorization, the better the person is able to learn to differentiate between threat-related and neutral stimuli and situations (Ben-Zion et al., 2018). Additionally, problems in flexibility might result in a rigid way of thinking and might therefore influence recovery from PTSD symptoms negatively (Brown et al., 2018; Kanagaratnam & Asbjørnsen, 2007).

In addition to working memory, inhibitory control, and flexibility, higher order executive functions such as planning, organizing, reasoning, and problem solving are skills that might also be necessary for an effective response to trauma-focused treatment. For example, problems in planning and organizing often lead to no show on appointments and being late, which is likely associated with both treatment dropout and lower treatment responsiveness. Difficulties in problem solving might influence treatment completion and responsiveness as sufficient problem-solving skills allow us to find solutions for practical problems and think 'outside the box'.

Looking at the empirical evidence to date, two studies examined executive functioning in relation to PTSD treatment completion and/or dropout, albeit in adults. First, a study among 74 veterans with PTSD and traumatic brain injury (TBI) investigated whether baseline executive functioning predicted treatment dropout and treatment response in trauma-focused cognitive processing therapy (Crocker et al., 2018). They found that lower problem-solving and cognitive flexibility were predictive of higher treatment dropout while lower levels of cognitive flexibility, inhibition, and working memory were predictive of poorer treatment response. This same study demonstrated that better problem-solving skills were also predictive of treatment completion, even when controlled for baseline PTSD symptom severity (Crocker et al. 2018). Another study, among 13 adult patients with PTSD found

that higher inhibition, as indicated by activation in the left dorsal striatal and frontal brain networks during an inhibitory control task predicted better cognitive behavioral treatment response, even after controlling for PTSD symptom severity (Falconer, Allen, Felmingham, Williams, & Bryant, 2013). However, performance on this task was not significantly associated with treatment response. There is some evidence available for treatment response for some other disorders than PTSD. Results of a systematic review on depression treatment in adults indicated that poorer executive functioning predicted worse treatment outcome (Groves, Douglas, & Porter, 2018). Two studies investigated executive functioning in relation to treatment response in persons with obsessive compulsive disorder (OCD). The results from the first study among 28 adults with OCD, indicated that better baseline cognitive flexibility measured by tasks was predictive of better treatment response on cognitive behavioral therapy (D'Alcante et al., 2012). However, another study found that higher executive functioning test performance was associated with lower treatment response in a sample of 100 children that were treated for OCD (Hybel, Mortensen, Lambek, Højgaard, & Thomsen, 2017). In contrast, in this study, executive functioning measured using the BRIEF was not predictive of treatment responsiveness. Both previous studies highlight possible differences between executive functioning as a predictor when measured by tasks or questionnaires. The findings of a study among 61 children with ADHD showed that children with poorer executive functioning – measured using neuropsychological tasks - did not benefit more from on an executive functioning training (Dovis et al, 2019). Another study among 159 adolescents with ADHD found that parent-rated planning problems did not interact with difference scores of ADHD symptoms from pretest to follow-up (Boyer et al., 2016).

In sum, even though executive functioning is impaired in trauma-exposed youth (Op den Kelder et al., 2018), and is likely associated with treatment dropout and responsiveness in children with PTSD, to date there is only limited empirical evidence about the role of executive functioning in predicting PTSD treatment completion and responsiveness in adults and none in children. Additionally, studies with other clinical groups reported mixed findings ranging from less treatment responsiveness when having higher levels of executive functioning and less responsiveness when having lower levels of executive functioning or even no evidence of executive functioning as a predictor of treatment response.

Current study

In our study we examined whether executive functioning, as assessed prior to treatment with both neuropsychological measures and a questionnaire, would predict dropout from- and responsiveness to trauma-focused treatment (TF-CBT and EMDR) in children aged 8-18 years old with PTSD. We hypothesized that poorer executive functioning would be

predictive of treatment dropout and that poorer executive functioning would predict lower treatment responsiveness.

Method

Sample

Our sample was part of a larger study that investigates (epi)genetics and neurological vulnerability in youth that received trauma treatment in an outpatient facility for children and adolescents (Diehle et al., 2015; Op den Kelder, Ensink, Overbeek, Maric, & Lindauer, 2017 (Chapter 4); Zantvoord et al., 2019). Our sample consisted of 94 children (56 girls) aged 8 to 18 years old. The mean age of our sample was 12.81 (SD = 2.89) years. Most children had a Dutch ethnicity (87.20%). The most reported types of index traumatic event were being a witness or victim of physical violence (33.0 %) and sexual abuse (25.60%). The mean age during the occurrence of the index trauma was 9.24 (SD = 4.21) years and in 42.60% of the cases the perpetrator was a person inside the (extended) family.

Procedure

We obtained permission for this study (2011_194 L35971.018.11) from the Medical Ethical Committee of the Academic Medical Center (AMC) in Amsterdam. Data was analyzed based on a pre-registration of our research question and a data analytic plan is registered as number 70563 on the website www.aspredicted.org. Participants were recruited at the Department of Trauma, Attachment and Family at the Bascule, an Academic Center for Child and Adolescent Psychiatry in Amsterdam, the Netherlands. Youth aged 8-18 and their caregivers were recruited during the intake phase. In this phase, researchers provided information about the research procedure and stressed that participation was voluntary and declining participation would not affect treatment possibilities. Diagnostic assessment was performed by a trained clinician using a comprehensive diagnostic interview for PTSD complaints with both the child and caregivers (CAPS-CA) (van Meijel, Ensink, Verlinden, & Lindauer, 2019; Nader, Kriegler, Blake, & Pynoos, 1996). Child and caregivers also filled out questionnaires to assess their mental health. We included treatment seeking youth in this study when they (1) were aged between 8 and 18 years old, (2) finished the diagnostic interview for PTSD complaints (see under Variables), and (3) completed at least one executive functioning measurement. There were five exclusion criteria for the overall study: (1) estimated intelligence quotient lower than 70, (2) acute suicidality, (3) comorbid problems such as: psychotic disorders, substance use disorders, pervasive development disorder, and medical illness influencing HPA-functioning, (4) pregnancy, and (5) the use of glucocorticoid

medication. Written informed consent was obtained from legal guardians and children aged above 11 years. Researchers were trained in administering the interviews, questionnaires, and neuropsychological tasks and were unaware of the treatment condition. Measurements were conducted at pretreatment (intake) and after 8-sessions of trauma-focused treatment. After regular diagnostic assessment, at the end of the intake phase, children were asked for participation in our study and appointments for neuropsychological assessment and fMRI were made. In most cases, these assessments were done in two separate appointments. Figure 5.1 shows a flow chart of the participant enrollment of the various measures.

Research treatment protocols for TF-CBT and EMDR contained of 8 sessions (Diehle et al., 2015). TF-CBT is a cognitive behavioral therapy with family therapy components. It consists of 8 modules of psycho-education, relaxation, affect modulation, cognitions, trauma narrative, in vivo reminders, combination session and future safety (Cohen & Mannarino, 2008). EMDR is also a cognitive behavioral therapy that uses eye-movements, buzzers or other exercises such a spelling words or counting backwards to load the working memory while retrieving a traumatic memory (de Jongh & ten Broeke, 2018).

Variables

Posttraumatic stress symptoms.

Using the clinician administered PTSD scale for children and adolescents (CAPS-CA) (van Meijel et al., 2019; Nader et al., 1996), PTSD symptoms were assessed at pre- and posttreatment. Post treatment assessment took place after 8 sessions of either EMDR or TF-CBT. The CAPS-CA is a clinical interview that can be administered by trained psychologists only. The interview consists of the life-events checklist in which traumatic exposure is assessed. These life-events consist of 26 events such as exposure to a disaster, domestic violence or sexual violence. Children are asked whether they have experienced it, saw it happen to somebody, heard about it by a loved one, or whether they were not sure if they experienced it or if it never happened to them. The second part of the interview assesses PTSD symptoms of the index trauma. Each symptom of each symptom cluster is assessed using a frequency and intensity score, resulting in a severity score. There is a child-rated score and a clinician-rated score, for both frequency and intensity. Examples are: "how often do you have nightmares per week?" for the frequency of nightmares and "how long does it take to fall back a sleep again" for the intensity of it. The severity scores per cluster were summed, so that total scores ranged from 0-120. We used the clinician-rated total scores as measure for level of posttraumatic stress symptoms. Previous research has shown both a good reliability and validity of the CAPS-CA (Diehle, de Roos, Boer, & Lindauer, 2013)

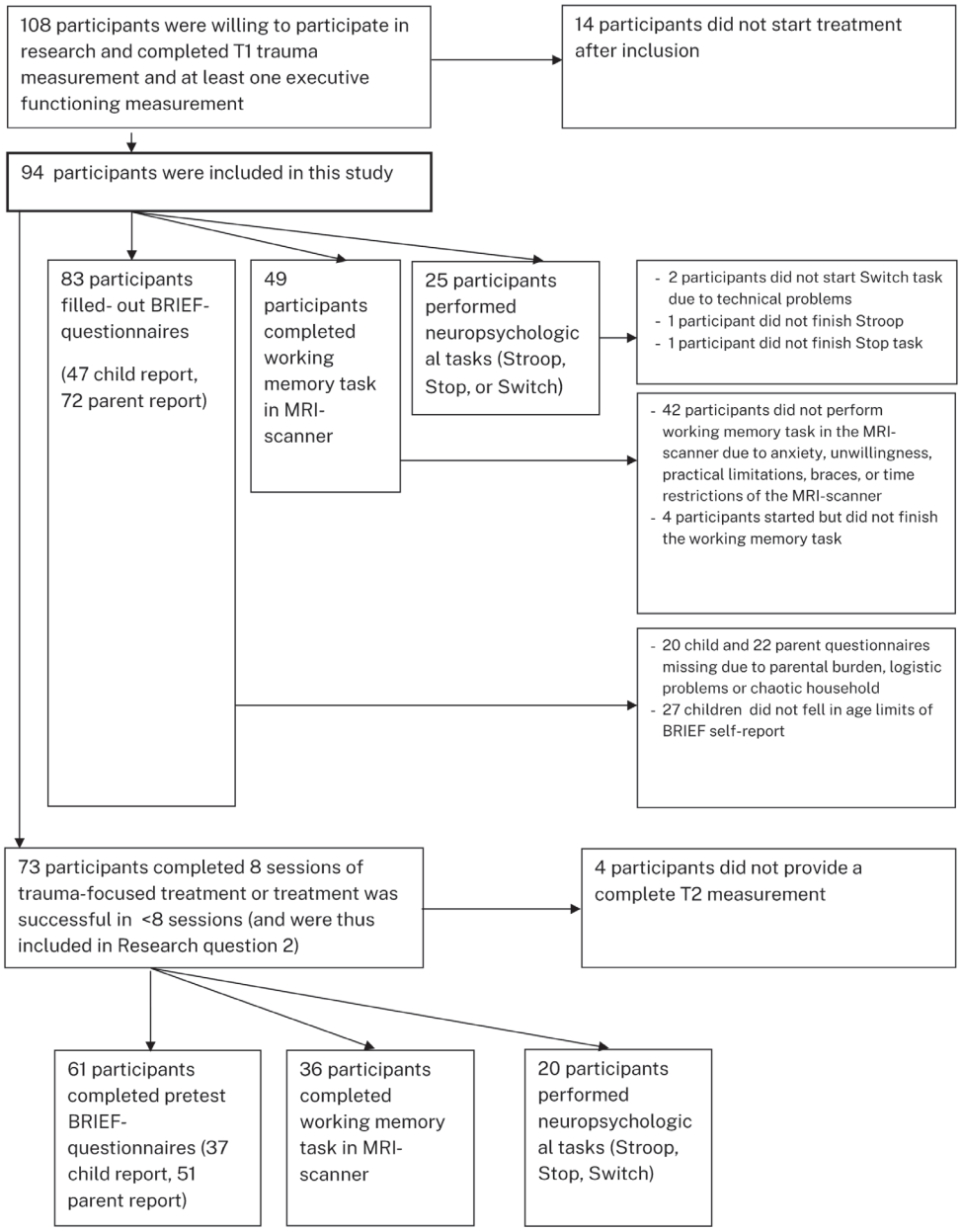


Figure 5.1 Flow chart of participant enrollment in executive functioning measurements

Executive functioning.

Both parent and self-report versions of the Dutch translation of the Behavior Rating Inventory for Executive Functioning (BRIEF) were used to measure executive functioning (Huizinga & Smidts, 2009). The parental questionnaire consists of 75 items, while the self-report version consists of 68 items. The BRIEF has several subscales: Inhibition, Flexibility, Emotion Regulation, Working Memory, Plan/Organize, Organization of Materials. Additionally, the subscale Task Completion (self-report) and Initiate (parent report). We used norm scores of the subscales in our analyses in which a norm score above 60 indicates a subclinical level of executive functioning problems. When two or more informants filled out their respective version of the questionnaire, we used a mean norm score. Previous research indicated a good reliability with Cronbach's alpha's ranging from .78 to .96 (Huizinga & Smidts, 2009). In our sample, the Cronbach alpha was .95 for the self-report questionnaire and .96 for the parent version. A higher score on the BRIEF reflects more executive functioning problems.

The Stroop task was used to assess inhibition (Stroop, 1935). In the first condition, participants had to name the printed words (the colors blue, green, red) on a sheet as fast as possible. The second condition consisted of naming the printed colors as fast as possible. In the third condition, words were printed in a non-corresponding color and participants had to inhibit naming the color and read the words as fast as possible. Each condition existed of 36 items and time was measured using a stopwatch. The outcome measure was the contrast time score (reaction time of condition 3 minus reaction time condition 2), with a higher score indicating worse performance. The Stroop task is often used and has shown a good reliability and validity (MacLeod, 1991; Strauss, Allen, Jorgensen, & Cramer, 2005).

We assessed cognitive flexibility with an adapted version (De Vries & Geurts, 2014) of the classical switch task (Rogers & Monsell, 1995). The gender-emotion switch task was presented on a 15-inch screen laptop and took approximately 17 minutes. Selected pictures of a male or female, looking angry or happy from the Karolinska Directed Emotional Faces Set (Lundqvist, Flykt, & Öhman, 1998) were presented on the screen. Participants had to alternate between responding on emotion or gender by pressing a left or right button. For 400 to 600 ms, a central fixation cross was displayed on the screen, directly followed by this fixation cross and the task cue (600 ms). The task cue existed of either an emoticon for emotional trials or a male/female symbol for the gender trials. Then, the target picture was displayed for 2000 ms or until a response was given (together with the task cue). The tasks started with three practice blocks (16 trials emotion, 16 trials gender, and 40 trials switch), which were repeated when the participants made more than 25% errors. After completion

of the practice block, three experimental blocks of 72 trials were administered. These trials were equally divided by one-third of switch trials, one-third of gender trials, and one-third of emotion trials. The outcome measure was reaction time switch cost (mean reaction time on all repeat trials subtracted from the mean reaction time on all switch trials).

We measured response inhibition using an adaptation (De Vries & Geurts, 2014) of the classical stop task (Logan, Schachar, & Tannock, 1997; Morein-Zamir, Hommersen, Johnston, & Kingstone, 2008). The task was administered via an 15-inch screen laptop in an individual test setting and took approximately 15 minutes. Participants were instructed to respond as fast as possible, except for the trials in which a stop signal appeared, when they were instructed to inhibit their response. The task was made more appealing for children by using a picture of a dog. The yellow dog (go signal) looked right or left and participants had to press the left or right button, unless the dog turned red (stop signal), when they had to inhibit their response. A tracking mechanism was used to adjust the stop-signal delay in which the delay was lengthened after a successful stop (increase difficulty) or shortened after an unsuccessful stop (decrease difficulty). The first stop signal appeared after 300ms, the stop signal delay was lengthened or shortened with 50ms. The task consisted of a practice block with 80 go trials, and three experimental blocks (approximately 30% stop signals). The outcome measure was the stop signal reaction time (SSRT; stop signal delay subtracted from the mean reaction time on correct go trials).

We assessed working memory with an adaptation (Oei, Tollenaar, Spinhoven, & Elzinga, 2009) of the Sternberg item-recognition task (Sternberg, 1966). This task was completed inside a 3tMRI scanner, using a mirror screen and press buttons. Before entering the scanner, a practice block was done at a 15 inch laptop. The working memory load was manipulated during the task. A letter sequence was presented (1-4 targets) and had to be held in memory for 1000ms. During the delay phase (1500ms) distracting stimuli, pictures of human faces from the International Affective Pictures System (Lang, Bradley, & Cuthbert, 1997) were shown. Half of these faces were of neutral emotional content and the other half had a negatively arousing content (e.g. angry faces). Participants had to ignore this distraction and had to press a yes (one target letter present) or no (no target letter present) button if they recognized any letter of the target display (1-4 letters) in the recognition display (1-4 letters). By varying the amount of letters that were displayed in the recognition display, working memory load was based on 2, 4, 12 or 16 comparisons. A total of 96 trials were administered in approximately 10 minutes. Each block consisted of 12 emotional or neutral trials and had either a low working memory load (2-4 comparisons) or a high working memory load (12-16 comparisons). The stimulus presentation software was

developed at the University of Amsterdam and automatically randomized and presented stimuli while recording reaction times and errors. We used accuracy of overall trials as outcome measure.

Please note that the number of participants differed for each executive functioning variable as the administration of neuropsychological tasks was not included at the start of the research protocol.

Data analytic plan

Unexpectedly, there were some negative correlations between subscales of the BRIEF and the Stroop task, Stop task, and gender-emotion switch task. After intensive investigation of the performance of these tasks, we still could not explain these negative correlations and question the validity of these observations. As we preregistered, given the small subsample, that we would run exploratory analyses with these tasks, we decided to solely report on these tasks in Supplement 5.1, but to exclude these tasks from the main analyses described below. It is important to note that we still included the working memory task in our analyses as there were no unexpected correlations with the BRIEF and more participants completed this task.

To investigate whether executive functioning predicts dropout of trauma-focused treatment for youth with PTSD, we conducted ten separate logistic regression analyses (for nine BRIEF subscales and the working memory task). We used executive functioning measures as independent variables and treatment completion (yes or no) as a dependent variable. Treatment was considered completed when a participant started treatment and finished eight treatment sessions or had no PTSD complaints within less than 8 sessions and the therapist decided to end trauma treatment. We included age and gender as covariates in the model. All participants were included in these analyses, except for those who did not complete baseline measurements or did not start treatment. To investigate our second research question, whether executive functioning predicts treatment responsiveness of trauma-focused treatment for youth with PTSD, we conducted separate regression analyses. Again, executive functioning was used as independent variables, PTSD total score at pretreatment was used as a covariate, and PTSD total score (CAPS-CA) at posttreatment was the dependent variable. Included participants were children who finished treatment and baseline measurements. As we performed multiple tests on a relatively small sample, we corrected for the increased risk of false positives by using the Benjamini-Hochberg procedure (Benjamini & Hochberg, 1995).

IBM SPSS version 25 (IBM Corp, 2017) was used to conduct our analyses. We used expectation maximization estimation to impute missing data for participants that filled in the questionnaires as we had missing data on some items. We found a 2.8% missing rate at item level for parental report and 5.6% for self-report. We checked normality of the data by investigating skewness and kurtosis and divided these statistics by their standard error. There were no univariate outliers and variables were normally distributed.

Results

In our sample, 24 participants (25.5%) were considered dropouts. Means and standard deviations of variables and their bivariate correlations are displayed in Table 5.1. As expected, all subscales of the BRIEF were positively correlated to each other. PTSD symptoms at baseline were significantly positively associated with PTSD symptoms at posttest and with more problems in working memory, organization of materials, and finishing tasks at pre/posttest.

To investigate whether executive functioning predicts PTSD treatment completion, we performed logistic regression analyses. We found that, after correcting for multiple testing using the Benjamini-Hochberg procedure, no significant associations between executive functions and treatment completion were found (see Table 5.2). To investigate whether executive functioning predicts PTSD treatment responsiveness, we performed multiple regression analyses. We found that, after correcting for multiple testing, executive functions were not significantly associated with treatment responsiveness (see Table 5.3).

Because, we did not preregister these analyses, in an explorative fashion we tested whether executive functions would predict treatment response on the separate PTSD symptom clusters. However, again no significant associations between executive and treatment responsiveness were found after using the Benjamini-Hochberg procedure.

Although not preregistered, we also investigated Bayes factors using JASP version 0.16 (JASP Team, 2021) to examine whether our null findings are likely to indeed indicate that executive functioning does not predict treatment responsiveness or completion. For research question 1 (treatment completion), by performing an Bayesian ANCOVA, we found anecdotal evidence for the null-hypothesis for all executive functions that were included in our analyses (BF10 ranged from 0.302 – 0.978). This means that, based on our analyses, there is a some evidence that indeed executive functioning does not predict treatment completion. For research question 2 (treatment responsiveness), by performing

an Bayesian ANCOVA, we found anecdotal to extreme evidence for the null-hypothesis (BF10 ranged from 0.002 to 0.586) evidence for our hypothesis. More specifically, for plan/organize and organization of materials we found anecdotal evidence for the null-hypothesis (respectively a BF10 of 0.303 and 0.309). For inhibition, flexibility, emotion regulation, working memory (questionnaire) we found moderate evidence for the null hypothesis (BF10 ranged from 0.252 to 0.267). For initiate, task completion, and working memory (task) we found strong to extreme evidence for the null hypothesis (BF10 ranged from 0.0009 to 0.071). This means that, based on our analyses, there is evidence that indeed executive functioning does not predict treatment responsiveness.

Table 5.1 Means, standard deviations, and correlations of all variables used in analyses

Variables	1	2	3	4	5	6	7	8	9	10	11	12
1. Age	1	0.161	0.004	-0.199	-0.047	0.093	0.019	0.053	-0.036	0.071	0.282*	0.214
2. PTSD pretest		1	0.656*	0.082	0.170	0.226*	0.269*	0.224*	0.256*	0.421*	0.036	-0.039
3. PTSD posttest			1	-0.013	0.042	0.046	0.201	0.023	0.017	0.192	-0.051	0.060
4. Inhibition (Q)				1	0.450*	0.479*	0.377*	0.486*	0.400*	0.242	0.256*	-0.190
5. Cognitive flexibility (Q)					1	0.678*	0.292*	0.414*	0.315*	0.396*	0.421*	-0.299
6. Emotion regulation (Q)						1	0.277*	0.419*	0.343*	0.430*	0.312*	-0.267
7. Working memory (Q)							1	0.719*	0.546*	0.716*	0.404*	0.089
8. Plan/Organize (Q)								1	0.652*	0.656*	0.571*	-0.028
9. Organization of Materials (Q)									1	0.594*	0.460*	-0.191
10. Task Completion (Q)										1	-0.087	-0.057
11. Initiate (Q)											1	-0.107
12. Working memory (T)												1
N	94	94	69	83	83	83	83	83	83	47	72	49
Mean	12.81	50.55	30.51	54.93	55.46	57.07	55.43	52.25	50.25	53.30	54.83	75.61
SD	2.890	25.79	24.70	8.86	8.50	7.99	8.17	8.30	9.86	10.56	10.37	11.68

Note. A higher score on the BRIEF correspondents with lower levels of executive functioning, while a higher score on the working memory tasks (12) correspondents with better performance.

*$p < 0.05$

Table 5.2 Logistic regression analyses of executive functioning on treatment completion with on the right side controlled for baseline PTSD symptoms

Variables	*n*	*B*	Wald Chi-Square	Odds Ratio	95% Confidence Interval odds ratio		*B*	Wald Chi-Square	Odds Ratio	95% Confidence Interval odds ratio	
					Lower	Upper				Lower	Upper
Inhibition	83	-0.024	0.567	0.977	0.918	1.039	-0.023	0.535	0.977	0.918	1.040
Sex		-0.024	0.002	0.976	0.322	2.962	-0.051	0.006	0.951	0.277	3.263
Age		0.007	0.005	1.007	0.828	1.225	0.008	0.007	1.009	0.828	1.229
Pretest PTSD							-0.001	0.009	0.999	0.976	1.022
Constant		2.514	1.051	12.355			2.545	1.060	12.747		
Flexibility	83	0.054	2.645	1.055	0.989	1.126	0.059	2.961	1.061	0.992	1.134
Sex		-0.084	0.022	0.919	0.298	2.835	-0.256	0.158	0.774	0.219	2.737
Age		0.029	0.084	1.029	0.847	1.251	0.034	0.112	1.034	0.848	1.262
Pretest PTSD							-0.008	0.383	0.992	0.969	1.017
Constant		-1.980	0.745	0.138			-1.850	0.638	0.157		
Emotion regulation	83	0.024	0.506	1.024	0.959	1.095	0.029	0.639	1.029	0.959	1.103
Sex		-0.056	0.010	0.945	0.310	2.881	-0.173	0.074	0.841	0.242	2.923
Age		0.014	0.021	1.014	0.837	1.229	0.016	0.025	1.016	0.837	1.233
Pretest PTSD							-0.005	0.178	0.995	0.972	1.019
Constant		-0.238	0.012	0.788			-0.194	0.008	0.824		
Working memory	83	-0.013	0.157	0.987	0.924	1.053	-0.012	0.131	0.988	0.924	1.056
Sex		-0.052	0.008	0.950	0.311	2.897	-0.081	0.017	0.922	0.272	3.126
Age		0.021	0.049	1.022	0.845	1.235	0.022	0.053	1.023	0.845	1.238
Pretest PTSD							-0.001	0.014	0.999	0.976	1.022
Constant		1.770	0.558	5.868			1.792	0.569	6.003		
Plan/Organize	83	0.019	0.326	1.019	0.955	1.088	0.021	0.376	1.021	0.955	1.091
Sex		0.032	0.003	1.033	0.337	3.163	-0.044	0.005	0.957	0.280	3.272
Age		0.022	0.053	1.023	0.844	1.238	0.025	0.062	1.025	0.845	1.243
Pretest PTSD							-0.004	0.092	0.996	0.974	1.020
Constant		-0.003	0.000	0.997			0.095	0.002	1.100		

Table 5.2 Continued

Variables	*n*	*B*	Wald Chi-Square	Odds Ratio	95% Confidence Interval odds ratio		*B*	Wald Chi-Square	Odds Ratio	95% Confidence Interval odds ratio	
					Lower	Upper				Lower	Upper
Organization of Materials	83	0.004	0.020	1.004	0.952	1.059	0.006	0.041	1.006	0.952	1.063
Sex		-0.011	0.000	0.989	0.328	2.985	-0.076	0.015	0.927	0.272	3.154
Age		0.023	0.058	1.024	0.846	1.238	0.026	0.068	1.026	0.847	1.243
Pretest PTSD							-0.003	0.060	0.997	0.974	1.021
Constant		0.797	0.164	2.218			0.858	0.187	2.359		
Initiate	72	0.035	1.409	1.035	0.978	1.097	0.036	1.427	1.036	0.977	1.098
Sex		0.113	0.035	1.120	0.341	3.674	-0.001	0.000	0.999	0.273	3.651
Age		-0.068	0.387	0.934	0.753	1.159	-0.066	0.353	0.936	0.753	1.164
Pretest PTSD							-0.005	0.206	0.995	0.972	1.018
Constant		0.137	0.006	1.147			-0.394	0.041	1.483		
Task Completion	47	0.036	0.876	1.037	0.962	1.117	0.042	1.068	1.043	0.963	1.130
Sex		0.871	0.831	2.389	0.368	15.526	0.647	0.367	1.911	0.235	15.540
Age		0.073	0.123	1.076	0.714	1.622	0.062	0.088	1.064	0.705	1.607
Pretest PTSD							-0.008	0.211	0.992	0.960	1.025
Constant		-1.714	0.202	0.175			-1.413	0.130	0.243		
Working Memory (Task)	49	-0.015	0.166	0.986	0.919	1.057	-0.017	0.225	0.983	0.915	1.055
Sex		0.927	1.123	2.527	0.455	14.030	0.738	0.569	2.092	0.307	14.233
Age		-0.195	1.636	0.823	0.610	1.109	-0.194	1.592	0.824	0.609	1.113
Pretest PTSD							-0.007	0.197	0.993	0.962	1.025
Constant		4.767	2.217	117.607			5.418	2.323	225.442		

Table 5.3 Multiple regression analyses of treatment responsiveness as a function of executive functions, sex, age and pretest PTSD

Variables	*N*	Unstandardized Beta	Standard error	*Beta*	*p*	R2	Adjusted R2	Unstandardized Beta	Standard error	*Beta*	*p*	R2	Adjusted R2
Inhibition	61					.240	0.200					0.473	0.435
Constant		35 .732	22 .809		0.123			16.035	19.565		0.416		
Sex		24 .595	5 .801	0.508	0.000			14.756	5.259	0.305	0.007		
Age		-1 .187	0.996	- 0.145	0.239			-0.035	0.263	-0.013	0.894		
Inhibition		- 0.047	0.313	- 0.017	0.882			-1.335	0.837	-0.163	0.116		
Pretest PTSD		-	-	-	-			0.525	0.105	0.526	0.000		
Cognitive Flexibility	61					0.247	0.208					0.474	0.436
Constant		18 .919	21 .919		0.392			19 .158	18 .488		0.305		
Sex		25 .013	5 .798	0.517	0.000			14 .392	5 .347	0.298	0.009		
Age		-1 .153	0.977	- 0.141	0.243			-1 .322	0.825	- 0.162	0.114		
Cognitive flexibility		0.244	0.316	0.089	0.443			- 0.099	0.276	- 0.036	0.722		
Pretest PTSD		-	-	-	-			0.535	0.109	0.536	0.000		
Emotion regulation	61					0.250	0.210					0.473	0.435
Constant		17.037	22.031		0.443			13.726	18.642		0.465		
Sex		25.136	5.798	0.520	0.000			14.758	5.346	0.305	0.008		
Age		-1.259	0.982	-0.154	0.205			-1.317	0.830	-0.161	0.118		
Emotion Regulation		0.294	0.338	0.101	0.388			0.003	0.292	0.001	0.992		
PTSD pretest		-	-	-	-			0.525	0.108	0.526	0.000		
Working memory	61					0.252	0.213					0.474	0.436
Constant		14.762	22.208		0.509			8.991	18.833		0.635		
Sex		23.525	5.855	0.486	0.000			14.559	5.288	0.301	0.008		
Age		-1.106	0.975	-0.135	0.261			-1.299	0.826	-0.159	0.122		
Working memory		0.329	0.335	0.115	0.330			0.093	0.288	0.032	0.749		
PTSD pretest		-	-	-	-			0.519	0.107	0.521	0.000		

Table 5.3 Continued

Variables	*N*	Unstandardized Beta	Standard error	*Beta*	*p*	R2	Adjusted R2	Unstandardized Beta	Standard error	*Beta*	*p*	R2	Adjusted R2
Planning and organizing	61					0.240	0.200					0.477	0.440
Constant		35.994	21.139		0.094			23.327	17.868		0.197		
Sex		24.684	5.824	0.510	0.000			14.925	5.245	0.309	0.006		
Age		-1.154	0.982	-0.141	0.245			-1.294	0.823	-0.158	0.121		
Plan/Organize		-0.063	0.347	-0.021	0.857			-0.197	0.291	-0.066	0.502		
PTSD pretest		-	-	-	-			0.531	0.105	0.533	0.000		
Organization of Materials	61					0.240	0.200					0.477	0.439
Constant		29.840	20.524		0.151			22.314	17.248		0.201		
Sex		24.599	5.801	0.509	0.000			14.501	5.255	0.300	0.008		
Age		-1.136	0.991	-0.139	0.256			-1.393	0.831	-0.170	0.099		
Organization of Materials		0.055	0.294	0.022	0.852			-0.160	0.250	-0.063	0.525		
PTSD pretest		-	-	-	-			0.536	0.107	0.538	0.000		
Initiate	51					0.238	0.189					0.511	0.468
Constant		34.103	18.893		0.077			13.300	15.843		0.406		
Sex		24.670	6.481	0.504	0.000			14.955	5.588	0.305	0.010		
Age		-1.077	1.148	-0.131	0.353			-10.213	0.930	-0.147	0.199		
Initiate		-0.054	0.326	-0.022	0.868			-0.042	0.264	-0.017	0.874		
PTSD pretest								0.548	0.108	0.561	0.000		
Task completion	37					0.299	0.235					0.566	0.512
Constant		54.663	33.874		0.116			40.873	27.233		0.143		
Sex		28.717	8.403	0.533	0.002			13.943	7.490	0.259	0.072		
Age		-3.356	1.970	-0.258	0.098			-2.400	1.588	-0.185	0.140		
Task completion		0.184	0.371	0.075	0.623			-.286	0.315	-0.116	0.370		
PTSD pretest		-	-	-	-			.631	0.142	0.630	0.000		

Table 5.3 Continued

Variables	*N*	Unstandardized Beta	Standard error	*Beta*	*p*	R2	Adjusted R2	Unstandardized Beta	Standard error	*Beta*	*p*	R2	Adjusted R2
Working memory (task)	36					0.229	0.157					0.517	0455
Constant		-7.668	31.505		0.809			-28.599	25.792		0.276		
Sex		24.143	7.917	0.484	0.005			9.625	7.205	0.193	0.191		
Age		-0.615	1.462	-0.068	0.677			-.450	1.176	-0.050	0.705		
Working memory		0.422	0.394	0.178	0.292			.397	0.317	0.168	0.219		
PTSD pretest		-	-	-	-			.594	0.138	0.610	0.000		

Discussion

In our study, we investigated whether executive functioning predicts trauma treatment completion and treatment responsiveness in children with PTSD aged 8 to18 years old. We hypothesized that poorer executive functioning would predict a lower rate of treatment completion and responsiveness. The dropout rate in our study of 25.5% is similar with previous empirical research for trauma treatment (Diehle et al., 2015; Ormhaug & Jensen, 2018; Yasinski et al., 2018), which emphasizes the importance and relevance of our study. However, while, as expected, we did observe that pretest PTSD symptoms and daily life executive functioning were related, executive functioning did not predict either treatment completion nor responsiveness.

First, we assessed whether executive functioning predicted treatment completion. Although previous research among adults with PTSD and TBI (Crocker et al., 2018) found that problem solving and switching measured by neuropsychological tasks predicted treatment completion, we did not find that for any type of executive functioning measured by the BRIEF. We also did not find that working memory, measured by a performance task, was predictive of treatment completion in contrast to the findings of this earlier study. In sum, although previous research among adults found that executive functioning measured with neuropsychological tasks predicted treatment completion, we did not find such an association.

In our second research question, we hypothesized that executive functioning predicted treatment responsiveness. However, we did not find any significant executive functioning predictors for responsiveness when measuring executive functioning with the BRIEF nor with a working memory task. This is, again, in contrast with previous research in adults with PTSD using neuropsychological tasks to measure working memory, inhibition, and cognitive flexibility (Crocker et al., 2018) and in research on depression (Groves et al., 2018). However, our findings are in line with previous research that did not find executive functioning to be predictive of treatment responsiveness when measured by the BRIEF for children with OCD(Hybel et al., 2017), for children with ADHD when measured by tasks (Dovis et al., 2019), and for adolescents with ADHD when parent-rated planning problems were measured (Boyer et al., 2016). In sum, this means that when we add our findings to the current scientific literature there is some contradiction: our results (no significant executive functioning predictors for treatment responsiveness) are similar to findings in children with OCD (measured with questionnaire) and children with ADHD (measured with tasks), but contradictory to research in adults with PTSD (measured with tasks) and

adults and children with OCD (measure with tasks). Although we did not find executive functioning to predict treatment completion or responsiveness, we did find some positive correlations between pretest PTSD symptoms and self/parent reported executive functioning (working memory, organization of materials and task completion). This means that – as expected based on previous research (Op den Kelder et al., 2017) - children who reported more PTSD problems at pretest also reported more self- and parent-reported executive functioning problems.

There are some explanations for our findings. First, it could be that executive functioning is more important in treatment completion for adults than for children. For children, caregivers and therapists could well be compensating for children's executive functioning problems by making extra efforts to help children complete their treatment. For example, therapists sometimes add external resources to solve logistic problems (e.g., a taxi service or colleague that brings the child to therapy) or send extra reminders for the appointments. Moreover, for children, it could be that the level of executive functioning of their caregivers might be more important than their own. From this developmental perspective, we could argue that caregivers have to commit to therapy as much as their children as they are the ones that have to arrange and organize the logistics. They also play a role in helping their child in finishing the treatment when it is difficult, by encouraging and regulating them. Additionally, other factors such as the level of social support, financial problems, or parental psychiatric symptoms might also be more predictive of children's trauma treatment completion than executive functioning of children. A second explanation could be that our sample showed a lot of variation in the level of executive functioning (BRIEF scores ranged from 33 to 75 with means between 50 and 55). As these mean scores are below the clinical cut-off score, it could be that we did not find significant predictions because executive functioning is only predictive for treatment responsiveness in a subgroup of children with more problems in executive functioning.

Strengths and limitations

Our study has various strengths. Our study is the first to examine executive functioning as a predictor for treatment completion and responsiveness in treatment-seeking children that have been exposed to traumatic events. This adds to the current literature and practice, as dropout and a limited treatment response results in negative long-term consequences due to long lasting effects of PTSD on the lives of individuals (Goenjian et al., 2005; Pacella et al., 2013; Pagotto et al., 2015). We gained information from both parents and children, making it a multi-informant approach. However, our study also has some limitations.

Although we included four tasks in our study, we did this on an exploratory level as there was insufficient power to detect significant associations with these smaller subgroups (except for the working memory task). Additionally, the confusing findings including these tasks (negative correlations among measures) make it more difficult to compare our results to previous research, but also makes it impossible to draw conclusions about whether executive functioning measured by these tasks predicts treatment completion and responsiveness in children with PTSD.

Future research

From a developmental perspective, it could be that executive functioning is more important in predicting treatment completion for adults and caregivers instead of children. More specifically, from this point of view, we argue that executive functioning gets more important in treatment completion when ages increases. As daily tasks that are expected from adolescents are of a more complex nature, there is a higher demand in executive functioning. Thus, executive functioning may be more important for adolescents than children in treatment completion. Research in diabetes treatment adherence, showed indeed an age component in the effect of executive functioning, such that executive functioning problems had a stronger association with treatment adherence in older children than in younger children (Goethals et al., 2018). Therefore, we urge future researchers to replicate our study with a larger sample size and investigate different age subgroups and the influence of parental PTSD and executive functioning. Furthermore, investigating whether therapist's strategies to help children completing and committing to their treatment, parental psychiatric problems, household chaos, and limited resources would give clinicians and scientists more information about how to lower dropout rates. This is of high importance as both treatment dropout and low responsiveness in PTSD treatment can have severe long-term consequences.

In conclusion, our results suggest that executive functioning does not predict treatment completion nor treatment responsiveness. Our findings are based on an outpatient sample aged 8-18 years old with a wide variation in executive functioning problems Although we did not find that executive functioning was predictive, it could be possible that executive functioning predicts treatment completion and responsiveness when measured by tasks. It could also be that the influence of executive functioning is dependent on age, level of executive functioning problems, or treatment type. We suggest to replicate our findings in a large outpatient sample which allows for the analysis of subgroups in terms of age, treatment type, and level of executive functioning problems.

References

Alisic, E., Zalta, A. K., Van Wesel, F., Larsen, S. E., Hafstad, G. S., Hassanpour, K., & Smid, G. E. (2014). Rates of post-traumatic stress disorder in trauma-exposed children and adolescents: Meta-analysis. *British Journal of Psychiatry*, *204*(5), 335–340. https://doi.org/10.1192/bjp.bp.113.131227

American Psychiatric Association. (2013). *Diagnostic and Statistical Manual of Mental Disorders, 5* (5th ed.). Arlington: VA: American Psychiatric Publishing.

Ben-Zion, Z., Fine, N. B., Keynan, N. J., Admon, R., Green, N., Halevi, M., … Shalev, A. Y. (2018). Cognitive flexibility predicts PTSD symptoms: Observational and interventional studies. *Frontiers in Psychiatry*, *9*, 1–9. https://doi.org/10.3389/fpsyt.2018.00477

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to multiple testing. *Journal of the Royal Statistical Society*, *57*(1), 289–300.

Brown, W. J., Dewey, D., Bunnell, B. E., Boyd, S. J., Wilkerson, A. K., Mitchell, M. A., & Bruce, S. E. (2018). A critical review of negative affect and the application of CBT for PTSD. *Trauma, Violence, and Abuse*, *19*(2), 176–194. https://doi.org/10.1177/1524838016650188

Cantin, R. H., Gnaedinger, E. K., Gallaway, K. C., Hesson-McInnis, M. S., & Hund, A. M. (2016). Executive functioning predicts reading, mathematics, and theory of mind during the elementary years. *Journal of Experimental Child Psychology*, *146*, 66–78. https://doi.org/10.1016/j.jecp.2016.01.014

Carrion, V. G., Weems, C. F., Ray, R., & Reiss, A. L. (2002). Toward an empirical definition of pediatric PTSD: The phenomenology of PTSD symptoms in youth. *Journal of the American Academy of Child and Adolescent Psychiatry*, *41*(2), 166–173. https://doi.org/10.1097/00004583-200202000-00010

Cohen, J. A., & Mannarino, A. P. (2008). *Behandeling van trauma bij kinderen en adolescenten: Met de methode Traumagerichte Cognitieve Gedragstherapie*. Houten: Bohn Stafleu van Loghum.

Copeland, W. E., Keeler, G., Angold, A., & Costello, E. J. (2007). Traumatic events and posttraumatic stress in childhood. *Archives of General Psychiatry*, *64*(5), 577–584. https://doi.org/10.1016/S0084-3970(08)79296-X

Crocker, L. D., Jurick, S. M., Thomas, K. R., Keller, A. V., Sanderson-Cimino, M., Boyd, B., … Jak, A. J. (2018). Worse baseline executive functioning is associated with dropout and poorer response to trauma-focused treatment for veterans with PTSD and comorbid traumatic brain injury. *Behaviour Research and Therapy*, *108*, 68–77. https://doi.org/10.1016/j.brat.2018.07.004

Cukor, J., Wyka, K., Jayasinghe, N., & Difede, J. A. (2010). The nature and course of subthreshold PTSD. *Journal of Anxiety Disorders*, *24*(8), 918–923. https://doi.org/10.1016/j.janxdis.2010.06.017

D'Alcante, C. C., Diniz, J. B., Fossaluza, V., Batistuzzo, M. C., Lopes, A. C., Shavitt, R. G., … Hoexter, M. Q. (2012). Neuropsychological predictors of response to randomized treatment in obsessive-compulsive disorder. *Progress in Neuro-Psychopharmacology and Biological Psychiatry*, *39*(2), 310–317. https://doi.org/10.1016/j.pnpbp.2012.07.002

De Jongh, A., & Ten Broeke, E. (2018). *Handboek EMDR: Een geprotocolleerde behandelmethode voor de gevolgen van psychotrauma* (7th ed.). Pearson Benelux BV.

De Vries, M., & Geurts, H. M. (2014). Beyond individual differences: Are working memory and inhibition informative specifiers within ASD? *Journal of Neural Transmission*, *121*(9), 1183–1198. https://doi.org/10.1007/s00702-014-1225-z

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Diehle, J., de Roos, C., Boer, F., & Lindauer, R. J. L. (2013). A cross-cultural validation of the Clinician Administered PTSD Scale for Children and Adolescents in a Dutch population. *European Journal of Psychotraumatology*, *4*, 1–9. https://doi.org/10.3402/ejpt.v4i0.19896

Diehle, J., Opmeer, B. C., Boer, F., Mannarino, A. P., & Lindauer, R. J. L. (2015). Trauma-focused cognitive behavioral therapy or eye movement desensitization and reprocessing: what works in children with posttraumatic stress symptoms? A randomized controlled trial. *European Child & Adolescent Psychiatry*, *24*(2), 227–236. https://doi.org/10.1007/s00787-014-0572-5

Dovis, S., Maric, M., Prins, P. J., & Van der Oord, S. (2019). Does executive function capacity moderate the outcome of executive function training in children with ADHD?. *Attention Deficit and Hyperactivity Disorders, 11(4),* 445-460. https://doi.org/10.1007/s12402-019-00308-5

Falconer, E., Allen, A., Felmingham, K. L., Williams, L. M., & Bryant, R. A. (2013). Inhibitory neural activity predicts response to cognitive-behavioral therapy for posttraumatic stress disorder. *Journal of Clinical Psychiatry*, *74*(9), 895–901. https://doi.org/10.4088/JCP.12m08020

Goenjian, A. K., Walling, D., Steinberg, A. M., Karayan, I., Najarian, L. M., & Pynoos, R. (2005). A prospective study of posttraumatic stress and depressive reactions among treated and untreated adolescents 5 years after a catastrophic disaster. *American Journal of Psychiatry*, *162*(12), 2302–2308. https://doi.org/10.1176/appi.ajp.162.12.2302

Goethals, E. R., de Wit, M., Van Broeck, N., Lemiere, J., Van Liefferinge, D., Böhler, S., … Luyckx, K. (2018). Child and parental executive functioning in type 1 diabetes: Their unique and interactive role toward treatment adherence and glycemic control. *Pediatric Diabetes*, *19*(3), 520–526. https://doi.org/10.1111/pedi.12552

Groves, S. J., Douglas, K. M., & Porter, R. J. (2018). A systematic review of cognitive predictors of treatment outcome in major depression. *Frontiers in Psychiatry, 9,* 382. https://doi.org/10.3389/fpsyt.2018.00382

Huizinga, M., & Smidts, D. (2009). *BRIEF: Vragenlijst executieve functies voor 5-18 jarigen*. Amsterdam: Hogrefe Uitgevers.

Hybel, K. A., Mortensen, E. L., Lambek, R., Højgaard, D. R. M. A., & Thomsen, P. H. (2017). Executive function predicts cognitive-behavioral therapy response in childhood obsessive-compulsive disorder. *Behaviour Research and Therapy*, *99*, 11–18. https://doi.org/10.1016/j.brat.2017.08.009

IBM Corp. (2017). IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.

ISTSS. (2018). Posttraumatic Stress Disorder Prevention and Treatment Guidelines Methodology and Recommendations, 1–29.

Jaffe, A. E., DiLillo, D., Gratz, K. L., & Messman-Moore, T. L. (2019). Risk for Revictimization Following Interpersonal and Noninterpersonal Trauma: Clarifying the Role of Posttraumatic Stress Symptoms and Trauma-Related Cognitions. *Journal of Traumatic Stress*, *32*(1), 42–55. https://doi.org/10.1002/jts.22372

JASP team (2021). *JASP version 0.16.*

Kanagaratnam, P., & Asbjørnsen, A. E. (2007). Executive deficits in chronic PTSD related to political violence. *Journal of Anxiety Disorders*, *21*(4), 510–525. https://doi.org/10.1016/j.janxdis.2006.06.008

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). International affective picture system (IAPS): Technical manual and affective ratings. *NIMH Center for the Study of Emotion and Attention*, 39–58.

Larsen, S. E., Bellmore, A., Gobin, R. L., Holens, P., Lawrence, K. A., & Pacella-LaBarbara, M. L. (2019). An initial review of residual symptoms after empirically supported trauma-focused cognitive behavioral psychological treatment. *Journal of Anxiety Disorders*, *63*(March 2018), 26–35. https://doi.org/10.1016/j.janxdis.2019.01.008

Lewey, J. H., Smith, C. L., Burcham, B., Saunders, N. L., Elfallal, D., & O'Toole, S. K. (2018). Comparing the Effectiveness of EMDR and TF-CBT for Children and Adolescents: a Meta-Analysis. *Journal of Child and Adolescent Trauma*, *11*(4), 457–472. https://doi.org/10.1007/s40653-018-0212-1

Logan, G. D., Schachar, R. J., & Tannock, R. (1997). Impulsivity and inhibitory control. *Psychological Science*, *8*, 60–64.

Lundqvist, D., Flykt, A., & Öhman, A. (1998). Karoslinska Directed Emotional Faces. *Cognition and Emotion*.

MacLeod, C. M. (1991). Half a century of research on the Stroop effect: An integrative review. *Psychological Bulletin*, *109*(2), 163–203. https://doi.org/10.1037//0033-2909.109.2.163

Magalhães, S., Carneiro, L., Limpo, T., & Filipe, M. (2020). Executive functions predict literacy and mathematics achievements: The unique contribution of cognitive flexibility in grades 2, 4, and 6. *Child Neuropsychology*, *26*(7), 934–952. https://doi.org/10.1080/09297049.2020.1740188

Meijel, V. E., Ensink, J. B. ., Verlinden, E., & Lindauer, R. J. L. (2019). *CAPS-CA DSM-5 Klinisch interview voor PTSS bij kinderen en adolescenten*. Houten, The Netherlands: Bohn Stafleu van Loghum.

Miyake, A., Friedman, N. P., Emerson, M. J., Witzki, A. H., Howerter, A., & Wager, T. D. (2000b). The unity and diversity of executive functions and their contributions to complex "frontal lobe" tasks: A latent variable analysis. *Cognitive Psychology*, *41*(1), 49–100. https://doi.org/10.1006/cogp.1999.0734

Morein-Zamir, S., Hommersen, P., Johnston, C., & Kingstone, A. (2008). Novel measures of response performance and inhibition in children with ADHD. *Journal of Abnormal Child Psychology*, *36*(8), 1199–1210. https://doi.org/10.1007/s10802-008-9243-7

Morina, N., Koerssen, R., & Pollet, T. V. (2016). Interventions for children and adolescents with posttraumatic stress disorder: A meta-analysis of comparative outcome studies. *Clinical Psychology Review*, *47*, 41–54. https://doi.org/10.1016/j.cpr.2016.05.006

Nader, K. O., Kriegler, J. A., Blake, D. D., & Pynoos, R. S. (1996). *Clinical Administered PTSD Scale, Child and Adolescent Version (CAPS-CA)*. White River Junction, VT: National Center for PTSD.

NICE. (2018). NICE guidelines Posttraumatic Stress Disorder. *Encyclopedia of Autism Spectrum Disorders*, (December 2018), 4642–4642. https://doi.org/10.1007/978-3-319-91280-6_301632

Oei, N. Y. L., Tollenaar, M. S., Spinhoven, P., & Elzinga, B. M. (2009). Hydrocortisone reduces emotional distracter interference in working memory. *Psychoneuroendocrinology*, *34*(9), 1284–1293. https://doi.org/10.1016/j.psyneuen.2009.03.015

Op den Kelder, R., Ensink, J. B. M., Overbeek, G., Maric, M., & Lindauer, R. J. L. (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. https://doi.org/10.1007/s11136-017-1535-3

Op den Kelder, R., Van den Akker, A. L., Geurts, H. M., Lindauer, R. J. L., & Overbeek, G. (2018). Executive functions in trauma-exposed youth: A meta-analysis. *European Journal of Psychotraumatology*, *9*(1), 1450595. https://doi.org/10.1080/20008198.2018.1450595

Ormhaug, S. M., & Jensen, T. K. (2018). Investigating treatment characteristics and first-session relationship variables as predictors of dropout in the treatment of traumatized youth. *Psychotherapy Research*, *28*(2), 235–249. https://doi.org/10.1080/10503307.2016.1189617

Pacella, M. L., Hruska, B., & Delahanty, D. L. (2013). The physical health consequences of PTSD and PTSD symptoms: A meta-analytic review. *Journal of Anxiety Disorders*, *27*(1), 33–46. https://doi.org/10.1016/j.janxdis.2012.08.004

Pagotto, L. F., Mendlowicz, M. V., Coutinho, E. S. F., Figueira, I., Luz, M. P., Araujo, A. X., & Berger, W. (2015). The impact of posttraumatic symptoms and comorbid mental disorders on the health-related quality of life in treatment-seeking PTSD patients. *Comprehensive Psychiatry*, *58*, 68–73. https://doi.org/10.1016/j.comppsych.2015.01.002

Rogers, R. D., & Monsell, S. (1995). Costs of a predictable switch between simple cognitive tasks. *Jounral of Experimental Psychology*, *124*(2), 297–231. https://doi.org/10.1037/0894-4105.20.6.675

Ropovik, I. (2014). Do executive functions predict the ability to learn problem-solving principles? *Intelligence*, *44*(1), 64–74. https://doi.org/10.1016/j.intell.2014.03.002

Sternberg, S. (1966). High-speed scanning in human memory. *Science*, *153*(3736), 652–654.

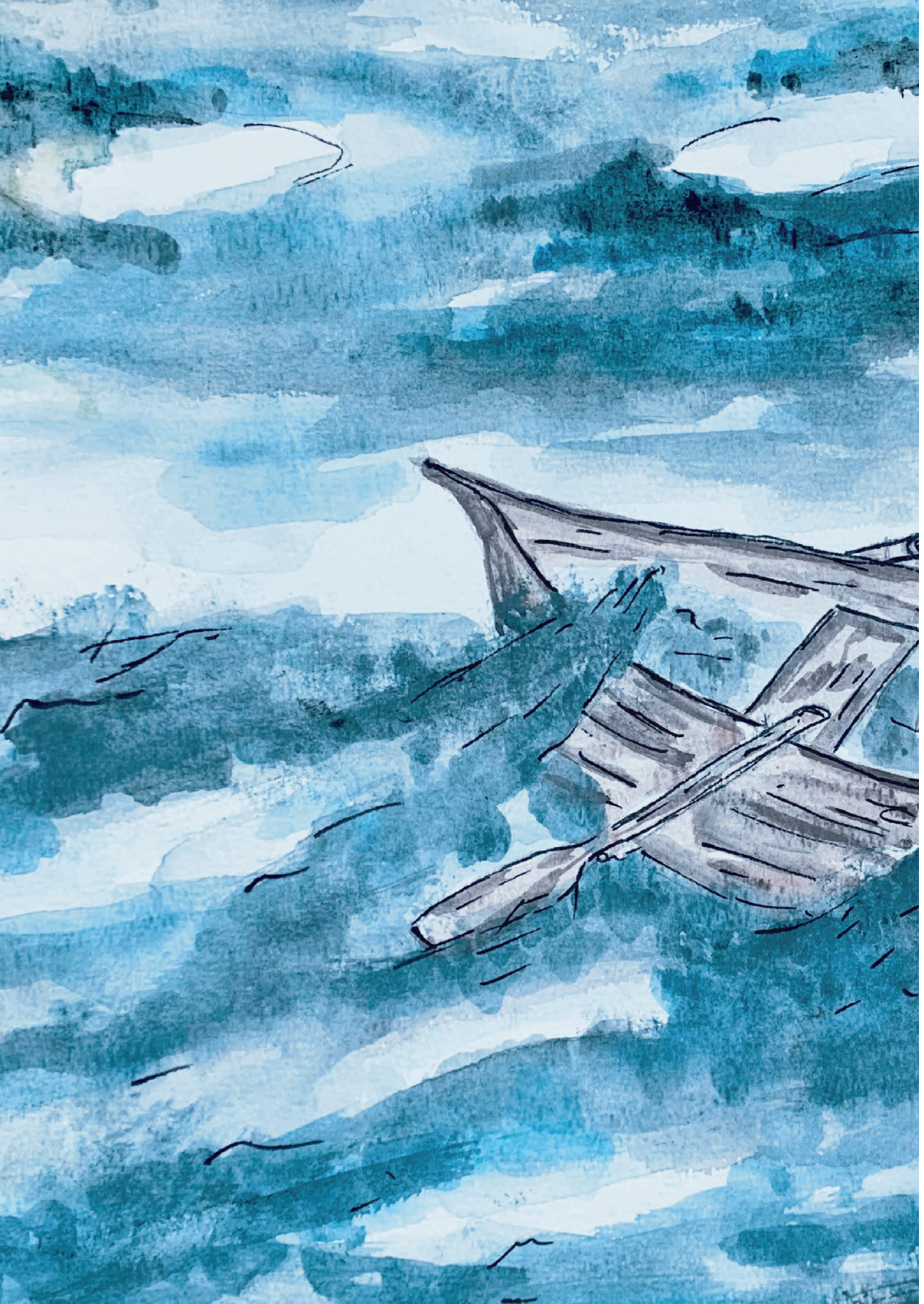
Strauss, G. P., Allen, D. N., Jorgensen, M. L., & Cramer, S. L. (2005). Test-retest reliability of standard and emotional Stroop tasks: An investigation of color-word and picture-word versions. *Assessment*, *12*(3), 330–337. https://doi.org/10.1177/1073191105276375

Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *18*, 643–662.

Wamser-Nanney, R. (2019). Risk factors for attrition from pediatric trauma-focused treatment. *Child Maltreatment*. https://doi.org/10.1177/1077559519874406

Yasinski, C., Hayes, A. M., Alpert, E., McCauley, T., Ready, C. B., Webb, C., & Deblinger, E. (2018). Treatment processes and demographic variables as predictors of dropout from trauma-focused cognitive behavioral therapy (TF-CBT) for youth. *Behaviour Research and Therapy*, *107*, 10–18. https://doi.org/10.1016/j.brat.2018.05.008

Zantvoord, J. B., Ensink, J. B. M., op den Kelder, R., Wessel, A. M. A., Lok, A., & Lindauer, R. J. L. (2019). Pretreatment cortisol predicts trauma-focused psychotherapy response in youth with (partial) posttraumatic stress disorder. *Psychoneuroendocrinology*, *109*, 104380. https://doi.org/10.1016/j.psyneuen.2019.104380



General Discussion

Aim of this dissertation

With the studies presented in this dissertation, we aimed to gain more knowledge about executive functioning of trauma-exposed children. Our first aim was to investigate whether trauma-exposed youth had lower levels of executive functioning and whether trauma-exposure precedes later executive functioning or the other way around. More knowledge about the relationship between executive functioning and trauma exposure, would generate an increased scientific and clinical understanding about children's development after exposure to traumatic events early in life. The second aim was to investigate the role of executive functioning in posttraumatic stress and its treatment. When problems in executive function are identified as possible consequences of trauma exposure or as a mediating factor of posttraumatic stress in children, this could be related to decreases in the effectiveness of evidence-based trauma therapies. Children could be less able to practice, integrate and generalize the learned skills and strategies learned in trauma treatment. The findings of this dissertation have implications for the improvement of mental health care for trauma-exposed children.

Summary of main findings

Chapter 2 presented a multi-level meta-analysis that investigated whether trauma-exposed youth (aged 2-25) showed lower levels of executive functioning. We found small to medium effect sizes for working memory (d = −0.49), inhibition (d = −0.46), and cognitive flexibility (d = −0.44). Our moderator analyses indicated that violence-exposed/abused and foster care/adopted youth showed more problems in inhibition, and foster care/adopted youth showed more problems in cognitive flexibility when compared with youth exposed to a single traumatic event. We found that when studies used working memory measurements of low quality the effect size was significantly stronger compared to studies that used measurements with a high quality.

Chapter 3 featured a study that used structural equation modeling to examine bidirectional longitudinal associations of trauma exposure and executive functioning in a community sample of 1006 children. Executive functioning was measured with both items of the BRIEF and neuropsychological tasks. Our results indicated that early life trauma exposure has a long-term impact on later executive functioning and not the other way around. Additionally, early trauma exposure also predicted subsequent trauma exposure between ages 6 and 12. We did not find evidence for a moderating effect of maternal parenting behavior.

Chapter 4 examined the possible mediating role of executive functioning in the link between trauma exposure and PTSD of 119 children aged 8-18 years old. The sample was divided into three groups: (1) a group that reported no exposure to traumatic event, (2) a single trauma group, and (3) a complex trauma group. Executive functioning was measured using Global Executive Composite of the BRIEF. Our results suggested that executive functioning partially mediates the development of PTSD for youth with complex trauma, but not for youth that was exposed to a single traumatic event. Our findings showed that youth exposed to complex trauma had more deficits in executive functioning compared to youth in the single trauma and control groups.

Chapter 5 examined whether executive functioning predicts trauma-treatment dropout and responsiveness in a sample of 94 treatment-seeking trauma-exposed children from 8-18 years-old using logistic and linear regression analyses. Executive functioning was measured with both the BRIEF and neuropsychological tasks. We did not find any significant predictive associations between executive functioning and treatment completion or responsiveness.

Key conclusions on executive functioning of trauma-exposed youth

We can draw some main conclusions from our findings. First, it is clear that trauma-exposed youth are at risk of having executive functioning problems. Findings from our meta-analysis indicate that trauma-exposed youth score lower on working memory, inhibition and cognitive flexibility than their peers that have not been exposed to traumatic events. These problems are not limited to a specific function, as there were few differences between the different executive functions under investigation. Thus, although there had been some mixed findings with regards to executive functions in trauma-exposed youth, it is clear from our findings that it is important to take into account possible executive functioning problems when treating trauma-exposed youth. Although the effect sizes with regards to type of executive functioning were quite similar overall, we did observe some differences with regards to the type of trauma. Violence-exposed/abused adopted/foster care youth show lower levels of inhibition and foster care/adopted youth show lower levels of cognitive flexibility than children who experienced a single traumatic event.

Although theories have posited that trauma may lead to problems with executive functioning through impacting the developing neurobiology of the child (De Bellis & Van Dillen, 2005; Gunnar & Quevedo, 2007), it could also be that children who are trauma-exposed are already characterized by lower levels of executive functioning - with

executive functioning problems being a risk factor for trauma exposure. This is because children with lower levels of executive functioning show more behavioral problems (Quistberg & Mueller, 2020; Schoemaker et al., 2013) and are at increased risk of peer victimization (Kloosterman, Kelley, Parker, & Craig, 2014; Ter-Stepanian et al., 2019). Results of this dissertation indicate that lower levels of executive functioning do not precede exposure to a traumatic event, but rather that lower executive functioning is predicted over time by earlier trauma exposure. This effect was visible even across a seven-year timespan, indicating that early trauma exposure may have long lasting impact. Although our findings are in line with theories indicating that lower levels of executive functioning are caused by trauma exposure, rather than the other way around, it should be noted that they are still correlational and can therefore not provide evidence of causation. Relatedly, they do not shed light on what the specific mechanisms explaining the association are. For instance, hypervigilance may impair attentional processes (Sharp, Miller, & Heller, 2015), and is associated with longer-term changes in amygdala reactivity to novel stimuli (Nitschke, Heller, Palmieri, & Miller, 1999). Anxious apprehension has been associated with activation in neural structures that are also connected to verbal working memory (Nitschke et al., 1999). Prolonged changes in activation may ultimately impact the structure of the developing brain in trauma-exposed individuals (du Plessis, Smeekens, Cillessen, Whittle, & Güroglu, 2019). More research is necessary to examine how these, and perhaps other processes may play a role in childhood and adolescence, and whether these changes will be reversed when these symptoms are treated. A neuro-imaging study of a part of our sample in Chapter 5, found no structural MRI-changes in trauma treatment responders, suggesting that structural brain abnormalities associated with PTSD do not directly normalize after successful treatment (Zantvoord et al., 2021). However, it seems important to intervene as early as possible to decrease the likelihood of long-lasting impairment. Our results indicate that trauma exposure often starts early and predicts continued trauma exposure, underscore this fact.

For youth with complex trauma, executive functioning problems partly explained their levels of posttraumatic stress symptoms, whereas for youth who had experienced single trauma it did not. Additionally, children exposed to single trauma had lower levels of posttraumatic stress and higher levels of executive functioning (at the same level as the control group). Although treatment thus seems vital, executive functionating problems could be a complicating factor in trauma treatment as children need to be able to focus their attention on treatment and to integrate new cognitive and behavioral coping strategies. Thus, problems in executive functioning could increase the risk for trauma

treatment dropout or increase the risk that children are less responsive to it. Although preliminary due to a relatively small sample size, our results seem reassuring in that they did not indicate that youth with lower levels of executive functioning were more likely to dropout from treatment or that they were less responsive to treatment. This may be due to the fact that for youngsters, caregivers may be especially important in determining whether they show up for treatment or not. Parents who do not have executive functioning problems themselves might be better at supporting their children in completing treatment. Additionally, therapists could compensate executive functioning problems of children and their parents if they also have executive functioning problems.

Strengths, limitations and future directions

This dissertation has several strengths. First, in this dissertation we aimed to further disentangle the link between trauma exposure and executive functioning by examining various levels and aspects of executive functioning. We used multiple sources of information to measure executive functioning: parent report, self-report, and neuropsychological tasks. Although this complicates interpretation of results, it is an important strength of this dissertation as it allowed us to examine whether problems that are reported by caregivers or youth themselves are also visible in performance on tasks measuring executive functioning. Second, in this dissertation we aimed to further disentangle the link between trauma exposure and executive functioning by examining various levels and aspects of executive functioning. This enabled us to investigate executive functioning in trauma-exposed youth at both a general and specific levels. Third, although trauma exposure was assessed retrospectively, by using the Life Events Checklist conducted by trained developmental psychologists, we improved trauma exposure assessment as much as possible. Fourth, we investigated associations between trauma exposure and executive functioning both in community samples and in a clinical sample of youth with PTSD. This allowed us to first focus on the broader impact of trauma exposure on executive functioning and later look more in depth at the role of executive functioning in traumatized youth with PTSD and trauma treatment.

Besides the strengths of this dissertation, there are also some limitations. First, although we measured trauma exposure in a valid and reliable way and we differentiated between various trauma types in Chapter 2 and 4, we did not focus on more specific characteristics of trauma exposure. Trauma exposure is a broad construct overall, including events ranging from a traffic accident to years of sexual abuse. Not all types of traumas may be equally related to (different aspects of) executive functioning. Characteristics of traumatic events in

terms of specific type, onset, duration, interpersonal/non-interpersonal, victim-perpetrator relationship may be important to investigate further. Additionally, although we looked at a linear moderation effect of age in chapter 2, we did not investigate whether there could be a specific critical time frame in which trauma exposure has the largest effect on executive functioning. Although most studies that examined timing of trauma exposure and problems in adulthood were cross-sectional and examined trauma exposure retrospectively, it is often found that trauma exposure in childhood leads to problems in executive functioning in adulthood (Gould et al., 2012; Majer, Nater, Lin, Capuron, & Reeves, 2010). Future research should incorporate the developmental phases of children when investigating the link between specific types and onset of trauma exposure and later executive functioning.

Another important issue in this dissertation is the measurement of executive functioning. The construct of executive functioning is the topic of continuous scientific discussion (Goldstein, Naglieri, Princiotta, & Otero 2014). There are two main points in these discussions: a) the definition of the construct executive functioning and b) the measurement of executive functioning. Across studies, many different definitions of executive functioning are used. For example, terms like executive control, self-control, and executive functioning are used to define the same construct (Goldstein, Naglieri, Princiotta, & Otero 2014). Executive functioning can be measured using both questionnaires and neuropsychological tasks. The most common questionnaire is the Behavior Rating Inventory for Executive Functioning (BRIEF). The BRIEF is often used in both research and clinical practice (Huizinga & Smidts, 2009). The BRIEF consists of items that measure executive functioning problems in daily life. It does not measure specific executive functions as such, but rather the daily behavior based on the level of these executive functions. This makes the BRIEF more ecologically valid than neuropsychological tasks. Another benefit from the BRIEF is the possibility to use multi-informant information (child, parent, teacher) in assessing the child's level of executive functioning. A disadvantage of the BRIEF, however, is that the measurement can be confounded with other factors. For example, questions such as "I get upset easily" or "I talk too loudly" are broadly phrased and could also be related to hyperactivity or hypervigilance or due to a lack of general motivation rather than executive functioning capacities. Of course, self- and parent-report questionnaires are subject to bias. Parents might be worried about their trauma-exposed children and see problems in all aspects of functioning as a result of this worry. Or caregivers may themselves be traumatized or overwhelmed which may impact how severe they judge their children's problems.

Neuropsychological tasks are not subject to this bias and come closer to purely measuring basic executive functioning capacity. However, with neuropsychological tasks there is a

much wider variety of instruments available. In general, executive functions are measured with approximately 35 different tasks and three times as many outcome measures are derived from these tasks. These tasks and the different measures derived from them, vary greatly in their purity of measuring a specific executive function and thus in the quality of the construct measurements. Outcome measures of an executive functioning task consist of the targeted executive function, the common executive functioning factor, non-executive functioning processes, and measurement error (Snyder, Miyake, & Hankin, 2015). For example, many tasks do not measure inhibition only, but also require some level of working memory or cognitive flexibility, attention and a common factor of executive functioning. It is essentially impossible to fully separately measure the different executive functions with neuropsychological tasks. Additionally, ecological validity of pressing keys on a keyboard for daily functioning of children may be limited. To deal with the problem of executive functioning measurement, we used measurement quality as a moderator in our meta-analyses. Actually, measurement quality reflected measurement purity more than quality itself. We found stronger associations between trauma exposure and working memory when instruments with a lower measurement purity were used. In this dissertation, we used high quality neuropsychological tasks in combination with the BRIEF (a lower measurement purity but a higher ecological validity) in Chapter 3 and 5. In Chapter 3 and 4 we focused on the overall level of executive functioning using the BRIEF while we focused on all subscales of the BRIEF in Chapter 5. Besides the task impurity problem in measuring executive functioning, discrepancies between tasks and questionnaire measurements are often found (Silver, 2014; Toplak, West, & Stanovich, 2013). Ideally, we would want to measure executive functioning in novel situations and daily life so that there is no learning effect of performing the same task multiple times. In that way, one can really measure the functioning needed for adaptation. However, most test situations are standardized to improve reliability and comparability across samples. A possible solution could be the use of more ecologically valid neuropsychological tasks such as the children's version of the Behavioral Assessment of Dysexecutive Syndrome (BADS-C) (Emslie, WIlson, Burden, Nimmo-Smith, & Wilson, 2003) in which children have to plan a route in the zoo or think of a tactic to find a lost key on a soccer field. These types of tasks are more adapted to create a novel situation. Another interesting development is the possibility to use virtual reality tasks to measure executive functioning in youth.

Considerations about the findings in this dissertation

In this dissertation, we focused specifically on the trauma—executive functioning link. However, based on our findings, we should not conclude that this is the only aspect

that needs attention in trauma-exposed youth as it is clear that trauma exposure affects multiple developmental domains, not only executive functioning. Previous research has shown that interpersonal trauma exposure also affects affective, behavioral, relational, somatic and identity development of children (e.g., D'Andrea, Ford, Stolbach, Spinazzola, & van der Kolk, 2012; van der Kolk, 2005). Moreover, trauma exposure never affects the child only. When children are exposed to traumatic events, many people around them are also, directly or indirectly, exposed to the same event. Using Bronfenbrenner's social ecology framework (Bronfenbrenner, 1979), systems at different levels of the child's ecology are affected or disrupted, and this is relevant for how the child reacts to trauma exposure. For example, when a child discloses sexual abuse by a grandfather, the immediate family is often in great distress, shock, anger and disbelief. Parents might react differently, which puts a strain on their relationship. Sometimes other people in the family or neighborhood do not believe the child, which causes hostility and disruption in the social network surrounding the child's family. Cultural norms and values about sexuality and incest could add to secrecy or shame, which make it more difficult to cope with the traumatic event and triggers. Because of absence and anger problems parents might lose their jobs, resulting in financial problems. In this dissertation, we gained insight in executive in trauma-exposed youth specifically by focusing on one aspect of this complex and dynamic system, but it is important to note that this is only a partial view on the development of trauma-exposed youth.

Clinical implications

Executive functions impact a great part of daily functioning as it is necessary for all goal-directed behaviors such as doing homework, awaiting turns, and learning (Diamond, 2013). Based on the findings of our dissertation – that trauma-exposure precedes lower levels of executive functioning – it becomes clear that it is important that clinicians become aware of this impact of trauma exposure on daily life functioning. Besides using this information in their assessment and treatment plan, the connection with other systems, such as the school and home environment is important. Although our findings did not indicate that overall parenting behavior influences the link between early trauma exposure and later executive functioning, caregivers may still play an important role in helping children to deal with the consequences of lower executive functioning in their daily life. Caregivers could do this for instance by helping children to adopt strategies such as taking a deep breath to help focus on a task, or by repeating/visualizing an instruction (Van der Donk, Tjeenk-Kalff, & Hiemstra-Beernink, 2015). Teachers may also play an important role here as executive functioning problems are likely to show up in the classroom (Kavanaugh et al.,

2019). Providing knowledge about the impact of trauma exposure on executive functioning could help teachers to not mis-interpret executive functioning deficits as attention or behavioral problems but see them in the scope of traumatization. This could help them to create a better and safer learning environment for trauma-exposed youth with executive functioning problems.

Executive functioning and trauma exposure as transdiagnostic factors

When our findings that trauma-exposed youth have lower levels of executive functioning are placed in the broader perspective of mental health care, they have some important implications. Previous research has shown that trauma-exposure is related to approximately 44.6% of childhood onset psychiatric disorders (Green et al., 2010) Additionally, 40-60% of individuals with PTSD are diagnosed with comorbid disorders such as depression, substance use disorder, anxiety disorder, eating disorder, and psychosis (Brady et al., 2000). At the same time, executive functioning have been indicated to be a transdiagnostic factor for these mental disorders (Bloemen et al., 2018; Martel et al., 2017). As executive functioning problems might appear similar in daily life and symptoms overlap between mental disorders, correct differential diagnosis is very complex. Especially when clinicians perform an inadequate trauma history assessment or when they don't assess it at all, they are at risk of missing a possible explanation of the child's complaints. It is possible that for children who present themselves with other mental disorders, traumatic experiences are an explanation for some of their executive functioning problems and psychiatric symptoms. When these children receive treatment that is not trauma-focused they are likely unrelieved from their complaints. This may have detrimental long-term effects, because persistent PTSD is associated with great impairments and puts children at greater risk for re-traumatization (Jaffe et al., 2019).

Training of executive functions in trauma-exposed youth

The findings in this dissertation showed that trauma-exposed youth have lower levels of executive functioning, that executive functioning partially mediates the relationship between chronic trauma-exposure and posttraumatic stress, and that executive functioning neither predicts treatment completion nor responsiveness. Although training of executive functioning could by some be considered a logical next step for improving the effectiveness of trauma treatment, our results do not directly indicate to start executive functioning trainings for trauma-exposed youth. At the start of this research project, we aimed to develop a pilot study of such an executive functioning training. However, we

decided to end this process. The effectiveness of training for executive functioning remains limited in a wide range of disorders, especially when isolated functions are trained (Kassai, Demotrovic, & Takacs, 2019). In these cases, most trainings reach near transfer effects on the trained components only. Trainings with both a compensatory component and a practice component are most effective in terms of far transfer (Kassai et al., 2019; Takacs & Kassai, 2019; Van der Donk et al., 2015). However, these trainings are very intensive and time-consuming. At this moment, we argue that larger-scale research efforts should be set up, to now first examine whether effective PTSD treatments actually result in a relief in executive functioning problems, before starting pilot studies examining the possible gains of an integrated trauma treatment and executive functioning training approach for both children and their parents/caregivers.

Final conclusions

The studies presented in this dissertation aimed to (1) examine the links between trauma exposure and executive functioning and (2) investigate whether executive functioning also influences the development of posttraumatic stress and treatment completion or responsiveness. The findings of this dissertation show that executive functioning is a complicating factor for trauma-exposed youth. After being exposed to a traumatic event, children experience negative consequences for their executive functioning and they are at increased risk for re-traumatization. This results in problems on various levels of daily functioning, which may last for a long time. The results of the studies in this dissertation also made clear that especially the impact of complex, as compared with single, trauma exposure on executive functioning is associated with more posttraumatic stress symptoms. Our results, finally, indicated that when youth have lower executive functioning this does not necessarily lead to a lower likelihood of treatment completion or less treatment responsiveness.

Based on the findings of this dissertation, two important recommendations can be made. First, it is important to identify trauma-exposed youth at a young age, as trauma exposure accumulates over time and has long term consequences for the level of executive functioning. Second, clinicians, caregivers and teachers need a better understanding of the impact of trauma exposure on executive functioning and its impact on daily life functioning both at school and at home.

References

Bloemen, A. J. P., Oldehinkel, A. J., Laceulle, O. M., Ormel, J., Rommelse, N. N. J., & Hartman, C. A. (2018). The association between executive functioning and psychopathology: general or specific?. *Psychological medicine, 48*(11), 1787-1794.

Boyer, B. E., Doove, L. L., Geurts, H. M., Prins, P. J., Van Mechelen, I., & Van der Oord, S. (2016). Qualitative treatment-subgroup interactions in a randomized clinical trial of treatments for adolescents with ADHD: Exploring what cognitive-behavioral treatment works for whom. *PloS one, 11(3),* https://doi.org/10.1371/journal.pone.0150698

Brady, K. T., Killeen, T. K., Brewerton, T., & Lucerini, S. (2000). Comorbidity of psychiatric disorders and posttraumatic stress disorder. *Journal of clinical psychiatry*, *61*, 22-32.

Bronfenbrenner, U. (1979). *The ecology of human development: Experiments by nature and design*. Harvard university press.

D'Andrea, W., Ford, J., Stolbach, B., Spinazzola, J., & van der Kolk, B. a. (2012). Understanding Interpersonal Trauma in Children: Why We Need a Developmentally Appropriate Trauma Diagnosis. *American Journal of Orthopsychiatry*, *82*(2), 187–200. https://doi.org/10.1111/j.1939-0025.2012.01154.x

De Bellis, M. D., & Van Dillen, T. (2005). Childhood post-traumatic stress disorder: An overview. *Child and Adolescent Psychiatric Clinics of North America*, *14*(4), 745–772. https://doi.org/10.1016/j.chc.2005.05.006

Diamond, A. (2013). Executive functions. *Annual Review of Psychology*, *64*, 135–168. https://doi.org/10.1146/annurev-psych-113011-143750

Du Plessis, M. R., Smeekens, S., Cillessen, A. H. N., Whittle, S., & Güroglu, B. (2019). Bullying the brain? Longitudinal links between childhood peer victimization, cortisol, and adolescent brain structure. *Frontiers in Psychology*, *9*, 1–9. https://doi.org/10.3389/fpsyg.2018.02706

Emslie, H., Wilson, F. C., Burden, V., Nimmo-Smith, I., & Wilson, B. A. (2003). *The Behavioural Assessment of the Dysexecutive Syndrome for Children (BADS-C)*. Bury St Edmunds: Thames Valley Test Company.

Goldstein, S., Naglieri, J.A., Princiotta, D.,& Otero, T.M. (2014). Introduction: A history of Executive Functioning as a theoretical and clinical construct. In: Handbook of Executive functioning (Eds. Goldstein, S., & Naglieri, J.A.). New York: Springer

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. https://doi.org/10.1016/j.jpsychires.2012.01.005

Green, J. G., McLaughlin, K. A., Berglund, P. A., Gruber, M. J., Sampson, N. A., Zaslavsky, A. M., & Kessler, R. C. (2010). Childhood adversities and adult psychiatric disorders in the national comorbidity survey replication I: Associations with first onset of DSM-IV disorders. *Archives of General Psychiatry*, *67*(2), 113–123. https://doi.org/10.1001/archgenpsychiatry.2009.186

Gunnar, M., & Quevedo, K. (2007). The Neurobiology of Stress and Development. *Annual Review of Psychology*, *58*(1), 145–173. https://doi.org/10.1146/annurev.psych.58.110405.085605

Jaffe, A. E., DiLillo, D., Gratz, K. L., & Messman-Moore, T. L. (2019). Risk for revictimization following interpersonal and noninterpersonal trauma: Clarifying the role of posttraumatic stress symptoms and trauma-related cognitions. *Journal of Traumatic Stress*, *32*(1), 42–55. https://doi.org/10.1002/jts.22372

Kassai, R., Futo, J., Demetrovics, Z., & Takacs, Z. K. (2019). A meta-analysis of the experimental evidence on the near-and far-transfer effects among children's executive function skills. *Psychological Bulletin*, *145*(2), 165.

Kavanaugh, B. C., Tuncer, O. F., & Wexler, B. E. (2019). Measuring and improving executive functioning in the classroom. *Journal of Cognitive Enhancement*, *3*(3), 271-280.

Kloosterman, P. H., Kelley, E. a., Parker, J. D. a, & Craig, W. M. (2014). Executive functioning as a predictor of peer victimization in adolescents with and without an Autism Spectrum Disorder. *Research in Autism Spectrum Disorders*, *8*(3), 244–254. https://doi.org/10.1016/j.rasd.2013.12.006

Majer, M., Nater, U. M., Lin, J. M. S., Capuron, L., & Reeves, W. C. (2010). Association of childhood trauma with cognitive function in healthy adults: A pilot study. *BMC Neurology*, *10*. https://doi.org/10.1186/1471-2377-10-61

Martel, M. M., Pan, P. M., Hoffmann, M. S., Gadelha, A., do Rosário, M. C., Mari, J. J., Manfro, G. G., Miguel, E. C., Paus, T., Bressan, R. A., Rohde, L. A., & Salum, G. A. (2017). A general psychopathology factor (P factor) in children: Structural model analysis and external validation through familial risk and child global executive function. *Journal of Abnormal Psychology, 126*(1), 137–148. https://doi.org/10.1037/abn0000205

Nitschke, J. B., Heller, W., Palmieri, P. A., & Miller, G. A. (1999). Contrasting patterns of brain activity in anxious apprehension and anxious arousal. *Psychophysiology*, *36*(5), 628–637. https://doi.org/10.1017/S0048577299972013

Quistberg, K. A., & Mueller, U. (2020). Prospective relations between kindergarteners' executive function skills and their externalizing and internalizing behaviors. *Clinical Neuropsychologist*, *34*(4), 845–862. https://doi.org/10.1080/13854046.2019.1591510

Schoemaker, K., Mulder, H., Deković, M., & Matthys, W. (2013). Executive functions in preschool children with externalizing behavior problems: A meta-analysis. *Journal of Abnormal Child Psychology*, *41*(3), 457–471. https://doi.org/10.1007/s10802-012-9684-x

Sharp, P. B., Miller, G. A., & Heller, W. (2015). Transdiagnostic dimensions of anxiety: Neural mechanisms, executive functions, and new directions. *International Journal of Psychophysiology*, *98*(2), 365–377. https://doi.org/10.1016/j.ijpsycho.2015.07.001

Silver, C. H. (2014). Sources of data about children's executive functioning: Review and commentary. *Child Neuropsychology*, *20*(1), 1–13. https://doi.org/10.1080/09297049.2012.727793

Snyder, H. R., Miyake, A., & Hankin, B. L. (2015). Advancing understanding of executive function impairments and psychopathology: Bridging the gap between clinical and cognitive approaches. *Frontiers in Psychology*, *6,* https://doi.org/10.3389/fpsyg.2015.00328

Takacs, Z. K., & Kassai, R. (2019). The efficacy of different interventions to foster children's executive function skills: A series of meta-analyses. *Psychological Bulletin, 145(7),* 653. https://psycnet.apa.org/doi/10.1037/bul0000180

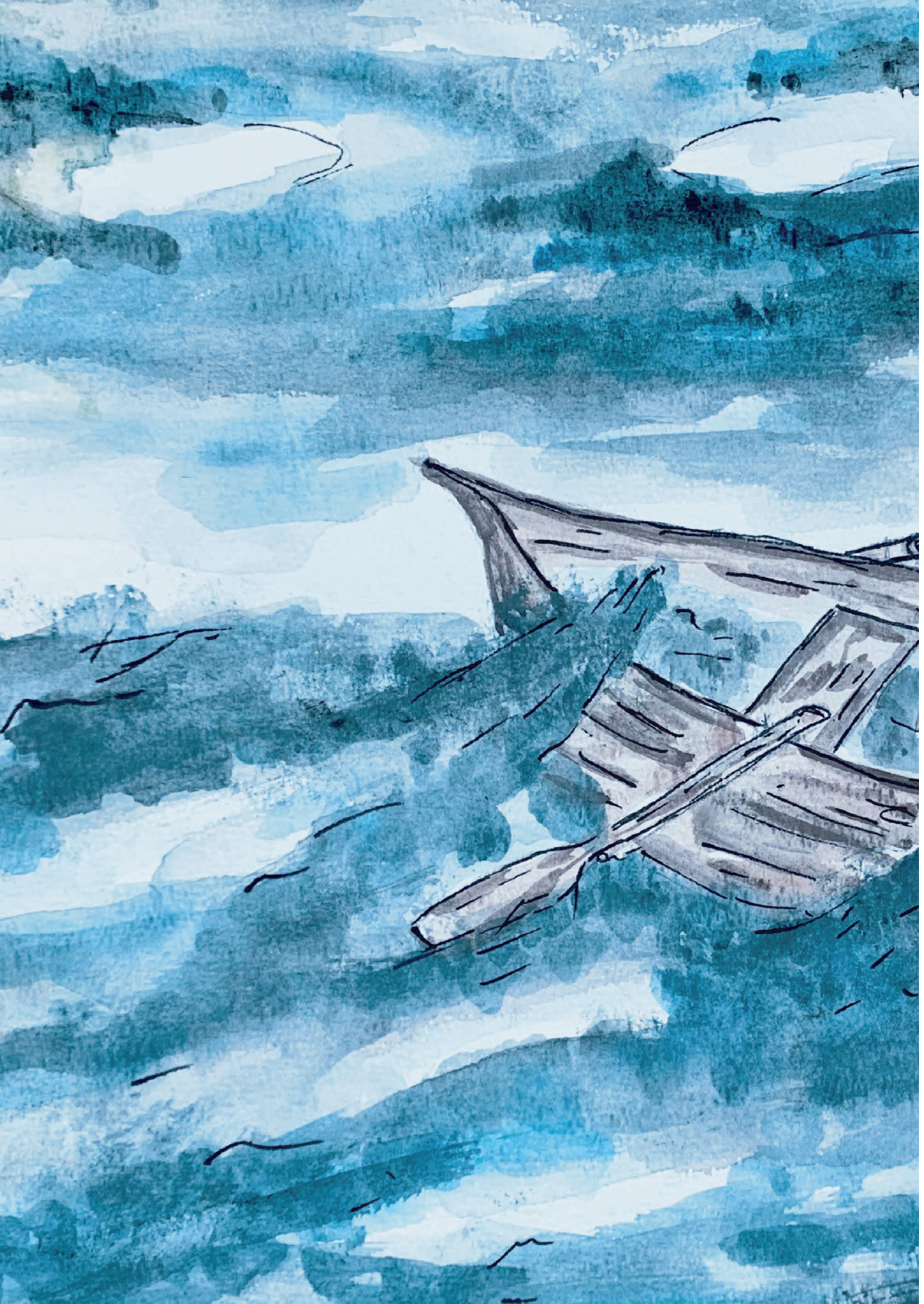
Ter-Stepanian, M., Martin-Storey, A., Bizier-Lacroix, R., Déry, M., Lemelin, J. P., & Temcheff, C. E. (2019). Trajectories of verbal and physical peer victimization among children with comorbid oppositional defiant problems, conduct problems and hyperactive-attention poroblems. *Child Psychiatry and Human Development*, *50*(6), 1037–1048. https://doi.org/10.1007/s10578-019-00903-7

Toplak, M. E., West, R. F., & Stanovich, K. E. (2013). Practitioner Review: Do performance-based measures and ratings of executive function assess the same construct? *Journal of Child Psychology and Psychiatry*, *54*(2), 131–143. https://doi.org/10.1111/jcpp.12001

Van der Donk, M., Tjeenk-Kalff, A., & Hiemstra-Brernink, A. (2015). *Beter Bij de Les: training in executieve functies*. Lannoo Campus.

Van der Kolk, B. A. (2005). Developmental trauma disorder: Towards a rational diagnosis for children with complex trauma histories. *Psychiatric Annals*, *35*(5), 401–409. https://doi.org/10.1038/472298a

Zantvoord, J. B., Zhutovsky, P., Ensink, J. B. M., Op den Kelder, R., van Wingen, G. A., & Lindauer, R. J. L. (2021). Trauma-focused psychotherapy response in youth with posttraumatic stress disorder is associated with changes in insula volume. *Journal of Psychiatric Research*, *132*, 207–214. https://doi.org/10.1016/j.jpsychires.2020.10.037



Summary (in Dutch)

Nederlandse Samenvatting

Achtergrond

Onderzoek laat zien dat ongeveer twee derde van de kinderen wordt blootgesteld aan traumatische gebeurtenissen in hun jeugd (Copeland et al., 2007; McLaughlin et al., 2013) Blootstelling aan een traumatische gebeurtenis kan een enorme impact hebben op het dagelijks leven van mensen. Zo kunnen mensen een posttraumatische stressstoornis (PTSS) ontwikkelen (o.a. Alisic, Jongmans, van Wesel, & Kleber, 2011) en laat onderzoek zien dat volwassenen die als jongeren een traumatische gebeurtenis hebben meegemaakt meer kans hebben op schooluitval, werkloosheid en armoede (Metzler, Merrick, Klevens, Ports, & Ford, 2017). Naast psychische en lichamelijke problemen, zijn er mogelijk ook problemen met het executief functioneren. Het eerste doel van dit proefschrift was te onderzoeken of getraumatiseerde kinderen lagere niveaus van executief functioneren hadden. Ook onderzochten we of blootstelling aan vroege traumatische gebeurtenissen voorafging aan later executief functioneren of dat vroeg executief functioneren geassocieerd werd met latere blootstelling aan traumatische gebeurtenissen. Het tweede doel was om te onderzoeken wat de rol was van executief functioneren in post-traumatische stress en traumabehandeling.

Bevindingen

Om een beter begrip te krijgen van de samenhang tussen blootstelling aan traumatische gebeurtenissen en het executief functioneren van jongeren opent dit proefschrift met een multi-level meta-analyse van 55 studies (**hoofdstuk 2**). Deze studies rapporteerden één of meerdere uitkomstmaten over de link tussen blootstelling aan traumatische gebeurtenissen en werkgeheugen, inhibitie of cognitieve flexibiliteit bij jongeren tussen de 2 en 25 jaar oud. Ook moderatie-analyses werden uitgevoerd om te onderzoeken hoe specifieke kenmeren van de studies, participanten en meetinstrumenten deze link beïnvloedden. We vonden kleine tot gemiddelde effectgroottes voor werkgeheugen (d = -0.49), inhibitie (d = -0.46) en cognitieve flexibiliteit (d = -0.44). Uit de moderatie-analyses bleek dat - in vergelijking met jongeren die eenmalig trauma hadden meegemaakt - jongeren die blootgesteld waren aan geweld of mishandeling meer problemen lieten zien in zowel inhibitie als cognitieve flexibiliteit en dat geadopteerde jongeren of pleegkinderen meer problemen lieten zien in inhibitie. Een andere belangrijke bevinding van de moderatie-analyse was dat bij studies met een lage kwaliteit van de meetinstrumenten het verband tussen trauma blootstelling en werkgeheugen sterker was dan wanneer er een meetinstrument van hoge kwaliteit gebruikt was.

Hoewel de meeste onderzoeken zich vanuit een neurobiologisch theoretisch kader richten op de impact van blootstelling aan trauma op executive functioneren, is het ook mogelijk

dat problemen in het executive functioneren de kans voor kinderen vergroten om te worden blootgesteld aan één of meerdere traumatische gebeurtenissen. In **hoofdstuk 3** hebben we daarom middels *structural equation modeling* gekeken naar de bidirectionele en longitudinale associaties tussen traumatische gebeurtenissen en executief functioneren in een community steekproef van 1006 kinderen in de leeftijd tussen 5 en 12 jaar. Executieve functies werden gemeten met zowel de BRIEF als neuropsychologische taken. De resultaten gaven aan dat trauma op 5-jarige leeftijd samenhing met executief functioneren op 12-jarige leeftijd, maar dat executief functioneren op 5-jarige leeftijd niet samenhing met traumatische gebeurtenissen tussen het 6e en 12e jaar. Daarnaast vonden we dat vroege blootstelling aan traumatische gebeurtenissen latere blootstelling aan trauma voorspelde. We vonden geen aanwijzingen dat opvoedgedrag van de moeder de relatie tussen trauma en executief functioneren beïnvloedde.

Vervolgens onderzochten we in **hoofdstuk 4** of executief functioneren de link tussen blootstelling aan trauma en posttraumatische stressklachten medieert. We onderzochten dit in een sample van 119 kinderen van 8 tot 18 jaar oud. De steekproef werd verdeeld in drie groepen: (1) een groep kinderen die geen blootstelling aan trauma rapporteerde, (2) een groep kinderen die één traumatische gebeurtenis had meegemaakt en (3) een groep kinderen die complex trauma had meegemaakt. Uit onze resultaten bleek dat jongeren die blootgesteld waren aan complex trauma meer problemen in executief functioneren rapporteerden dan jongeren die enkelvoudig trauma of geen trauma hadden meegemaakt en dat deze problemen de associatie tussen het meemaken van complex trauma en posttraumatische stressklachten gedeeltelijk medieerden.

In hoofdstuk 5 keken we of executief functioneren bij de start van een behandeling geassocieerd was met het voltooien van en de mate van respons op de traumabehandeling. We onderzochten dit in een sample van 94 getraumatiseerde kinderen (8-18 jaar oud) die behandeling zochten voor de nare gebeurtenissen die zij hadden meegemaakt. Executief functioneren werd gemeten met de BRIEF en neuropsychologische taken. De resultaten waren ondanks de kleine steekproef enigszins geruststellend in de zin dat ze niet lieten zien dat jongeren met lagere niveaus van executief functioneren eerder stopten met traumabehandeling of minder responsief waren voor de behandeling.

Toekomstig onderzoek

Een traumatische gebeurtenis is een breed concept, waar zowel verkeersongelukken als jarenlang seksueel misbruik onder vallen. Niet alle typen traumatische gebeurtenissen lijken even sterk gerelateerd te zijn aan executief functioneren. Daarom is het interessant

voor vervolgonderzoek om te kijken naar verschillende typen trauma's, startleeftijden, duur, frequentie en dader-slachtofferrelaties. Hoewel we in hoofdstuk 2 wel hebben gekeken naar een lineair moderatie-effect van leeftijd, hebben we niet onderzocht of er een specifiek kritisch tijdskader is waarin blootstelling aan trauma het grootste negatieve effect heeft op het executief functioneren. Daarom zou toekomstig onderzoek de ontwikkelingsfasen van kinderen moeten meenemen in hun waarbij ook aandacht besteed wordt aan specifieke traumatische gebeurtenissen.

Het meten van executief functioneren is een complexe taak. Vragenlijsten zijn gevoeliger voor bias terwijl het bij neuropsychologische taken moeilijk is om een "pure" executieve functie te meten. Executief functioneren zouden we idealiter willen meten in nieuwe situaties in het dagelijks leven zodat er geen leereffect optreedt zoals bij het herhaaldelijk uitvoeren van een taak. Dit is echter in de meeste testsituaties niet mogelijk omdat de testen gestandaardiseerd zijn om de betrouwbaarheid en vergelijkingen tussen steekproeven te verhogen. Een mogelijke oplossing zou kunnen zijn om meer ecologisch valide neuropsychologische taken te gebruiken zoals de Behavioral Assessment of Dysexecutive Syndrome (BADS-S) (Emslie, Wilson, Burden, Nimmo-Smith, & Wilson, 2003). Dit type taken bootst meer een nieuwe situatie na. Daarnaast zijn er ook recente ontwikkelingen waarbij *virtual reality* gebruikt wordt om executief functioneren in jongeren te meten.

Implicaties voor de praktijk

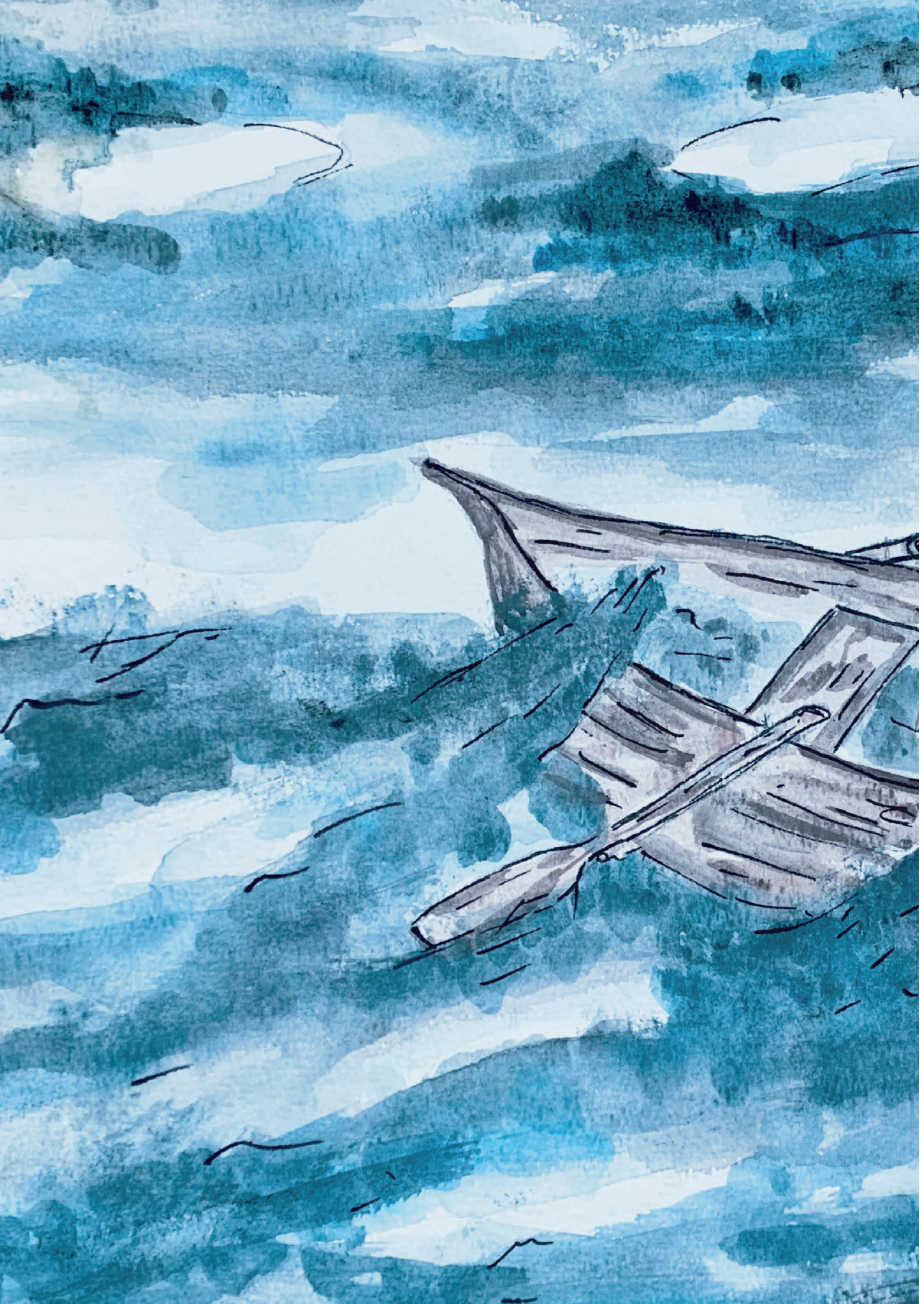
Executieve functies spelen een belangrijke rol in ons dagelijks leven, omdat deze functies noodzakelijk zijn voor doelgericht gedrag zoals huiswerk, leren, plannen en op onze beurt wachten. Gebaseerd op de bevindingen in deze dissertatie – namelijk dat blootstelling aan traumatische gebeurtenissen invloed heeft op de mate van executief functioneren – wordt het duidelijk dat het belangrijk is dat clinici zich hiervan bewust zijn. Zeker als dit in breder perspectief wordt gezet, namelijk dat 44.6% van de gevallen waarbij een psychiatrische stoornis start in de kindertijd er sprake is van blootstelling aan traumatische gebeurtenissen (Green et al, 2010). Daarnaast wordt zelfs 40 tot 60% van de mensen met PTSD ook gediagnosticeerd met een andere stoornis zoals depressie, angststoornissen, eetstoornissen of psychose (Brady et al., 2000). Tegelijkertijd lijkt executief functioneren een transdiagnostische factor te zijn in mentale stoornissen (Bloemen et al., 2018; Martel et al., 2017). Aangezien problemen in executief functioneren in het dagelijks leven kunnen lijken op symptomen van deze stoornissen kan het erg complex zijn om een correcte diagnose te stellen. Het risico op een incorrecte diagnose of beperkt beschrijvend beeld

wordt daardoor groter als de traumageschiedenis niet adequaat wordt uitgevraagd. Als kinderen met mentale problemen daardoor geen traumagerichte therapie aangeboden wordt, kan dit vervelende gevolgen hebben op de lange termijn, aangezien niet behandelde traumaklachten kunnen leiden tot langdurige PTSS met alle beperkende gevolgen.

Conclusie

De bevindingen van deze dissertatie laten zien dat executive functies een complicerende factor zijn in het leven van kinderen die traumatische gebeurtenissen hebben meegemaakt. Na het meemaken van een traumatische gebeurtenis hebben kinderen vaker lagere niveaus van executief functioneren en lopen ze meer risico op herhaalde blootstelling aan traumatische gebeurtenissen. Onze bevindingen laten ook zien dat specifiek voor complex getraumatiseerde jongeren, executive functies geassocieerd zijn met meer posttraumatische stressklachten. Als laatste lieten onze bevindingen zien dat een lager executief functioneren niet noodzakelijkerwijs leidt tot een lagere kans op het voltooien van de behandeling of de effectiviteit (in termen van PTSS klachten) van de traumabehandeling.

De belangrijkste aanbevelingen op basis van dit onderzoek zijn: (1) het is belangrijk om getraumatiseerde jongeren zo vroeg mogelijk te identificeren aangezien blootstelling aan traumatische gebeurtenissen consequenties heeft voor de mate van executief functioneren en (2) behandelaren, opvoeders en docenten hebben meer kennis nodig over de impact van trauma op het niveau van executief functioneren en de daarbij passende problemen in het dagelijks functioneren.



APPENDICES

Appendices chapter 2

Appendix 2.1

Table 2.1.A. Search strategy for the Embase database.

1. Aircraft accident/ or destruction/ or falling/ or structure collapse/ or traffic accident/ or exp victim/ or fire/ or explosion/ or mass disaster/ or natural

disaster/ or hurricane/ or tornado/ or threat/ or assault/ or battering/ or child abuse/ or family violence/ or exp partner violence/ or battered

woman/ or ethnic conflict/ or genocide/ or homicide/ or human trafficking/ or infanticide/ or physical violence/ or torture/ or sexual aggression/ or

exp female genital mutilation/ or sex trafficking/ or sexual coercion/ or sexual exploitation/ or exp sexual abuse/ or exp rape/ or exp sexual abuse/

or exp sexual harassment/ or exp child abuse/ or emotional abuse/ or physical abuse/ or war crime/ or war/ or kidnapping/ or abduction/ or

hostage/ or stalking/ or detention/ or suicide/ or suicide attempt/ or exp child death/ or early life stress/ or orphanage/ or foster care/ or

earthquake/ or incest/

2. (psychiatr* or psychol* or neurocogn* or cognit* or neuropsych* or psycho or psychosocial).ab,jx,kw,ti.

3. 1 and 2

4. 2 and (mass fatalit* or catastrophe or disaster? or accident? or aircraft crash or destruction or annihilation or falling or fall? or collapse or

automobile collision or flood* or inundation or hurricane* or tornado* or cyclone* or typhoon* or twister or earthquake* or tsunami* or fire or

wildfire* or blast* or threat or harassment or assault or battering or ethnic conflict or racial conflict or genocide or ethnic cleansing or ethnocide or

homicide or assassination or murder or trafficking or infanticide or torture or sexual aggression or female genital mutilation or circumcised wom?n

or female circumcision or female genital circumcision or female genital cutting or FGM or ritual female genital surgery or sexual coercion or sexual

exploitation or forced prostitution or rape or sexual abuse or molestation or sex abuse? or frotteurism or child abuse or abused child or child

negligence or neglected child or child neglect or emotional abuse or emotional neglect or physical neglect or physical abuse or battered wom?n or

partner abuse or spouse abuse or wife beating or battered wife or shooting or armed attack or war or warfare or child soldier or unwanted child or

abandoned child or kidnap* or abduct* or hostage or stalk* or detention or police custody or arrested or accidental death or ((suicide or self killing

or suicidal) adj3 witness*) or (death adj3 (sibl* or brother or sister)) or unnatural death or death bod* or corpse? or psychotrauma or emotional

trauma or mental trauma or psychical trauma or psychological trauma or psychic trauma or early life stress or orphan or orphanage or institutional

care or rejected child or foster care or foster family or foster home or drowning or volcano eruption or child maltreatment or child mistreatment or

killing* or wrongful death* or sex offense* or physical maltreatment or parental death or maternal death or paternal death or shell shock or

corporal punishment or punishment or psychological abuse or battered females or incest* or acute stress or traumatic stress or Victim? or violent

or violence or traumatic or trauma or psychotraum* or maltreatment or abuse or neglect or deprivation or bullying or bullied).ab,kw,ti.

5. posttraumatic stress disorder/ or acute stress disorder/ or exp psychotrauma/ or exp psychotrauma assessment/ or bullying/

6. (ptsd or ptss or posttraumatic stress or post traumatic stress or posttraumatic symptom? or post traumatic symptom? or bullying or bullied or

cyberbullying).ab,kw,ti.

7. (life change event? and trauma*).ab,kw,sh,ti.

8. or/3–7 [traumatic events]

9. adolescent/ or child/ or minors/ or child, abandoned/ or exp child, exceptional/ or child, orphaned/ or child, unwanted/

10. (young adult? or childhood or youth* or boy? or girl? or sibling* or child or children or adolescents or adolescence or juvenile or minors or teen or

teens or teenage* or young people or toddler? or pre school* or preschool* or infancy or infant? or school age).ab,kw,ti.

11. (pe?diatr* or child*).jw.

12. or/9–11 [0–25 yrs]

13. (((school or campus or universit* or bus) and (accident? or shoot* or massacre or violence or disaster?)) or utoya).ab,kw,ti.

14. 8 and (12 or 13)

15. *executive function/ or exp *attention/ or exp *memory/ or *problem solving/ or *self control/ or *self evaluation/ or *creativity/ or *delay

discounting/ or *attentional bias/ or *memory bias/ or exp *'inhibition (psychology)'/

16. (executive function? or executive dysfunction? or dysexecutive syndrome or executive control or cognitive control or (inhibitory adj2 control) or

self-control or selective attention or cognitive inhibition or interference control or focused attention or attentional inhibition or attentional control

or endogenous attention or voluntary attention or top-down attention or active attention or goal driven attention or executive attention or

delaying gratification or delayed gratification or Temporal Discounting or Intertemporal Preference* or Intertemporal Decision Making or Deferred

Gratification or response inhibition or working memory or verbal working memory or nonverbal working memory or visual spatial working memory

or cognitive flexibility or cognitive development or set shifting or mental flexibility or mental set shifting or creativity or verbal fluency or category

fluency or semantic fluency or task switching or planning or reasoning or problem-solving or fluid intelligence or self regulation or effortful

control).ab,kw,ti.

17. or/15–16

18. 14 and 17

19. exp executive function test/

20. (Conners Continuous Performance TEST or (Stroop adj3 (task? or Test)) or D-KEFS or Delis-Kaplan Executive Function System or Wisconsin Card

Sorting Test or WCST or card sorting test or Porteus maze? or Rey-Osterrieth Complex Figure or RCFT or (brief adj3 (behavior or task? or test* or

inventory)) or 'behavior rating inventory of executive functions' or BADS or 'behavioural assessment of the dysexecutive syndrome' or 'Stop/go' or

'stop/signal' or 'Go/no go' or Flanker or Dimensional card sorting task or Self-ordered pointing task or Conflict task or Gambling task or attention

bias).ab,kw,ti. [specific tests]

21. 19 or 20

22. 14 and 21

23. Bender Gestalt Test/ or 'Kaufman assessment battery for children'/ or 'test of everyday attention'/ or Wechsler adult intelligence scale/ or Wechsler

intelligence scale for children/ or Wechsler memory scale/ or exp maze test/

24. (NEPSY or neuropsychological assessment or KABC or kaufman assessment or 'WJ-III' or woodcock johnson or 'Test of Everyday Attention' or WISC

or wechsler intelligence or WRAML2 or 'wide range of assessment and learning' or 'Test of Problem Solving' or differential ability scales or VMI or

Visual Motor Integration or cognitive Assessment System or children memory scale or Cambridge Neuropsychological Test Automated Battery or

CANTAB).ab,kw,ti. [generic relevant tests]

25. 23 or 24

26. 14 and 25

27. or/18,22,26

28. (tbi or traumatic brain or abi or acquired brain).kw,sh,ti.

29. 27 not 28

30. (animal/ or animal experiment/ or animal model/ or nonhuman/ or rat/ or mouse/ or (rat or rats or mouse or mice).ti.) not human/

31. 29 not 30

32. remove duplicates from 31

Table 2.1.B. Search strategy for the MEDLINE database.

1. Accidental falls/ or accidents, Aviation/ or Accidents, home/ or accidents, traffic/ or drowning/ or mass casualty incidents/ or disaster victims/ or

explosions/ or cyclonic storms/ or earthquakes/ or tornadoes/ or exp ethnic violence/ or exp child abuse/ or physical abuse/ or exp intimate partner

violence/ or domestic violence/ or spouse abuse/ or torture/ or battered woman/ or exp genocide/ or homicide/ or exp sex offenses/ or infanticide/

or sexual harassment/ or circumcision, female/ or exp war crimes/ or stalking/ or parental death/ or maternal death/ or suicide, attempted/ or

suicide, assisted/ or foster home care/ or orphanages/ or incest/

2. (psychiatr* or psychol* or neurocogn* or cognit* or neuropsych* or psycho or psychosocial).ab,jw,kf,ti.

3. 1 and 2

4. 2 and (mass fatalit* or catastrophe or disaster? or accident? or aircraft crash or destruction or annihilation or falling or fall? or collapse or automobile

collision or flood* or inundation or hurricane* or tornado* or cyclone* or typhoon* or twister or earthquake* or tsunami* or fire or wildfire* or

blast* or threat or harassment or assault or battering or ethnic conflict or racial conflict or genocide or ethnic cleansing or ethnocide or homicide or

assassination or murder or trafficking or infanticide or torture or sexual aggression or female genital mutilation or circumcised wom?n or female

circumcision or female genital circumcision or female genital cutting or FGM or ritual female genital surgery or sexual coercion or sexual

exploitation or forced prostitution or rape or sexual abuse or molestation or sex abuse? or frotteurism or child abuse or abused child or child

negligence or neglected child or child neglect or emotional abuse or emotional neglect or physical neglect or physical abuse or battered wom?n or

partner abuse or spouse abuse or wife beating or battered wife or shooting or armed attack or war or warfare or child soldier or unwanted child or

abandoned child or kidnap* or abduct* or hostage or stalk* or detention or police custody or arrested or accidental death or ((suicide or self killing

or suicidal) adj3 witness*) or (death adj3 (sibl* or brother or sister)) or unnatural death or death bod* or corpse? or psychotrauma or emotional

trauma or mental trauma or psychical trauma or psychological trauma or psychic trauma or early life stress or orphan or orphanage or institutional

care or rejected child or foster care or foster family or foster home or drowning or volcano eruption or child maltreatment or child mistreatment or

killing* or wrongful death* or sex offense* or physical maltreatment or parental death or maternal death or paternal death or shell shock or

corporal punishment or punishment or psychological abuse or battered females or incest* or acute stress or traumatic stress or Victim? or violent or

violence or traumatic or trauma or psychotraum* or maltreatment or abuse or neglect or deprivation or bullying or bullied).ab,kf,ti.

5. exp 'Trauma and Stressor Related Disorders'/ or bullying/

6. (ptsd or ptss or posttraumatic stress or post traumatic stress or posttraumatic symptom? or post traumatic symptom? or bullying or bullied or

cyberbullying).ab,kf,ti.

7. (life change event? and trauma*).ab,kf,sh,ti.

8. or/3–7 [traumatic events]

9. adolescent/ or child/ or minors/ or child, abandoned/ or exp child, exceptional/ or child, orphaned/ or child, unwanted/

10. (young adult? or childhood or youth* or boy? or girl? or sibling* or child or children or adolescents or adolescence or juvenile or minors or teen or

teens or teenage* or young people or toddler? or pre school* or preschool* or infancy or infant? or school age).ab,kf,ti.

11. (pe?diatr* or child*).jw.

12. or/9–11 [0–25 yrs]

13. (((school or campus or universit* or bus) and (accident? or shoot* or massacre or violence or disaster?)) or utoya).ab,kf,ti.

14. 8 and (12 or 13)

15. executive function/ or attention/ or Memory, Short-Term/ or exp problem solving/ or self control/ or creativity/ or delay discounting/ or 'Inhibition

(Psychology)'/

16. (executive function? or executive dysfunction? or dysexecutive syndrome or executive control or cognitive control or (inhibitory adj2 control) or

self-control or selective attention or cognitive inhibition or interference control or focused attention or attentional inhibition or attentional control

or endogenous attention or voluntary attention or top-down attention or active attention or goal driven attention or executive attention or

delaying gratification or delayed gratification or Temporal Discounting or Intertemporal Preference* or Intertemporal Decision Making or Deferred

Gratification or response inhibition or working memory or verbal working memory or nonverbal working memory or visual spatial working memory

or cognitive flexibility or cognitive development or set shifting or mental flexibility or mental set shifting or creativity or verbal fluency or category

fluency or semantic fluency or task switching or planning or reasoning or problem-solving or fluid intelligence or self regulation or effortful control).

ab,kf,ti.

17. or/15–16

18. 14 and 17

19. (Conners Continuous Performance TEST or (Stroop adj3 (task? or Test)) or D-KEFS or Delis-Kaplan Executive Function System or Wisconsin Card

Sorting Test or WCST or card sorting test or Porteus maze? or Rey-Osterrieth Complex Figure or RCFT or (brief adj3 (behavior or task? or test* or

inventory)) or 'behavior rating inventory of executive functions' or 'BEHAVIOURAL ASSESSMENT OF THE DYSEXECUTIVE SYNDROME' or 'Stop/go' or

'stop/signal' or 'Go/no go' or Flanker or Dimensional card sorting task or Self-ordered pointing task or Conflict task or Gambling task or attention

bias).ab,kf,ti. [specific tests]

20. 14 and 19

21. Wechsler Scales/

22. (NEPSY or neuropsychological assessment or KABC or kaufman assessment or 'WJ-III' or woodcock johnson or 'Test of Everyday Attention' or WISC

or wechsler intelligence or WRAML2 or 'wide range of assessment and learning' or 'Test of Problem Solving' or differential ability scales or VMI or

Visual Motor Integration or cognitive Assessment System or children memory scale or Cambridge Neuropsychological Test Automated Battery or

CANTAB).ab,kf,ti.

23. 21 or 22 [generic relevant tests]

24. 14 and 23

25. or/18,20,24

26. (tbi or traumatic brain or abi or acquired brain).kf,sh,ti.
27. 25 not 26
28. animals/ not humans/
29. 27 not 28
30. remove duplicates from 29
31. limit 30 to (dutch or english)

Table 2.1.C. Search strategy for the PsycInfo database.

1. Falls/ or home accidents/ or pedestrian accidents/ or exp transportation accidents/ or exp disasters/ or threat/ or coercion/ or punishment/ or

school violence/ or physical abuse/ or emotional abuse/ or exp harassment/ or victimization/ or human trafficking/ or kidnapping/ or battered

females/ or domestic violence/ or exposure to violence/ or exp partner abuse/ or exp sex offenses/ or circumcision/ or battered females/ or

kidnapping/ or exp suicide/ or homicide/ or emotional trauma/ or foster children/ or foster care/ or orphans/ or orphanages/

2. (psychiatr* or psychol* or neurocogn* or cognit* or neuropsych* or psycho or psychosocial).ab,jx,id,ti.

3. 1 and 2

4. 2 and (mass fatalit* or catastrophe or disaster? or accident? or aircraft crash or destruction or annihilation or falling or fall? or collapse or

automobile collision or flood* or inundation or hurricane* or tornado* or cyclone* or typhoon* or twister or earthquake* or tsunami* or fire or

wildfire* or blast* or threat or harassment or assault or battering or ethnic conflict or racial conflict or genocide or ethnic cleansing or ethnocide or

homicide or assassination or murder or trafficking or infanticide or torture or sexual aggression or female genital mutilation or circumcised wom?n

or female circumcision or female genital circumcision or female genital cutting or FGM or ritual female genital surgery or sexual coercion or sexual

exploitation or forced prostitution or rape or sexual abuse or molestation or sex abuse? or frotteurism or child abuse or abused child or child

negligence or neglected child or child neglect or emotional abuse or emotional neglect or physical neglect or physical abuse or battered wom?n or

partner abuse or spouse abuse or wife beating or battered wife or shooting or armed attack or war or warfare or child soldier or unwanted child or

abandoned child or kidnap* or abduct* or hostage or stalk* or detention or police custody or arrested or accidental death or ((suicide or self killing

or suicidal) adj3 witness*) or (death adj3 (sibl* or brother or sister)) or unnatural death or death bod* or corpse? or psychotrauma or emotional

trauma or mental trauma or psychical trauma or psychological trauma or psychic trauma or early life stress or orphan or orphanage or institutional

care or rejected child or foster care or foster family or foster home or drowning or volcano eruption or child maltreatment or child mistreatment or

killing* or wrongful death* or sex offense* or physical maltreatment or parental death or maternal death or paternal death or shell shock or

corporal punishment or punishment or psychological abuse or battered females or incest* or acute stress or traumatic stress or Victim? or violent or

violence or traumatic or trauma or psychotraum* or maltreatment or abuse or neglect or deprivation or bullying or bullied).ab,id,ti.

5. posttraumatic stress disorder/ or acute stress disorder/ or exp bullying/

6. (ptsd or ptss or posttraumatic stress or post traumatic stress or posttraumatic symptom? or post traumatic symptom? or bullying or bullied or

cyberbullying).ab,id,ti.

7. (life change event? and trauma*).ab,id,sh,ti.

8. or/3–7 [traumatic events]

9. ('140' or '180' or '200' or '320').ag.

10. (young adult? or childhood or youth* or boy? or girl? or sibling* or child or children or adolescents or adolescence or juvenile or minors or teen or

teens or teenage* or young people or toddler? or pre school* or preschool* or infancy or infant? or school age).ab,id,ti.

11. (pe?diatr* or child*).jx.

12. or/9–11 [0–25 yrs]

13. (((school or campus or universit* or bus) and (accident? or shoot* or massacre or violence or disaster?)) or utoya).ab,id,ti.

14. 8 and (12 or 13)

15. executive function/ or attention/ or exp memory/ or exp problem solving/ or self control/ or creativity/ or delay discounting/ or dysexecutive

syndrome/

16. (executive function? or executive dysfunction? or dysexecutive syndrome or executive control or cognitive control or (inhibitory adj2 control) or

self-control or selective attention or cognitive inhibition or interference control or focused attention or attentional inhibition or attentional control

or endogenous attention or voluntary attention or top-down attention or active attention or goal driven attention or executive attention or

delaying gratification or delayed gratification or Temporal Discounting or Intertemporal Preference* or Intertemporal Decision Making or Deferred

Gratification or response inhibition or working memory or verbal working memory or nonverbal working memory or visual spatial working memory

or cognitive flexibility or cognitive development or set shifting or mental flexibility or mental set shifting or creativity or verbal fluency or category

fluency or semantic fluency or task switching or planning or reasoning or problem-solving or fluid intelligence or self regulation or effortful

control).ab,id,ti.

17. or/15–16

18. 14 and 17

19. Stroop effect/ or Stroop Color Word Test/

20. (Conners Continuous Performance TEST or (Stroop adj3 (task? or Test)) or D-KEFS or Delis-Kaplan Executive Function System or Wisconsin Card

Sorting Test or WCST or card sorting test or Porteus maze? or Rey-Osterrieth Complex Figure or RCFT or (brief adj3 (behavior or task? or test* or

inventory)) or 'behavior rating inventory of executive functions' or BADS or 'BEHAVIOURAL ASSESSMENT OF THE DYSEXECUTIVE SYNDROME' or

'Stop/go' or 'stop/signal' or 'Go/no go' or Flanker or Dimensional card sorting task or Self-ordered pointing task or Conflict task or Gambling task or

attention bias).ab,id,ti. [specific tests]

21. 19 or 20

22. 14 and 21

23. Bender Gestalt Test/ or Wechsler Intelligence Scale for Children/ or Woodcock Johnson Psychoeducational Battery/ or Digit span testing/ or

Porteus Maze Test/ or 'Kaufman Assessment Battery for Children'/ or Wechsler Adult Intelligence Scale/ or Wechsler Preschool Primary Scale/ or

Kohs Block Design Test/

24. (NEPSY or neuropsychological assessment or KABC or kaufman assessment or 'WJ-III' or woodcock johnson or 'Test of Everyday Attention' or WISC

or wechsler intelligence or WRAML2 or 'wide range of assessment and learning' or 'Test of Problem Solving' or differential ability scales or VMI or

Visual Motor Integration or cognitive Assessment System or children memory scale or Cambridge Neuropsychological Test Automated Battery or

CANTAB).ab,id,ti. [generic relevant tests]

25. 23 or 24

26. 14 and 25

27. or/18,22,26

28. (tbi or traumatic brain or abi or acquired brain).id,sh,ti.

29. 27 not 28

30. cognitive control.ab,id,ti.

31. (executive function? or executive dysfunction? or dysexecutive syndrome or executive control or cognitive control or (inhibitory adj2 control)).ab,id,ti.

32. (self-control or selective attention or cognitive inhibition or interference control or focused attention or attentional inhibition or attentional

control).ab,id,ti.

33. (task switching or planning or reasoning or problem-solving or fluid intelligence or self regulation or effortful control).ab,id,ti.

34. (cognitive development or set shifting or mental flexibility or mental set shifting or creativity or verbal fluency or category fluency or semantic

fluency).ab,id,ti.

35. (response inhibition or working memory or verbal working memory or nonverbal working memory or visual spatial working memory or cognitive

flexibility).ab,id,ti.

36. (gratification or delayed gratification or Temporal Discounting or Intertemporal Preference* or Intertemporal Decision Making or Deferred

Gratification).ab,id,ti.

37. (endogenous attention or voluntary attention or top-down attention or active attention or goal driven attention or executive attention or delaying

gratification).ab,id,ti.

38. 8 and 9

Appendix 2.2

Table 2.2B
Eligibility assessment criteria

Types of studies	
	We included studies that compared trauma-exposed youth with a control group in terms of inhibition, working memory, or cognitive flexibility.
	We included studies that investigated the association between trauma exposure and inhibition, working memory, or cognitive flexibility in youth, with the exception of samples of orphans, institutionalized and adopted youth.
	We included studies that compared orphans, institutionalized, and adopted youth with a control group in terms of inhibition, working memory, or cognitive flexibility
Types of participants	
	We included samples with traumatized youth aged 0 to 25 years, in which the upper age limit could not exceed 25 years of age.
	We excluded samples when participants were reported to have physical disabilities or illness: such as traumatic brain injury, poisoning, cancer, heart problems, epilepsy.
Trauma criteria	
	Population: Orphans, foster children, adopted children
	Experiencing/witnessing/hearing about:
	Natural disaster (e.g. hurricane, earthquake) Fire/explosion Accident (traffic, school, home, neighborhood) Bullying (extreme) Physical attack (beaten, kicked, etcetera) Shooting War/community violence Verbal abuse Domestic violence Rape, sexual abuse Stalking Police arrest Physical neglect Emotional neglect Abduction/kidnapping Severe illness Death by violence Death of a loved one

Table 2.2B Continued

Outcome measures	
	Working memory: Visuo-spatial working memory Spatial working memory Verbal working memory
	Inhibition Response inhibition Inhibitory control Interference control Cognitive inhibition Selective attention Focused attention Effortful control Cognitive flexibility
	Set shifting Task switching Shifting
Correlations or means	We included studies that reported raw correlations between measures or means and standard deviations between two groups

Appendix 2.3

Table 2.3A. Coding scheme

Variable	Variable labels
Study characteristics	
PaperID	Paper identification number (001,002,003 etc.)
SampleID	Sample identification number (001,002,003 etc.)
ESID	Effict size identification number (001,002,003 etc.)
Authors	Author names
Year	Publication year
Publication Status	1=Published 0=not published
N	Number of participant of total sample
AgeMean	Mean age total sample
AgeSD	Standard deviation age total sample
Gender	Percentage girls in total sample
Ethnicity	Percentage minority ethnicity in total sample
SES	1= controlled for SES, 0 not controlled for SES
N_control	Number of participant of control group
AgeMean_control	Mean age control group
AgeSD_control	Standard deviation age control group
Gender_control	Percentage girls in control group
Ethnicity_control	Percentage minority ethnicity in control group
N_trauma	Number of participant of trauma group
AgeMean_trauma	Mean age trauma group
AgeSD_trauma	Standard deviation age trauma group
Gender_trauma	Percentage girls in trauma group
Ethnicity_trauma	Percentage minority ethnicity in trauma group
Trauma-characteristics	
PTSD_measure	PTSD measurement instrument: 1= CRIES (child), 2=CRIES (parent), 3=TSCC, 4=PDS, 5=UCLA PTSD index, 6=CAPS-CA, 7=PCL, 8=PCL-C, 9=TSCYC, 10=PSSC, 11=KSADS, 12= observation, 13=mini-KID,14=IES,15=psychiatric evaluation, 16=SCDID
PTSD_Diagnosis	1= PTSD diagnoses in sample, 0= no PTSD diagnoses in sample
Type_trauma	1= disaster, 2=fire or explosion, 3=vehicle accident, 4=accident, 5=overall abuse, 6=overall neglect, 7= physical abuse/threat, 8=verbal abuse/threat, 9=emotional neglect, 10=physical neglect, 11=domestic violence, 12=sexual abuse/rape, 13=(witness) shooting, 14= stalking, 15=person in family arrested, 16=severe bullying (with physical threat), 17=abduction, 18=witness of a violent death, 19=death of a loved one, 20=adoption/foster care with known history of abuse or neglect, 21=adoption/foster care with unknown history, 22=severe illness or medical condition in loved one, 23=indirect victimization 24= community violence (later subsumed into 1= single trauma exposure, 2 violence exposed/abused/neglect, 3= adopted or foster care youth
Onset	Mean age (years) of onset trauma exposure
Duration	Mean age (years) of duration of trauma exposure

Table 2.3A. Continued

Measurement characteristics	
WM_Task	Working memory outcome measure
WM_mean_control	Mean score on working memory outcome measure for control group
WM_SD_control	Standard deviation on working memory outcome measure for control group
WM_mean_trauma	Mean score on working memory outcome measure for trauma group
WM_SD_trauma	Standard deviation on working memory outcome measure for trauma group
WM_correlation	Correlation between trauma exposure and working memory outcome measure
WM_quality	1=high, 2=medium, 3=low
INH_Task	Inhibition outcome measure
INH_mean_control	Mean score on inhibition outcome measure for control group
INH_SD_control	Standard deviation on inhibition outcome measure for control group
INH_mean_trauma	Mean score on inhibition outcome measure for trauma group
INH_SD_trauma	Standard deviation on inhibition outcome measure for trauma group
INH_correlation	Correlation between trauma exposure and inhibition outcome measure
INH_quality	1=high, 2=medium, 3=low
FLEX_Task	Cognitive flexibility outcome measure
FLEX_mean_control	Mean score on cognitive flexibility outcome measure for control group
FLEX_SD_control	Standard deviation on cognitive flexibility outcome measure for control group
FLEX_mean_trauma	Mean score on cognitive flexibility outcome measure for trauma group
FLEX_SD_trauma	Standard deviation on cognitive flexibility outcome measure for trauma group
FLEX_correlation	Correlation between trauma exposure and cognitive flexibility outcome measure
FLEX_quality	1=high, 2=medium, 3=low

Appendix 2.4

Table 2.4A
Quality coding of included working memory outcome measures

Task – outcome measure	Measures:	Quality
(WISC) Digit Span		
Overall	Verbal working memory	Low
Backwards-forwards	Verbal working memory	High
Backwards	Verbal working memory	Medium
WISC WMI index	Working memory	Low
CANTAB SWM		
SWM between errors 4-8 boxes	Spatial working memory	Medium
Within errors 4-8 boxes	Spatial working memory	Medium
Double errors	Spatial working memory	Medium
Total errors 4-8 boxes (key outcome)	Spatial working memory	High
Strategy (key outcome)	Spatial working memory	High
Mean score	Spatial working memory	Low
CANTAB Spatial Span (SSP)		
SSP Errors	Spatial working memory	High
SSP length	Spatial working memory	High
SSP strategy	Spatial working memory	High
SSP latency	Spatial working memory	Medium
WJ-II		
Numbers reversed	Verbal working memory	Medium
NEUROPSI		
Digit backwards span	Verbal working memory	Medium
Spatial backwards span	Spatial working memory	Medium
CAT		
Spatial working memory (overall)	Spatial working memory	Low
Combined tasks		
Digit span (WISC) + corsi block test	Working memory (spatial + verbal)	Medium
Listening recall task	Verbal working memory	Medium
Odd-one-out	Verbal working memory	Medium
Spin the pots (# stickers)	Working memory (spatial)	Medium
Six boxes (scrambled)	Working memory (spatial)	Medium
BRIEF		
Working memory subscale	Working memory	Low

Table 2.4B Quality coding of included inhibition outcome measures

Task – outcome measure	Measures:	Quality
Stroop		
Errors card III	Interference control	Medium
RT card III	Interference control	Medium
Interference score (card III - II)	Interference control	High
Delis Kaplan Color Word Interference		
Mean score	Interference control	Medium
Errors card III	Interference control	Medium
Contrast time/errors (difference card III-II/I)	Interference control	High
Go/No-go		
Percentage correct no-go responses	Response inhibition	High
Percentage errors of commission	Response inhibition	High
Reaction time errors of commission	Response inhibition	High
Total percentage correct	Response inhibition	Low
Total reaction time	Response inhibition	Low
Conners Performance Test II		
Commission errors	Response inhibition	High
Stop Signal Test		
SSRT	Inhibit prepotent response	High
Proportion successful stops	Inhibit prepotent response	Medium
Stop signal delay	Inhibit prepotent response	Medium
Mean probability of inhibition over all delay intervals corrected for omission errors	Inhibit prepotent response	High
Flanker		
Accuracy incongruent	Interference control	Medium
RT incongruent	Interference control	Medium
Incongruent-congruent RT	Interference control	High
Interference score	Interference control	High
Nepsy		
Knock and tap : accuracy score	Motor inhibition	High
Statue: accuracy score	Motor inhibition	High
Gradual Onset Continuous Performance Task		
Slope of commission errors	Interference control	High
Logan Stop-Change		
% correct responses for tone delay trials	Interference control	Medium
Mean reaction time for tone delay trials	Interference control	High
Change task (McClure)		
CSRT	Interference control	High
Three pegs task	Prepotent response inhibition	Medium
Tapping task	Prepotent response inhibition	Medium

Table 2.4B Continued

Task – outcome measure	Measures:	Quality
Day night		
Proportion correct test trials	Interference control	Low
NEUROPSI		
Motor functions (go/no-go + luria's)	Inhibition	Low
BRIEF		
Inhibition subscale	Inhibition	Low
Verbal Inhibition/Motor Inhibition task		
Combined number of errors	Inhibition	low
Luria's hand game based task		
Combined number of errors	Inhibition	Low

Note. Assignment of quality is partly based on the paper of Geurts, van den Bergh, & Ruzzano (2014).

Table 2.4C Quality coding of included cognitive flexibility outcome measures

Task – outcome measure	Measures:	Quality
Trail Making Test (TMT)		
TMT-B	Cognitive flexibility	Medium
TMT A + B	Cognitive flexibility	Low
TMT B-A	Cognitive flexibility	High
DKEFS Category switching		
Average score CF- average score switching	Verbal flexibility	High
Average score Con1 +2 – raw score Con3	Non-verbal flexibility	High
DCCS		
Highest level achieved	Set shifting	Low
CANTAB IED		
Total errors/errors block 6/errors block 8	Set shifting	Medium
Total errors adjusted	Set shifting	Medium
Stages completed	Set shifting	Medium
EDS errors	Set shifting	High
PRE ED errors	Set shifting	Medium
Total trials	Set shifting	Medium
Total trials adjusted	Set shifting	Medium
Mean score	Set shifiting	Low
WCST		
Perseverative errors	Set shifting	High
Perseverative responses	Set shifting	Medium
Total errors	Set shifting	Low
Categories completed	Set shifting	Low
Failure to maintain set	Set shifting	High

Table 2.4C Continued

Task – outcome measure	Measures:	Quality
Flexible item task		
Proportion correct	Set shifting	Medium
BRIEF		
Cognitive flexibility subscale	Cognitive flexibility	Low
Cognitive flexibility inventory	Cognitive flexibility	Low
Combined tasks		
TMT-B + WCST perseveration	Cognitive flexibility	Medium

Note. Assignment of quality is partly based on the paper of Geurts, Corbett, & Solomon (2009).

Table 2.4D Excluded tasks and outcome measures

Tasks – outcome measures	Measures:
Go/No-go	
Correct Go responses (number of correct 'go' responses)	Selective attention
% Correct Go responses (percentage of 'go' trials correct)	Selective attention
Incorrect Go responses (number of incorrect 'go' responses)	Selective attention
Go trial non responses (non responses on 'go' trials)	Selective attention
Mean Go trial RT (mean reaction time of correct 'go' responses)	Selective attention
Conners Performance Test II	
Correct detection	Selective attention
RT	Selective attention
Omission errors	Selective attention
Variability	Sustained attention
Stop Signal Test	
SSD	Time interval between go and stop signals
Go RT	Selective attention
Direction errors	Selective attention
Flanker	
Accuracy congruent	Selective attention
RT congruent	Selective attention
Combined scores congruent	Selective attention
Logan Stop-Change	
Go RT	Selective attention
SSD	Selective attention
WISC digit span	
Forwards	Attention/short term memory

Table 2.4D Continued

Tasks – outcome measures	**Measures:**
CANTAB SWM	
Mean time to first response	Speed
Sentence repetition	Short term memory
TMT	
TMT-A	Psychomotor speed
Digital Vigilance Test	Vigilance + alertness
COWAT	
Animal naming	Verbal fluency
Total words	Verbal fluency
Grooved Pegboard	Planning + psychomotor speed
California Verbal Learning Test	
List A	Verbal learning
List B	Verbal learning
Short delay free recall	Verbal learning
Long delay free recall	Verbal learning
Discriminability	Verbal learning
WISC-III	
Block Design	Visual-motor coordination
Object Assembly	Visual organizing/reasoning
Coding	Visual short-term memories
Similarities	Reasoning
Arithmetic	Arithmetic abilities
Rey Osterrieth Complex Figure recall	Memory
Rey Osterrieth Complex Figure copy	Visual-spatial ability
Money Road map	Left-right discrimination
Judgement of Line Orientation	Visual-spatial ability
Tower of London	Planning
Reading span of Daneman & Carpenter	Short term memory
Self-control scale	Self-control
Conflict task (Egner 2008)	Conflict interference (emotional)
Hayling sentence repetition	Selective attention
Sentence repetition span	Verbal memory:
Paired Associate Learning test CANTAB	Visual memory + new learning
Dot-probe	Attention bias
Retrospective Self Report of Inhibition (RSRI)	Behavioral Disinhibition (trait)
Stanford Binet Sentence, objects and Digits	Short term memory
Bayley scales	Overall cognitive function
BIS/BAS scales	Behavioral inhibition (trait)
Barrat Impulsivity Scale	Impulsivity

Table 2.4D Continued

Tasks – outcome measures	**Measures:**
Childrens' Behavior Questionnaire (CBQ)	Temperament
FDI index WISC	Attention
Gift delay task	Behavioral inhibition
Composite score of DCCS, Day/Night/CBCL	Overall (executive) functioning
WCST	
Non perseverative errors	Random errors

Appendix 2.5 References of papers used in meta-analyses for working memory, inhibition, and cognitive flexibility

Almas, A. N., Degnan, K. A., Nelson, C. A., Zeanah, C. H., & Fox, N. A. (2016). IQ at age 12 following a history of institutional care: Findings from the Bucharest Early Intervention Project. *Developmental Psychology, 52(11)*, 1858–1866. doi:10.1037/dev0000167

Augusti, E.-M., & Melinder, A. (2013). Maltreatment is associated with specific impairments in executive functions: A pilot study. *Journal of Traumatic Stress, 26*, 780–783. doi:10.1002/jts

Barrera, M., Calderon, L., Bell, V., Calderón, L., & Bell, V. (2013). The cognitive impact of sexual abuse and PTSD in children: A neuropsychological study. *Journal of Child Sexual Abuse, 22(6)*, 625–638. doi:10.1080/10538712.2013.811141

Bauer, P. M., Hanson, J. L., Pierson, R. K., Davidson, R. J., & Pollak, S. D. (2009). Cerebellar volume and cognitive functioning in children who experienced early deprivation. *Biological Psychiatry, 66(12)*, 1100–1106. doi:10. 1016/j.biopsych.2009.06.014

Beers, S. R., & De Bellis, M. D. (2002). Neuropsychological function in children with maltreatment-related posttraumatic stress disorder. *The American Journal of Psychiatry, 159*, 483–486. doi:10.1176/appi.ajp.159.3.483

Bos, K. J., Fox, N., Zeanah, C. H., & Nelson III, C. A. (2009). Effects of early psychosocial deprivation on the development of memory and executive function. *Frontiers in Behavioral Neuroscience, 3*, 1–16. doi:10.3389/neuro.08.016.2009

Brett, Z. H., Sheridan, M., Humphreys, K., Smyke, A., Gleason, M. M., Fox, N., . . . Drury, S. (2014). A neurogenetics approach to defining differential susceptibility to institutional care. *International Journal of Behavioral Development*, 1–11. doi:10.1177/0165025414538557

Bruce, J.,McDermott, J.M., Fisher, P. A., & Fox, N. A. (2009). Using behavioral and electrophysiological measures to assess the effects of a preventive intervention: A preliminary study with preschool-aged foster children. *Prevention Science, 10(2)*, 129–140. doi:10.1007/s11121-008-0115-8

Bücker, J., Kapczinski, F., Post, R., Cereser, K. M., Szobot, C., Yatham, L. N., . . . Kauer-Sant'Anna, M. (2012). Cognitive impairment in school-aged children with early trauma. *Comprehensive Psychiatry, 53*, 758–764. doi:10.1016/j.comppsych.2011.12.006

Burgers, D. E., & Drabick, D. A. G. (2016). Community violence exposure and generalized anxiety symptoms: Does executive functioning serve a moderating role among low income, urban youth? *Journal of Abnormal Child Psychology, 44*, 1543–1557. doi:10.1007/s10802-016-0144-x

Cardona, J. F., Manes, F., Escobar, J., López, J., & Ibáez, A. (2012). Potential consequences of abandonment in preschool-age: Neuropsychological findings in institutionalized children. *Behavioural Neurology, 25*, 291–301. doi:10.3233/BEN-2012-110205

Carrion, V. G., Garrett, A., Menon, V., Weems, C. F., & Reiss, A. L. (2008). Posttraumatic stress symptoms and brain function during a response-inhibition task: An fMRI study in youth. *Depression and Anxiety, 25*, 514–526. doi:10.1002/da.20346

Cecil, C. A. M., Viding, E., McCrory, E. J., & Gregory, A. M. (2015). Distinct mechanisms underlie associations between forms of childhood maltreatment and disruptive nocturnal behaviors. *Developmental Neuropsychology, 40(3)*, 181–199. doi:10.1080/87565641.2014.983636

Cowell, R. A., Cicchetti, D., Rogosch, F. A., & Toth, S. L. (2015). Childhood maltreatment and its effect on neurocognitive functioning: Timing and chronicity matter. *Development and Psychopathology, 27*, 521–533. doi:10.1017/S0954579415000139

De Bellis, M. D., Woolley, D. P., & Hooper, S. R. (2013). Neuropsychological findings in pediatric maltreatment. *Child Maltreatment, 18(3)*, 171–183. doi:10.1177/1077559513497420

Dileo, J. F., Brewer, W., Northam, E., Yucel, M., Anderson, V., Brewer, W., . . . Anderson, V. (2017). Investigating the neurodevelopmental mediators of aggression in children with a history of child maltreatment: An exploratory field study. *Child Neuropsychology, 23(6)*, 655–677. doi:10.1080/09297049.2016.1186159

Eigsti, I.-M., Weitzman, C., Schuh, J., de Marchena, A., & Casey, B. J. (2011). Language and cognitive outcomes in internationally adopted children. *Development and Psychopathology, 23*, 629–646. doi:10.1017/S0954579411000204

Fishbein, D., Warner, T., Krebs, C., Trevarthen, N., Falnnery, B., & Hammond, J. (2009). Differential relationships between personal and community stressors and children's neurocognitive functioning. *Child Maltreatment, 14(4)*, 299–315. doi :10.1177/1077559508326355

Fox, N. A., Almas, A. N., Degnan, K. A., Nelson, C. A., & Zeanah, C. H. (2011). The effects of severe psychosocial deprivation and foster care intervention on cognitive development at 8 years of age: Findings from the Bucharest Early Intervention Project. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 52(9)*, 919–928. doi: 10.1111/j.1469-7610.2010.02355.x

Fu, F., & Chow, A. (2017). Traumatic exposure and psychological well-being: The moderating role of cognitive flexibility. *Journal of Loss and Trauma, 22*, 24–35. doi:10.1080/15325024.2016.1161428

Gustafsson, H. C., Coffman, J. L., & Cox, M. J. (2015). Intimate partner violence, maternal sensitive parenting behaviors, and children's executive functioning. *Psychology of Violence, 5(3)*, 266–274. doi:10.1037/a0037971

Gustafsson, H. C., Coffman, J. L., Harris, L. S., Langley, H. A., Ornstein, P. A., & Cox, M. J. (2013). Intimate partner violence and children's memory. *Journal of Family sychology, 27*, 937–944. doi:10.1037/a0034592

Hanson, J. L., Chung, M. K., Avants, B. B., Rudolph, K. D., Shirtcliff, E. A., Gee, J. C., … Pollak, S. D. (2012). Structural variations in prefrontal cortex mediate the relationship between early childhood stress and spatial working memory. *Journal of Neuroscience, 32*, 7917–7925. Doi: 10.1523/JNEUROSCI.0307-12.2012.

Helder, E. J., Behen, M. E., Wilson, B., Muzik, O., & Chugani, H. T. (2014). Language difficulties in children adopted internationally: Neuropsychological and functional neural correlates. *Child Neuropsychology, 20(4)*, 470–492. doi:10.1080/09297049.2013.819846

Hostinar, C. E., Stellern, S. A., Schaefer, C., Carlson, S. M., & Gunnar, M. R. (2012). Associations between early life adversity and executive function in children adopted internationally from orphanages. *Proceedings of the National Academy of Sciences of the United States of America, 109*, 17208–17212. doi:10.1073/pnas.1121246109

Kavanaugh, B.,&Holler, K. (2014). Executive, emotional, and language functioning following childhood maltreatment and the influence of pediatric PTSD. *Journal of Child and Adolescent Trauma, 7(2)*, 121–130. doi:10.1007/s40653-014-0014-z

Kavanaugh, B., & Holler, K. (2015). Brief report: Neurocognitive functioning in adolescents following childhood maltreatment and evidence for underlying planning & organizational deficits. *Child Neuropsychology, 21(6)*, 840–848. doi:10.m1080/09297049.2014.929101

Kavanaugh, B., Holler, K., & Selke, G. (2015). A neuropsychological profile of childhood maltreatment within an adolescent inpatient sample. *Applied Neuropsychology: Child, 4*, 9–19. doi:10.1080/21622965.2013.789964

Kirke-Smith, M., Henry, L., & Messer, D. (2014). Executive functioning: Developmental consequences on adolescents with histories of maltreatment. *British Journal of Developmental Psychology, 32*, 305–319. doi:10.1111/bjdp.12041

Kirke-Smith, M., Henry, L. A., & Messer, D. (2016). The effect of maltreatment type on adolescent executive functioning and inner speech. *Infant and Child Development, 25*, 516–532. doi:10.1002/icd.1951

Li, Y., Dong, F., Cao, F., Cui, N., Li, J., & Long, Z. (2013). Poly-victimization and executive functions in junior college students. *Scandinavian Journal of Psychology, 54(6)*, 485–492. doi:10.1111/sjop.12083

Lim, L., Hart, H., Mehta, M. A., Simmons, A., Mirza, K., & Rubia, K. (2015). Neural correlates of error processing in young people with a history of severe childhood abuse: An fMRI study. *American Journal of Psychiatry, 172(9)*, 892–900. doi:10.1176/appi.ajp.2015.14081042

Lind, T., Lee Raby, K., Caron, E. B., Roben, C. K. P., & Dozier, M. (2017). Enhancing executive functioning among toddlers in foster care with an attachment based intervention. *Development and Psychopathology, 29*, 575–586. doi:10.1017/S0954579417000190

McDermott, J. M., Westerlund, A., Zeanah, C. H., Nelson, C. A., & Fox,N. A. (2012). Early adversity and neural correlates of executive function: Implications for academic adjustment. *Developmental Cognitive Neuroscience, 2*, S59–S66. doi:10. 1016/j.dcn.2011.09.008

Meguid, N., & Reda, M. (2016). Salivary cortisol levels in abused children with attention deficit hyperactivity disorder. *Journal of Psychiatry, 19*, 1–6. doi:10.4172/2378-5756.1000348

Mezzacappa, E., Kindlon,D.&Earls, F. (2001).Child abuse and performance task assessments of executive functions in boys. *Journal of Psychology and Psychiatry, 42(8)*, 1041–1048. doi:10.1111/1469-7610.00803

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. doi:10.1111/camh.12068

Mueller, S. C., Maheu, F. S., Dozier, M., Peloso, E., Mandell, D., Leibenluft, E., . . . Ernst, M. (2010). Early life stress is associated with impairment in cognitive control in adolescence: An fMRI study. *Neuropsychologia, 48(10)*, 3037–3044. doi:10.1016/j.neuropsychologia.2010.06.013

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

Navalta, C. P., Polcari, A., Webster, D. M., Boghossian, A., & Teicher, M. T. (2006). Effects of childhood sexual abuse on neuropsychological and cognitive function in college women. *Journal of Neuropsychiatry and Clinical Neuroscience, 18(1)*, 45–53. doi:10.1176/appi.neuropsych18.1.45

Nolin,P.,& Ethier, L. (2007).Using neuropsychological profiles to classify neglected children with or without physical abuse. *Child Abuse and Neglect, 31(6)*, 631–643. doi:10.1016/j.chiabu.2006.12.009

Op den Kelder, R., Ensink, J. B.M., Overbeek,G., Maric, M.,& indauer, R. J. L. (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

Park, S., Kim, B.-N., Choi, N.-H., Ryu, J., McDermott, B., Cobham, V., . . . Cho, S.-C. (2014). The effect of persistent posttraumatic stress disorder symptoms on executive functions in preadolescent children witnessing a single incident of death. *Anxiety, Stress & Coping: An International Journal, 27*, 241–252. doi:10.1080/10615806.2013.853049

Perna, R. B., & Kiefner, M. (2013). Long-term cognitive sequelae: Abused children without PTSD. *Applied Neuropsychology: Child, 2(1)*, 1–5. doi:10.1080/09084282.2011.595460

Pollak, S. D., Nelson, C. A., Schlaak, M. F., Roeber, B. J., Wewerka, S. S., Wiik, K. L., . . . Gunnar, M. R. (2010). Neurodevelopmental effects of early deprivation in postinstitutionalized children. *Child Development, 81(1)*, 224–236. doi:10.1111/j.1467-8624.2009.01391.x

Saigh, P. A, Yasik, A. E., Oberfield, R. a, Halamandaris, P. V, & Bremner, J. D. (2006). The intellectual performance of traumatized children and adolescents with or without posttraumatic stress disorder. *Journal of Abnormal Psychology, 115(2)*, 332–340. doi:10.1037/0021-843X.115.2.332

Samuelson, K. W., Krueger, C. E., & Wilson, C. (2012). Relationships between maternal emotion regulation, parenting, and children's executive functioning in families exposed to intimate partner violence. *Journal of Interpersonal Violence, 27(17)*, 3532–3550. doi:10.1177/0886260512445385

Spann, M. N., Mayes, L. C., Kalmar, J. H., Guiney, J., Womer, F. Y., Pittman, B., . . . Blumberg, H. P. (2012). Childhood abuse and neglect and cognitive flexibility in adolescents. *Child Neuropsychology, 18(2)*, 182–189. doi:10.1080/09297049.2011.595400

Stewart, J. G., Kim, J. C., Esposito, E. C., Gold, J., Nock, M. K., & Auerbach, R. P. (2015). Predicting suicide attempts in depressed adolescents: Clarifying the role of disinhibition and childhood sexual abuse. *Journal of Affective Disorders, 187*, 27–34. doi:10.1016/j.jad.2015.08.034

Tibu, F., Sheridan, M. A., McLaughlin, K. A., Nelson, C. A., Fox, N. A., & Zeanah, C. H. (2016). Disruptions of working memory and inhibition mediate the association between exposure to institutionalization and symptoms of attention deficit hyperactivity disorder. *Psychological Medicine, 46*, 529–541. doi:10.1017/S0033291715002020

Tran, N. K., Van Berkel, S. R., van IJzendoorn, M. H., & Alink, L. R. A. (2017). The association between child maltreatment and emotional, cognitive, and physical health functioning in Vietnam. *BMC Public Health, 17*, 1–13. doi:10.1186/s12889-017-4258-z

Valentino, K., Bridgett, D. J., Hayden, L. C., & Nuttall, A. K. (2012). Abuse, depressive symptoms, executive functioning, and general memory among a psychiatric sample of children and adolescents. *Journal of Clinical Child and Adolescent Psychology, 41(4)*, 491–498. doi:10. 1080/15374416.2012.660689

Viezel, K. D., Freer, B., & Lowell, A. (2015). Cognitive abilities of maltreated children. *Journal of Adolescence, 52(1)*, 92–106. doi:10.1002/pits

Zou, Z., Meng, H., Ma, Z., Deng, W., Du, L., Wang, H., . . .Hu, H. (2013). Executive functioning deficits and childhood trauma in juvenile violent offenders in China. *Psychiatry Research, 207*, 218–224. doi:10.1016/j.psy chres.2012.09.013

Appendix chapter 5

Appendix 5.1

To enhance transparency, here we show bivariate correlations between all executive functioning measures, ages and PTSD symptoms as displayed in Table 5.1.A. In this supplement, we will aim to clarify our decisions and steps regarding three neuropsychological tasks that were excluded from analyses.

First, although not significant, it is surprisingly that the Stroop task has negative correlations with some subscales of the BRIEF (Cognitive Flexibility, Emotion Regulation, Organization of Materials and Task Completion). One participant did not finish the task. To ensure that the task was performed correctly, we investigated whether children performed as expected on the various cards. We found that, indeed, children made more mistakes and were slower on card 3 compared to card 2 and 1, and on card 2 compared to card 1. This led us to think that the task was conducted correctly.

Second, although also not significant, the Stop Signal Reaction Time (SSRT; Stop task) had also some negative correlations with subscales of the BRIEF. Specifically, there was a negative correlation between the SSRT and subscales of the BRIEF (Inhibit, Cognitive flexibility, Emotion Regulation, Plan/Organize, Organization of Materials, and Initiate). Additionally, there was also a negative correlation between the SSRT and PTSD pretest (non-significant) and posttest (significant). We assessed the internal consistency of the stop task before conducting our analyses. We checked if the tracking algorithm worked by investigating the mean reaction time of go trials and stop trials and by investigation the probability of inhibition (De Vries & Geurts, 2014). One participant did not finish all trials of the task. Four participants had a higher mean reaction time for stop trials compared to go trials, and one participant was excluded because the percentage of 50% of inhibition exceeded the range of two standard deviations (mean= 0.57, sd = 0.07). These participants were therefore excluded from analyses. However, as this left the negative correlations unexplained, we investigated more in depth what happened during the performance of this task. We found significant correlations between the mean reaction time on go trials with pretest PTSD symptoms and found that the more PTSD complaints, the longer the mean reaction time. This might indicate that our group of participants did not fully obtained the automatic prepotent response during go-trials that is necessary to inhibit this response in stop trials.

Third, again although not significant, the switch cost on the gender-emotion switch tasks was negatively correlated with some subscales of the BRIEF (Inhibit, Cognitive Flexibility, Emotion Regulation, and Organization of Materials), Stroop task, and pretest PTSD. Two

participants did not start the task. Three participants were excluded from analyses as they were faster on switch trials than on repeat trials. Investigation of omission errors, commission errors, and reaction time showed that there was indeed a switch effect as children performed faster on repeat than on switch trials. However, while comparing our results with the results in the paper of De Vries & Geurts (2012) in which they looked at 8-12 year old typically developing children and children with ASD, we found that the children in our sample made relatively more commission errors in repeat trials (16% vs 10% in ASD sample and 9.4% in typically developing children). This might indicate that our sample used a strategy in which they found speed more important that accuracy.

Table 5.1.A Means, standard deviations, and correlations of all variables used in analyses

Variables	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1. Age	1	0.161	0.004	-0.199	-0.047	0.093	0.019	0.053	-0.036	0.071	0.282*	**-0.329**	**-0.055**	0.028	0.214
2. PTSD pretest		1	0.656*	0.082	0.170	0.226*	0.269*	0.224*	0.256*	0.421*	0.036	**-0.451***	**-0.284**	**-0.171**	-0.039
3. PTSD posttest			1	-0.013	0.042	0.046	0.201	0.023	0.017	0.192	-0.051	**-0.269**	**-0.395**	0.144	0.060
4. Inhibition (Q)				1	0.450*	0.479*	0.377*	0.486*	0.400*	0.242	0.256*	0.336	**-0.348**	**-0.132**	-0.190
5. Cognitive flexibility (Q)					1	0.678*	0.292*	0.414*	0.315*	0.396*	0.421*	**-0.103**	**-0.413**	**-0.235**	-0.299
6. Emotion regulation (Q)						1	0.277*	0.419*	0.343*	0.430*	0.312*	**-0.286**	**-0.358**	**-0.323**	-0.267
7. Working memory (Q)							1	0.719*	0.546*	0.716*	0.404*	-0.061	0.456	0.148	0.089
8. Plan/Organize (Q)								1	0.652*	0.656*	0.571*	0.103	**-0.085**	0.098	-0.028
9. Organization of Materials (Q)									1	0.594*	0.460*	**-0.071**	**-0.415**	**-0.081**	-0.191
10. Task Completion (Q)										1	-0.087	**-0.203**	0.428	0.077	-0.057
11. Initiate (Q)											1	0.011	**-0.048**	0.077	-0.107
12. Inhibition, (T; Stroop)												1	0.341	**-0.029**	-0.626
13. Inhibition, (T; Stop)													1	0.268	0.248
14. Cognitive flexibility (T)														1	0.725
15. Working memory (T)															1
N	94	94	69	83	83	83	83	83	83	47	72	24	19	20	49
Mean	12.81	50.55	30.51	54.93	55.46	57.07	55.43	52.25	50.25	53.30	54.03	54.83	209.22	116.77	75.61
SD	2.890	25.79	24.70	8.86	8.50	7.99	8.17	8.30	9.86	10.56	10.37	27.50	100.22	84.68	11.68

Note. A higher score on the BRIEF, Stroop task (12), Stop Task (13) and Switch Task (14) represents worse executive functioning performance. A higher score on the working memory task represents better performance.

* $p < 0.05$

Contributions of authors

Chapter 2 is published as: Op den Kelder, R., Van den Akker, A.L., Geurts, H.M., Lindauer, R.J.L., & Overbeek, G. Executive functions in trauma-exposed youth: A meta-analysis (2018). *European Journal of Psychotraumatology, 9,* 1-25. https://doi.org/10.1080/20008198.2018.1450595

Contributors: All authors designed the study. RodK conducted literature searches, coded the studies, and conducted the statistical analyses. AvdA assisted with the statistical analyses. HG assisted with categorization of the data. RodK wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Chapter 3 is published as: Op den Kelder, R., Van den Akker, A. L., Ensink, J. B. M., Geurts, H. M., Overbeek, G., de Rooij, S. R., Vrijkotte, T.G.M., & Lindauer, R. J. L. (2022). Longitudinal associations between trauma exposure and executive functions in children: findings from a Dutch birth cohort study. *Research on child and adolescent psychopathology, 50(3),* 295-308

Contributors: RodK, AvdA, GO, HG, and RL designed the study. SdR did the data management of the longitudinal cohort. TV was the project leader of the ABCD study. RodK and JE collected the data. RodK conducted the statistical analysis with assistance of AvdA. RodK wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Chapter 4 is published as: Op den Kelder, R., Ensink, J., 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.

Contributors: RodK, JE, GO, and RL designed the study. RodK and JE, collected data. RodK conducted the statistical analyses with assistance of GO. RodK wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript.

Chapter 5 is to be submitted as: Op den Kelder, R., Van den Akker, A.L., Ensink, J.B.M., Zantvoord, J.B., Geurts, H.M., Overbeek, G., Lindauer, R.J.L. Executive functioning as a predictor of PTSD treatment completion and responsiveness in youth aged 8-18 years old

Contributors: All authors designed the study. Rodk, JE, and JZ collected the data. RodK conducted the statistical analyses. AvdA assisted with the statistical analyses and checked data and syntax. RodK wrote the first draft of the manuscript. All authors contributed to and have approved the final manuscript

Over de auteur

Rosanne op den Kelder (Hoorn, 1990) is de dochter van Tineke Roos en Harry op den Kelder en heeft een jongere zus, Marloes. In 2008 rondde ze haar VWO af op de Oscar Romero in Hoorn. Nadat zij een jaar "Gezondheid en Leven" studeerde aan de Vrije Universiteit in Amsterdam, startte zij in 2009 met de bachelor Pedagogische Wetenschappen aan de Universiteit van Amsterdam (UvA). Tijdens de bachelor nam ze deel aan het Honoursprogramma en werkte ze als onderzoeksassistent bij prof. dr. Ruben Fukkink. In 2012 startte ze met een combinatietraject van de Research Master Child Development and Education en de reguliere master pedagogische wetenschappen aan de UvA. Ze schreef hierin een tweede masterscriptie dat de basis vormde voor hoofdstuk 4. Na de afronding van beide masters werkte ze als onderzoeksassistent bij de onderzoeksafdeling van het Academisch Medisch Centrum (AMC) in Amsterdam en de Bascule. In deze periode schreef zij samen met prof. dr. Geertjan Overbeek en prof. dr. Ramón Lindauer een onderzoeksvoorstel voor een promotietraject. Dit voorstel werd gehonoreerd door de Universiteit van Amsterdam. In oktober 2015 startte zij haar promotietraject. Rosanne werd hierbij begeleid door prof. dr. Ramón Lindauer, prof. dr. Geertjan Overbeek, prof. dr. Hilde Geurts en Alithe van den Akker.

In 2018 startte Rosanne met het Topklas traject van de RINO-groep, waarin zij de opleiding tot gezondheidszorgpsycholoog (2018-2021) en vervolgens de opleiding tot klinisch psycholoog (vanaf 2022) combineerde met haar promotietraject.

Publicaties

Op den Kelder, R., Van den Akker, A. L., Ensink, J. B. M., Geurts, H. M., Overbeek, G., de Rooij, S. R., Vrijkotte, T.G.M., & Lindauer, R. J. L. (2022). Longitudinal associations between trauma exposure and executive functions in children: findings from a Dutch birth cohort study. *Research on child and adolescent psychopathology, 50(3)*, 295-308.

Zantvoord, J. B., Zhutovsky, P., Ensink, J. B., Op den Kelder, R., van Wingen, G. A., & Lindauer, R. J. L. (2021). Trauma-focused psychotherapy response in youth with posttraumatic stress disorder is associated with changes in insula volume. *Journal of psychiatric research, 132*, 207-214.

Regoli-Bakker, S., Kampschuur, M., & Op den Kelder, R. (2021). De kracht van woord en beeld. *Tijdschrift Kinder & Jeugdpsychotherapie, 1*, 12-29.

Struik, A., Pijpers, M., van Dal., M, Regoli-Bakker, S., Kampschuur, M, & Op den Kelder, R. (2021). Levensverhaal en Voorbereidingsverhaal Traumaverwerking. *Tijdschrift Kinder en Jeugdpsychotherapie, 1*, 30-55.

van der Bij, J., Op den Kelder, R. Montagne, B., & Hagenaars, M. A. (2020). Inhibitory Control in Trauma-Exposed Youth: A Systematic Review. *Neuroscience & Biobehavioral Reviews, 118*, 451-462.

Fukkink, R., Jilink, L., Op den Kelder, R., Zeijlmans, K., Bollen, I., & Koopman, L. (2019). The development of interaction skills in preservice teacher education: A mixed-methods study of Dutch pre-service teachers. *Early Childhood Education Journal, 47*, 321-329.

Zantvoord, J. B., Ensink, J. B. M., Op den Kelder, R., Wessel, A. M. A., Lok, A., & Lindauer, R. J. L. (2019). Pretreatment cortisol predicts trauma-focused psychotherapy response in youth with (partial) posttraumatic stress disorder. *Psychoneuroendocrinology, 109*, 104380.

Op den Kelder, R. & Schlattmann, N. (2019). Stemmen in je hoofd de baas: TF-CBT bij een meisje met auditieve hallucinaties en PTSS. *Kind en Adolescent Praktijk, 18,* 20-26.

Op den Kelder, R., Van den Akker, A.L., Geurts, H.M., Lindauer, R.J.L., & Overbeek, G. (2018). Executive functions and trauma-exposed youth: A meta-analysis. *European Journal of Psychotraumatology, 9*, 1-25.

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.

Dankwoord

Najaar 2022. Het is zeven jaar later. Mijn proefschrift is eindelijk af. Toen ik in oktober 2015 aan dit project begon, had ik nooit kunnen denken wat het me zou brengen op zowel professioneel als persoonlijk vlak. In dit dankwoord wil ik stilstaan bij mensen die ik een warm hart toedraag en die hebben bijgedragen aan dit project of aan mijn ontwikkeling tijdens het schrijven van het proefschrift. Dit proefschrift is "maar" een proefschrift, maar voor mij staat het symbool voor zoveel meer.

Als eerste wil ik alle ouders en kinderen die deelnamen aan het onderzoek enorm bedanken! Zonder jullie was dit proefschrift niet tot stand gekomen.

De leden van de promotiecommissie, **Hilde Huizenga, Bram Orobio de Castro, Lisbeth Utens, Arne Popma en Carlijn de Roos,** wil ik hartelijk bedanken voor het kritisch beoordelen van dit proefschrift en hun bereidheid deel te nemen aan mijn promotiecommissie.

Geertjan, Ramón, Hilde & Alithe, wat ben ik blij dat jullie mijn begeleidingsteam waren. Naast dat jullie me enorm veel hebben geleerd heb ik me enorm gesteund gevoeld. Jullie waren mijn navigatie om koers te houden op een soms stormachtige zee. **Geertjan**, jouw vermogen om opbouwende kritiek te geven, verbanden te leggen en perspectief te bieden waren van onschatbare waarde voor het uitvoeren, schrijven, doorzetten en afronden van dit proefschrift. In de overleggen zorgden jouw kalmte, optimisme en luchtigheid altijd voor een prettige sfeer. **Ramón**, bedankt dat je me de kans hebt gegeven om me op zowel klinisch als academisch vlak te ontwikkelen. Door jouw klinische ervaring met getraumatiseerde kinderen leerde ik wetenschap met praktijk te verbinden. **Hilde**, jouw expertise op het gebied van executieve functies waren onmisbaar in dit traject. Door jouw kritische, maar optimistische, houding daagde jij me uit ingewikkelde begrippen in het veld van executief functioneren zelf te begrijpen in plaats van dat jij mij vertelde hoe het werkte. **Alithe**, jij was de degene die het meest direct betrokken was bij de totstandkoming van dit proefschrift, zowel inhoudelijk, academisch als mentaal. Dankzij jou leerde ik open te zijn met een vriendelijke en kritische houding. Ik heb door jou veel geleerd over mezelf in uitdagende situaties. Zonder jouw steun was het me niet gelukt dit proefschrift af te maken. Midden in de heftigste storm was jij de reddingsboei die me even op adem liet komen en weer overzicht gaf. Kortom, ik had me geen betere begeleiders kunnen wensen.

Bedankt alle lieve onderzoekscollega's van PJO en Levvel/de Bascule. Door jullie ging ik met plezier naar werk: **Anita, Maud, Jolien, Liesbeth, Lidewij, Els, Inger, Eva, Esther, Maj, Anita, Chaya, Els, Esther, Eva, Hend, Inger, Jolien, Liesbeth, Lidewij, Lieke, Loes,**

Maj, Mariëlle, Maud, Moniek, Patty, Rosanne, Loes, Susan & Suzan. En specifiek noem ik jou **Brechtje**. Hoewel we elkaar nu niet zo vaak meer zien, ben ik heel blij dat ik een groot deel van het promotietraject samen met jou heb doorlopen. Jouw ononderbroken enthousiasme en gezelligheid maakten de werkdagen op de UvA heel fijn.

Ook een aantal Levvel-collega's in het bijzonder wil ik graag bedanken. **Ariane, Bregje, Carlijn, Carola, Chaim, Irma, Julian, Marie, Maria, Manon, Marieke, Marjolein, Nadina, Nina, Peggy, Petra, Ria, Rianne, Raoul, Sabine, Sandra, Landelijk team, team Amsterdam Zuidoost, team Nieuw-West,** jullie hebben mij gesteund, geïnspireerd en gemotiveerd om door te zetten. Bedankt!

Dan wil ik nog in het bijzonder stil staan bij jullie, **Judith en Jasper.** Eerst als masterstudent en later als promovendus werkte ik samen met jullie op het onderzoeksproject. Jullie hebben me geleerd hoe dataverzameling werkt. En niet te vergeten onze gezamenlijke trip naar het congres in Chicago, waar ook ruimte voor lol en gezelligheid was. Lieve **Judith**, we zijn meer dan collega's en ik ben dankbaar voor jouw steun. Want zonder jou was dit proefschrift ook nooit tot stand gekomen. Jouw eindeloze ambities inspireren mij.

Nathalie, bedankt dat je jouw enthousiasme voor het vak op mij hebt overgedragen en dat je mij zoveel hebt geleerd. Je hebt me altijd aangemoedigd om mezelf verder te ontwikkelen. **Marlies**, bedankt dat je mijn potentieel hebt gezien en me de kans hebt gegeven om dit combinatietraject aan te gaan. Jouw vertrouwen in mij als professional hielpen mij te groeien als mens en psycholoog.

Zonder alle studenten was de uitvoer van dit project onmogelijk geweest. **Dieke, Inga, Marthe, Lous, Olga, Jolien, Shanthy, Fatima & Melissa** bedankt dat jullie me hielpen de data voor dit proefschrift te verzamelen en verwerken. **Joost Daams,** bedankt voor jouw hulp bij de zoektocht naar artikelen voor de meta-analyse.

Ook wil ik graag de mensen in mijn opleidingsgroepen **GZ-2018-W, Topklas** en **KP22B** bedanken, want zonder jullie had ik niet zoveel geleerd als *scientist-practitioner*.

En mijn allerliefste vriendinnen, bedankt voor de ontspanning en plezier die ik met jullie kon maken, maar ook door de immense emotionele steun die jullie mij vooral dit laatste jaar hebben gegeven. Lieve **Laurine,** al sinds de kleuterklas vriendinnen en nu nog steeds bij elkaar. Ik kan me geen leven indenken zonder jou, onze levens zijn al vanaf de kleuterklas met elkaar verweven. Ik heb geen woorden om uit te drukken hoeveel onze vriendschap voor mij betekent. Bedankt dat je er altijd voor me bent. Je luistert naar me zonder oordeel

waardoor ik me geliefd en geborgen voel. Lieve **Daphne,** allereerst bedankt voor het ontwerpen van mijn omslag. Het weerspiegelt zowel de stormachtige tijd tijdens mijn proefschrift als de chaos in het hoofd van getraumatiseerde kinderen waardoor ze soms stuurloos zijn in het dagelijks leven. Maar gelukkig schijnt ergens ver weg altijd de zon. Jouw hand heeft dit gevoel prachtig vertaald. Als vriendin ben je iemand die steun geeft op precies de juiste momenten en jouw hartstochtelijke creativiteit zorgt voor lichtpuntjes als het moeilijk is. Lieve **Mandy,** ik ben dankbaar dat jij in mijn leven bent. Ook jouw steun is van onschatbare waarde voor mij. Jouw liefdevolle en vriendelijke blik maakt dat ik milder naar mezelf en de wereld kijk. Jij kan als geen ander jouw kwetsbaarheid op een krachtige manier laten zien en dat inspireert mij. Als groep vriendinnen - samen met jullie partners en kinderen - voel ik me enorm gedragen en gelukkig.

Lieve **Thierry & Manouk,** onze inspirerende gesprekken, vakanties, weekendjes weg, dineravondjes en wandelingen door het Amsterdamse bos hielpen mij ontspannen. Jullie voelen dichtbij mij en ik ben jullie dankbaar voor onze vriendschap.

Lotte en Bo, de vriendschap die wij bouwden tijdens de bachelor is voor mij speciaal. Onze gesprekken over het werk als orthopedagoog waren altijd inspirerend en onze stapavonden tijdens de bachelor, master en daarna waren super leuk en gezellig!

Julia, we leerden elkaar kennen tijdens de bachelor, maar onze vriendschap ontwikkelde zich verder in de research master en daarna. Jouw luisterend oor maakt dat ik me altijd geliefd en gehoord voel als ik met je praat. Jouw evenwicht inspireert mij, omdat jij dat met wijsheid en vriendelijkheid uitstraalt naar je omgeving. Bedankt voor jouw steun in de vorm van een luisterend oor, lieve kaartjes of een warme maaltijd.

Dear **Signe**, your view on the world, outgoing personality, and kindness, made me reflect on my opinions and life. I'll always remember our adventures together ranging from studying together to overnight hikes through the Rocky Mountains. I love spending time with you, and although we live far you always feel close by.

Dear **Eliala,** your brilliance, authenticity, and abundant energy makes you very special to me as a colleague and close friend. I'm forever grateful for our friendship that started during our first statistics class in the research master. Being around you brings brightness. To me you're like the sun and the moon together. Thank you for standing by my side during my defense.

Lieve **Anne,** de periode in D9.12 waarin we onze werkdagen op elkaar afstemden waren ontzettend fijn en gezellig. Vooral het laatste jaar zijn we dichter naar elkaar toe gegroeid. Als ik bel neem je op en maak je tijd. Jouw vermogen om dingen vanuit een groter perspectief te zien brengen mij tot rust. Bedankt dat je er bent. Ik ben heel blij dat jij als paranimf naast mij wil staan tijdens mijn verdediging.

Jan, ook jij hoort in dit dankwoord. Uit onze gesprekken putte ik altijd weer hoop en vertrouwen. Doordat jij jouw wijsheid met mij deelde, leerde ik meer vanuit mijn hart te luisteren, kijken en leven. Hierin ben ik onderweg, maar op de juiste weg. Bedankt dat jij mijn gids wilt zijn.

Marcel, Silva & Sharmayne, jullie spelen een belangrijke en betekenisvolle rol in mijn leven. Jullie hebben me geholpen een aantal missende puzzelstukjes neer te leggen. Ik ben dankbaar dat jullie er zijn.

Zonder mijn familie had ik hier nu niet gestaan. Lieve **Anna & Bert**, jullie zijn mijn tweede thuis. Door jullie steun als schoonouders voor mij en ons gezin is het mij gelukt dit proefschrift af te maken. **Sander & Ruben,** jullie zijn voor mij als broers. Lieve **mama**, bedankt voor jouw onvoorwaardelijke liefde, steun en aandacht. Van jou heb ik geleerd door te zetten, ook als het moeilijk wordt. Je bent mijn veilige haven. Lieve **papa**, zonder jou was ik nooit zo nieuwsgierig en enthousiast geweest, want op mijn eindeloze waarom-vragen reageerde jij altijd met een uitleg vol respect en liefde. In ons gezin ben jij de rots in de branding. Lieve **Marloes**, na vele stormen zijn we nu zoveel dichter bij elkaar. Jouw wijsheid en rake observaties helpen me verder en jouw humor maakt me (soms) aan het lachen. Bedankt voor alle steun en liefde, bedankt voor wie jij bent.

Lieve **David**, mijn grote liefde. Bedankt voor wie jij wezenlijk bent en voor wie jij mij laat zijn. Met je positieve kijk op het leven en de verre avonturen die we samen hebben beleefd, heb je mijn serieuze en hardwerkende kant van veel tegengas voorzien. Op de momenten dat ik bijna verzoop, hielp je me blijven drijven zonder het van me over te nemen, want jij hebt eindeloos vertrouwen. Ik hou van jou. Lieve **Jonathan,** je bent mijn hart. Als ik bij jou ben, schijnt de zon. In jou zie ik de toekomst. Je bent het allermooiste dat me is gegeven. Ik hou van je.

Als allerlaatste, lieve **Dylan,** kom jij. Dit proefschrift draag ik op aan jou. Zonder jou was dit proefschrift er nooit geweest, want dan was ik er niet aan begonnen. Je bent een overlever van een woeste zee. Jij bent mijn inspiratie en motivatie. Ik ben zo ongelooflijk trots op wie jij werkelijk bent; de lieve en grappige kleine jongen die je bent geweest, de leuke en gezellige jongeman die je bent geworden en de wijze, spontane en sociale volwassen man die je ooit zult zijn. Ik zal er altijd voor je zijn.