Executive functioning in children and adolescents with posttraumatic stress reactions: A systematic review

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Abstract

Background: Posttraumatic stress symptoms are normal reactions to non-typical situations. It is natural for a child to have psychological reactions to a traumatic event, but for some, these reactions may develop into more severe or persistent subclinical symptoms or a full manifestation of the clinical condition of posttraumatic stress disorder (PTSD). Typical symptoms entail episodes with "flashbacks" where the child experience intrusive memories, dreams or nightmares, a perception of "numbing" and a feeling of emotional flattening. They also tend to feel a distance from other people, reduced reactions on the surroundings, anhedonia (an inability to experience pleasure) and avoidance of activities and situations that potentially can remind of the traumatic event. Because of the high rates of youths experiencing traumatic events and their possibility of developing PTSD, the importance of understanding their cognitive functioning could be important in professions that work with children and adolescents. Executive functioning is one domain of particular interest, as the functions are important in daily life, both in social settings and especially in relation to school achievement.

Method: The literature search was done in Scopus and 133 studies were identified and systematically reviewed for the thesis. A total of 15 studies were eligible for the review. These studies form the basis of this master thesis.

Results and conclusion: Median effect sizes in complex executive functioning showed medium to large ($d = 0.77$) differences between children and adolescents with posttraumatic stress reactions compared to unexposed controls. Comparisons of groups exposed to traumatic events with and without PTSD showed smaller effect sizes (Median $d = 0.39$) in complex measures. Investigating more specific executive functions, fluency and shifting showed the largest effect sizes in PTSD compared to unexposed controls (Median $d = 0.91$ and median $d = 0.73$) but when compared to a group of children and adolescents exposed to traumatic events without PTSD working memory updating seemed to be most affected (median $d = 0.48$). In sum, the results give implications for assessment and clinical work with youth exposed to traumatic events. We should be aware of the poor executive functioning that may be an issue in children with a history of traumatic exposure, and the big impact this could have on social functioning and school performance.

Sammendrag

Bakgrunn: Posttraumatiske stress symptomer er vanlige reaksjoner på ikke-typiske situasjoner. Det er naturlig for et barn å ha psykologiske reaksjoner på en traumatisk hendelse, men for noen kan dette utvikle seg til mer vedvarende subklikiske symptomer eller en forekomst av den kliniske formen av posttraumatisk stresslidelse (PTSD). Typiske symptomer innebærer episoder med «flashbacks» hvor barnet opplever påtrengende minner, drømmer eller mareritt, en følelse av «nummenhet» og en følelse av emosjonell «utflating». De tenderer også til å føle en avstand fra andre mennesker, reduserte reaksjoner ovenfor omgivelsene, vansker med å oppleve glede og unngåelse av aktiviteter og situasjoner som potensielt kan minne om den traumatiske hendelsen. På grunn av den høye forekomsten av barn og unge som opplever traumatiske hendelser og deres mulighet for å utvikle PTSD, er det viktig å forstå deres kognitive fungering. Denne kan være viktig i profesjoner som jobber med barn og unge. Eksekutiv fungering er en domene av spesiell interesse, da disse funksjonene er viktig i daglig liv, både i sosiale settinger og spesielt med tanke på skoleprestasjoner.

Metode: Gjennom en systematisk litteraturgjennomgang ble 133 studier identifisert og gjennomgått, og 15 av disse møtte kriteriene for inklusjon. Dette danner grunnlaget for denne masteroppgaven.

Resultater og konklusjon: Medianen i komplekse mål av eksekutiv fungering viste medium til stor effektstørrelse ($d = 0.77$) i forskjeller mellom barn og ungdom med posttraumatiske stressreaksjoner, sammenlignet med en ueksponert kontrollgruppe. Sammenligninger av grupper som var eksponert for traumatiske hendelser med og uten PTSD viste mindre effektstørrelser i kompleks eksekutiv fungering (median $d = 0.39$). Når mer spesifikke eksekutive funksjoner ble undersøkt, viste «fluency»/kognitiv fleksibilitet og «shifting»/endring i fokus de største effektstørrelsene sammenlignet med ueksponerte kontrollgrupper (Median $d = 0.91$ og median $d = 0.73$). Når de ble sammenlignet med en gruppe barn og ungdom eksponert for traumatiske hendelser uten PTSD, viste arbeidsminne seg å være mest påvirket (median $d = 0.48$). Oppsummert gir resultatene implikasjoner for utredning og klinisk arbeid med barn og ungdom utsatt for traumatiske hendelser. Vi burde være klar over at eksekutive funksjoner kan være svake hos unge med en historie av traumatiske hendelser bak seg, og den store påvirkningen det kan ha på sosial fungering og skoleprestasjon.

Preface

My journey started with a year of psychology, when I discovered my interest in children and development. I further took a bachelor's degree in pedagogy with focus on educational psychology. The destination was always a master´s degree in educational psychology counselling, and I am now at the finish line. My time at the University of Oslo have been rewarding, challenging and I am now ready for new challenges.

First of all, I want to thank my supervisor of this master thesis, Christian Krog Tamnes, for always being inspiring and full of knowledge. Furthermore, I would like to thank my co-supervisor, Egil Nygaard that has an enormous amount of knowledge about children that has experienced traumatic events.

The work with this master thesis have been exciting, given me a lot of knowledge as well as it has been challenging at times.

Thanks to all the people I have got to know these last six years of studies. Especially to all of my fellow students and friends at PPR for making these two last year's wonderful. You are going to be the best educational psychology counsellors. Thanks to all of my friends for respecting my busy schedule. Especially thanks to my mum that have encouraged me and read through my essays through all of these years.

Blindern, May 2018
Otelie Nyvold

Contents

1 Introduction

This chapter contains an introduction and a background for my choice of topic. First, the actualization of the chosen topic will be discussed, as well as the importance and relevance of this issue in the discipline. Furthermore, I will present my delimitations and my choice of research questions.

1.1 Background and choice of theme

Many of the children that are referred to the mental health specialist health service have been exposed to traumatic experiences. In a Norwegian study of 184 children in the specialist health service that assessed the children for trauma exposure, they found that 47.2% of the sample had been exposed to one or more traumatic event (Ormhaug, Jensen, Hukkelberg, Holt & Egeland, 2012). Traumatic events are typically understood as situations that leave the young person in state of perceived helplessness. Terr (1991) separated between single traumatic events, like accidents or natural disasters, and repeated events. The latter includes war, maltreatment etc. A subgroup of children exposed to traumatic events develop posttraumatic stress disorder (PTSD). This is a clinical condition defined by four distinct factors: 1) re-experiencing of the trauma, 2) effortful avoidance of trauma reminders, 3) negative alteration in mood and cognition and 4) alterations in arousal and reactivity (American Psychiatric Association [APA], 2013).

There is promising treatment for children and youth with posttraumatic stress disorder (Jensen et al., 2014; Sachser, Keller & Goldbeck, 2017), but for assessment and counselling to the individuals surrounding children and youth that struggles with posttraumatic stress reactions, it is important to understand the cognitive challenges the disorder could cause.

It is thought that prefrontal regions of the brain may be harmed by persistent stress and maltreatment, and these regions are known to be central for executive functions (Arnsten, 1998; Arnsten, Raskind, Taylor & Connor, 2015). Amygdala, that is a centre that respond to danger, will be highly activated when children experiences threats. This is a subjective feeling, and while some children handle a lot of stress, others may not. Uncontrollable stress will strengthen the amygdala because the brain responds to a threat, but at the same time

weaken the prefrontal cortex function, which is important for regulation of behaviour, thought and emotion (Arnsten et al., 2015). Executive functions describe a set of higher-order cognitive processes involved in this regulation. Examples of these cognitive processes are attention control, inhibition, working memory, cognitive flexibility, planning and problem solving. Executive functions are important functions for daily functioning, interpersonal situations and social situations as well for academic performance in school (Hulme & Snowling, 2009).

School psychologists should be aware of the link between posttraumatic stress reactions and executive functions when working with children with a history of traumatic exposure. Knowledge about the connection may help us to better understand their current functioning and the assessment results. It could also help us to better educate family members, school personnel and the community about the effects of exposure to traumatic event(s). Furthermore, this knowledge may help us work towards prevention (Davis, Moss, Nogin & Webb, 2015). PTSD can interfere with learning, self-control and peer relationships within the school and it is therefore important to help schools at being better prepared to help traumatized children (Dyregrov, 2004, cited in Thapar et al., 2016).

When working with children that have been or still are exposed to traumatic events, the importance of understanding their cognitive functioning and the consequences of their experience is essential. This master thesis will give knowledge about posttraumatic stress reactions and executive functions, and a deeper insight into the associations between trauma exposure and associated reactions on executive functioning in children. Such knowledge can be central in understanding several children as a teacher, as an educational psychology counsellor and for other occupations working with children and adolescents.

1.2 Research questions

Many studies have reported a connection between deficits in executive functioning and different types of psychopathology (Snyder, Miyake et al., 2015, cited in Friedman & Miyake, 2016). Among the disorders with known group-level deficits in executive functioning are autism spectre disorder (Hulme & Snowling, 2009). Children with attention deficit hyperactivity disorder have also in several studies been shown to on average have

deficits in response inhibition (Aupperle, Melrose, Stein & Paulus, 2012; Hulme & Snowling, 2009). The main aim of this systematic review is to explore the connections between posttraumatic stress reactions and executive functions in children. More specifically the thesis focuses on the following research questions:

1. *Is there a connection between posttraumatic stress disorder and executive functioning in children and adolescents?*
2. *Are specific executive functions particularly affected in children and adolescents with posttraumatic stress disorder?*
3. *Do children and adolescents with posttraumatic stress disorder show deficits in executive functioning compared to children and adolescents exposed to traumatic events without posttraumatic stress disorder?*

1.3 The structure of the thesis

This first chapter includes an actualization of the theme and a presentation of the research questions.

Chapter 2 presents definitions of trauma and posttraumatic stress disorder. It will also contain a presentation of different forms of maltreatment and other situations that can be traumatizing for children and youth. I will also briefly discuss the issue of resilience. Furthermore, the chapter will comprise theories of PTSD, and work by theorists including Horowitz, Brewin, Ehlers & Clark will be presented as a background for understanding trauma.

Chapter 3 will give definitions of executive functions. It will also entail a discussion of the challenge in operationalize the term. The unity and diversity model of executive functions given by Friedman and Miyake will then be presented, and in coherence with this model, the functions of inhibition, updating and shifting will be presented as three central parts of executive functions. I will also present some tools that are frequently used in the assessment of executive functioning.

The fourth chapter discusses how poor executive functioning may be an issue in children and youth with posttraumatic stress reactions. We will look at cognitive theories and their

possible relations to aspects of executive functioning, at prefrontal areas of the brain that may connect poor executive functioning to maltreatment, as well as other points that may connect poor executive functioning to posttraumatic stress reactions.

Chapter 5 is the methods chapter and will include a presentation of the method systematic review. I will give an overview of the criteria for the selection, and discuss some central terms such as validity, reliability and effect sizes.

Chapter 6 is the results chapters. The results of the systematic review will be presented, including overviews of the tasks used to measure executive functions and the main findings. The included research will be presented and summarized according to the specific research questions.

Chapter 7 covers the discussion of the presented studies in relation to the research questions. I will summarize the main aspects of the studies with a critical view. I will also discuss related questions, such as whether it could be that those children who develop PTSD have weaker executive functions also prior to developing these symptoms. Further, there will be a discussion of mediating factors that could have contributed to the questions, like intelligence or type of traumatic event the child have been exposed to. I will also look at whether different types of traumatic events could have an impact on the executive functioning among the children with posttraumatic stress reactions.

The last chapter, chapter 8 will discuss implications. Specifically, I will evaluate what significance the findings have for practise as an educational psychology counsellor, as well as implication for further research.

2 Traumatic events and posttraumatic stress reactions

The purpose of this chapter is to introduce the clinical condition of posttraumatic stress disorder and related phenomena. The chapter will also give an historical view of the theme, where the focus will be on the work by Horowitz, Brewin, Ehlers and Clark.

2.1 Definitions and prevalence

Children can be exposed to various types of traumatic events, including separate types of maltreatment, as well as disasters. The reactions to these events vary among children and youth. For example, while some children experiencing a divorce between the parents as a traumatic event and develop unhealthy psychological reactions to this, others are more resilient and show minimal long-term reactions. With the term psychological trauma, we refer to overwhelming, uncontrollable events that entail an extraordinary psychological strain for the child or adolescent that is exposed to the event. Usually this kind of event arises as a surprise, but some events are repeated in more or less identical forms. The event often leaves the child helpless and vulnerable (Dyregrov, 1998, cited in Raundalen & Schultz, 2006).

It is obviously natural for a child to have psychological reactions to a traumatic event, but for some, these reactions may develop into subclinical symptoms or a full manifestation of the clinical condition of PTSD.

It is estimated that between 50% and 60% of people will experience a serious traumatic event, such as sexual assault or severe accidents, throughout their life´s (Kessler et al., 1995, cited in Aupperle et al., 2012). More recent studies have found that between 20% and 48% of youth were exposed to different types of traumatic events (Saunders & Adams, 2014). The prevalence of all kinds of sexual abuse in studies have been found to range from 15% to 30% of girls and from 5% to 15% of boys (Danesem & McCrory. 2015). The prevalence of physical maltreatment has been found to be between 5% and 35%, and of emotional mistreatment between 4% and 9% (Danesem & McCrory, 2015). Between 10% and 20% of children and adolescents are exposed to violence between their parents in their homes

(Danesem & McCrory, 2015). The prevalence of neglect has in England and the US been found to be between 6% and 12% (Danesem & McCrory, 2015). A study performed by the UK National Society for the Prevention of Cruelty to Children (NSPCC) found that approximately 1 of 5 children (18.6%) had experienced a kind of mistreatment. Earlier studies done by NSPCC also found that children who had experienced a form of maltreatment were 2-3 times more likely to experience another form of mistreatment and to be a victim for other crimes over time (Danesem & McCrory, 2015). This shows us the extreme importance of both prevention, individual adaptation in schools and treatment of these children. While experiencing a traumatic event for all children will cause some form of stress reactions not all children will develop PTSD. The statistics on this are however somewhat different depending partly upon the type of traumatic event.

Studies in war torn countries find the incidence of PTSD to be high among the people exposed to the traumatic event (Salmon & Bryant, 2002). Sexual abuse also results in high rates of PTSD (Salmon & Bryant, 2002), and this is also found in children witnessing violence (Margolin & Gordis, 2000, cited in Yule & Smith, 2015). A study done on the 200 survivors of the sinking ship "Jupiter" reported a prevalence of 51% with PTSD (Yule et al., 2000, cited in Yule & Smith, 2015). After a club fire in Gothenburg, 25% met the diagnostic criteria for PTSD 18 months later (Broberg, Dyregrov & Lilled, 2005). The prevalence of PTSD also varies in different studies and also vary among different types of traumatic events. The prevalence of experiencing a traumatic event seem to have higher rates in countries emerging from conflict (Atwoli, Stein, Koenen & McLaughlin, 2015). It has been estimated that about 30-40% of children and adolescents that experience traumatic events, will develop PTSD (Fletcher, 1996, cited in Ormhaug et al., 2012). Some of these do have PTSD for a while, and respond well to the treatment, while other do struggle with the disorder for the rest of their life. The lifetime prevalence in the general population is reported to be between 5-9% (Giaconia et al., 1995; Merikangas et al., 2010; Elklit, 2002, cited in Yule & Smith, 2005).

PTSD is classified as an anxiety disorder, but it has also been argued that it should be recognized as a disorder of memory (O´Donohue & Elliot, 1992, cited in Yule & Smith, 2015). The diagnosis was first conceptualized after observations of the Vietnam war veterans' reactions. It was noticed that the veterans often had symptoms in three clusters: 1)

intrusive memories of a traumatic event, 2) emotional numbing and avoidance of reminders of the event as well as 3) physiological hyperarousal (American Psychiatric Association, 1987, cited in Yule & Smith, 2015). One can say that posttraumatic stress symptoms are normal reactions to non-typical situations (O´Donohue & Elliot, 1992). It is normal for children that experiences traumatic events to also experience reactions after the incident(s). But this will only in some cases develop into the diagnose PTSD (Yule & Smith, 2015). More recently, as the work with ICD-11 is ongoing, the separation between PTSD and a more complex type of the disorder – complex PTSD (CPTSD) is also under construction and will be done in 2018. A study performed by Sachser, Keller and Goldbeck (2017) investigated 155 children and youth in Germany between 7 and 17 years, that all were exposed to one or more traumatic events and had developed at least medium distressing posttraumatic stress-symptoms. They wanted to find out if treatment had various effect on PTSD versus CPTSD. The results support the distinction between the two diagnoses (Saschser, Keller & Goldbeck, 2017).

Traumatic events do not always lead to posttraumatic stress disorder, and one of the reasons why some children overcome the traumatic events easier than others could be explained by the phenomenon of resilience. Resilience refers to a positive adoption, despite experiencing adversity (Herrman, Stewart, Diaz-Granados, Berger, Jackson & Yuen, 2011). Resilience involves protective factors, including psychological traits such as openness, extraversion and agreeableness, internal locus of control and self-efficacy and self-esteem (Herrman et al., 2011). A critical environmental factor that also has a large impact on how the individual copes with traumatic events is social support, both from family members and peers (Herrman et al., 2011). Further, secure attachment from a non-abusive parent has been found to be an important factor for coping and well-being in children exposed to traumatic events (Herrman et al., 2011).

2.2 ICD-10 & DSM-5

One of the criteria in the diagnostic guidelines in the International Classification of Diseases and related health problems, version 10 (ICD-10) is that there is proof that symptoms of PTSD appeared within six months after the traumatic event. Typical symptoms entail episodes with “flashbacks” where the child experience intrusive memories, dreams or

nightmares, a perception of “numbing” and a feeling of emotional flattening. They also tend to feel a distance from other people, reduced reactions on the surroundings, anhedonia (an inability to experience pleasure) and avoidance of activities and situations that potentially can remind of the traumatic event. In some occasions where the traumatized individual experience reminders of the trauma, it can result in critical outbreaks with fear, panic or aggression, triggered by stimuli that triggers an abrupt re-experience of the trauma or the aboriginal reaction of the trauma. Emotional distance and avoidance of stimuli that can cause revival of the traumatic event often occurs (World Health Organization [WHO], 1999).

Diagnostic and Statistical Manual of Disorders, fifth edition (DSM-5) mainly divides the diagnostic criteria in to three main categories: re-experience, avoidance and activation. The first cluster (A) of symptoms demands that the individual have been exposed to some sort of traumatic event. The second cluster of symptoms contains the traumatic memories and how they appear, for example as distressing dreams or dissociative reactions as flashbacks. The third cluster (C) is about persistent avoidance of stimuli associated with the traumatic event, and explains how the individual would avoid memories, thoughts of feelings by for example avoid reminders such as places, people, activities, conversations etc. Cluster D is about alterations in cognitions and mood that is associated with the traumatic event(s), as negative beliefs or expectations about oneself or the world, negative feelings about guilt and shame and feelings of detachment from others and inability to experience positive emotions. The last cluster consist of six symptoms as irritable behaviour, reckless or self-destructive behaviour, hypervigilance, problems with concentration and issues with sleep and exaggerated startle response (APA, 2013).

2.3 Separate categories of traumatic events

Terr (1991) divided traumatic events into different categories. He argued that there were two types of traumatic events and named them type 1 and type 2. The children suffering of type 1 traumatic conditions experience one single event, while type 2 entails longstanding or repeated exposure to external events. These repeated events will leave the child to constantly try to protect the psyche. Terr argues that these two types will yield dissimilar reactions, with generally more severe reactions to repeated trauma (type 2). Both of these types of traumatic events can however lead to PTSD but may vary in how often they do so. In general, situations

that often are repeated or ongoing over time, like sexual abuse, war and children witnessing violence, have higher rates of PTSD compared to single events like accidents (Terr, 1991). Others have suggested that it is important to separate between "familial maltreatment trauma" and "non-familial trauma" and that this distinction can help explain some of the inconsistent results in research on cognitive consequences of traumatic experiences (Malarbi, Abu-Rayya, Muscara & Stargatt, 2016).

2.4 Theoretical perspectives

2.4.1 Horowitz

Among the earlier theories about trauma, Horowitz´s work is central. Horowitz said that the traumatized individual always would be in between the two extremes; between the need of pushing away the thoughts to protect itself of being overwhelmed by the traumatic memories, and the need to express and work through the experience(s). If the traumatized person don´t get the opportunity to work through the thoughts and process the experience, it would result in chronic posttraumatic stress disorder, according to Horowitz (Raundalen & Schultz, 2006).

2.4.2 Dual representation theory

Chris Brewin´s theory describes that traumatic memories are stored and remembered in a different way than ordinary, daily memories. The healing of the posttraumatic stress-symptoms takes place by transforming the separated memories to ordinary memories that are easier to talk about. This process is by Brewin called dual representation theory. He proposed that there are two memory systems; verbally accessible memory system (VAM) and situationally accessible memory system (SAM). The thought of two separated systems of memory dates back as far as to Pierre Janet, a French neurologist who distinguished traumatic memory from ordinary or narrative memory. Janet suggested that frightening experiences would be unable to adopt into a person´s ordinary beliefs, and because of that would be stored in a different form, "dissociated" from conscious awareness (Brewin, 2003). The verbally accessible memory system contains ordinary memories that is easier to talk about, while the situationally accessible memory system is where the traumatic memories often are kept. More precisely the VAM memories are available for verbal communication with others, but the content is somewhat restricted because they record just what has been intentionally attended to. On the other side SAM memories cover information that is not that consciously

attended to, such as sights and sounds that were present in the traumatic event but that was not recorded in the VAM memory. The flashbacks that often appear in PTSD is triggered by situational reminders of trauma, and one can assume that this is reminders from the situationally accessible memory system. The emotions that accompany SAM memories are mainly feelings like shame, fear, helplessness and horror attached to the traumatic event(s) (Brewin, 2003).

2.4.3 Ehlers & Clark

Ehlers and Clark´s model is inspired by Brewin, Horowitz and other theorists work, and is designed to explain the persistence of PTSD and to provide a framework for the cognitive-behavioural treatment of PTSD. Ehlers and Clark claim that during the trauma appraisal mental defeat is a central thought process. By mental defeat they mean the perceived loss of all psychological autonomy and the sense of not being human any longer. This has an important role in the interpretation of the traumatic event, as patients who experience mental defeat are more likely than other victims of trauma to interpret the trauma as evidence for a negative view of themselves (Ehlers & Clark, 2000). An example of this could be a child who gets sexually abused. If the child experiences mental defeat, the child will more likely interpret the trauma as evidence for that the child are not a worthy person or that they are permanently damaged by the trauma.

Posttraumatic stress disorder is classified as an anxiety disorder. While the cognitive model of anxiety disorder is a result of appraisals related to impending threat, it is in PTSD a memory of an event who have already happened that is the problem. Ehlers and Clark propose that this puzzle could be resolved by suggesting that PTSD occurs only if the individual process the traumatic events in a way that gives a sense of current threat. The model proposes that two processes lead to this sense of current threat. Individual differences in evaluation of the traumatic event and/or its consequences is the first part of the two processes. The second part of the process that lead to the sense of current threat is individual differences in the memories of the event and its link to autobiographical memories (Ehlers & Clark, 2000). In other words, the model explains the fact the people who experience chronic PTSD, are afraid in the presence and for the future, while the trauma belongs to the past (Raundalen & Schultz, 2006).

It is assumed that the individuals who experience PTSD are unable to see the trauma as a time-limited event that don't have a global negative implication of their future. This threat to the individual could be either external (the world is full of evil) or internal (the threat to one´s view of oneself) (Ehlers & Clark, 2000). The posttraumatic stress-symptoms is maintained by an amount of guilt, self-blame, negative thoughts, thoughts of hopelessness and reduced self-confidence (Raundalen & Schultz, 2006).

2.5 Summary

Posttraumatic stress symptoms are normal reactions to non-typical situations. It is normal for a child who has experienced a traumatic event to show psychological and physiological reactions after the incident(s), but in a minority this will develop in to the clinical condition PTSD. The disorder is described in both ICD-10 and DSM-5 with quite similar descriptions (APA, 2013; WHO, 1999). ICD-11 – a version of ICD that will be ready in 2018, additionally includes a more complex type of posttraumatic stress disorder (CPTSD).

Several theories have had an influence on the field, and among these, Horowitz, Brewin, Ehlers and Clark have played an important role. These have had an impact on treatments and understanding of the term. Common for these theories, is the search for an explanation of the reactions to trauma. While Brewin describes it as different memory systems (Brewin, 2003), Horowitz claim that the disorder is a result of an imbalance between pushing the memory away and the need to work through the thoughts (Raundalen & Schultz, 2006). Ehlers and Clark are inspired by both of the theories and provides us with a framework explaining that the individuals experiencing PTSD, are afraid of the future, while the trauma belongs to the past (Ehlers & Clark, 2000).

3 Executive functions

3.1 Definitions

Executive function deficits, classically described in neuropsychological studies of patients with frontal lobe damage, refer to problems with control and regulation of behaviour (Miyake & Friedman, 2000). As a result of scientific interest in the 1840s to understand the functions of the frontal brain lobes, and especially the prefrontal cortex, the concept of executive functioning evolved (Harlow, 1848, 1868; Luria, 1966, cited in Barkley, 2012). Today, executive functions are an umbrella term that describes a broad set of cognitive processes. Different theorists define the term in somewhat different ways, but in common, executive functions are considered to be processes that operate in a "top-down" way to control and organize other cognitive processes when the individual is performing complex cognitive tasks (Barkley, 2012; Hulme & Snowling, 2009). Examples of specific executive functions are attention control, inhibition, working memory, cognitive flexibility, planning and problem solving (Barkley, 2012). Executive functions are important functions in daily functioning, interpersonal situations and social situations as well for academic achievement (Hulme & Snowling, 2009). If a child has poor executive functioning, the child may struggle with switching between tasks and focusing on the task when having other irrelevant information that disrupt the relevant task. Further, working memory is closely linked to executive functioning, and is important for performance on several school situations. Further, the child could struggle with attending social situations because of missing focus on the message being brought up by the others, because they often struggle with shutting of irrelevant information like thoughts or the environment around the situation (noise etc.).

Friedman & Miyake (2016) defines executive functions as high-level cognitive processes that influence lower level processes and makes it possible for individuals to regulate thoughts and actions during goal-directed behaviour. The abilities include to stop automatic responses, the ability to not be distracted by irrelevant stimuli in the environment or memory, to switching between task sets, as well as aspects of working memory processes, and planning and fluency.

Barkley (2012) argued that the lack of agreement when it comes to which specific cognitive functions that should be included in the umbrella term executive functions is related to vague and varying definitions of executive functions. He describes an example from a conference he attended, where ten experts on executive functions were asked to list terms that would be considered executive functions. In total, they came up with 33 terms, and among these responses, they argued that the following six components should be considered executive functions: self-regulation, sequencing of behaviour, flexibility, response inhibition, planning and organization of behaviour (Barkley, 2012). This plethora of definitions and concepts also lead to challenges with assessment of executive functions.

As a more precise definition, Barkley suggests that executive function could be related to self-regulation. Self-regulation is a form of self-directed action that entails modifying one´s behaviour to accomplish a future goal or outcome more or less likely to occur (Barkley, 1997a, 1997b, cited in Barkley, 2012). Executive functions can therefore be defined as "those self-directed actions needed to choose goals and to create, enact, and sustain actions toward those goals, or more simply as self-regulation to achieve goals" (Barkley, 2012, p. 60).

Barkley separated between four components of executive functions that depend on inhibition. These four components are working memory, self-regulation of affect, motivation and emotional arousal, internalized speech and reconstruction (Hulme & Snowling, 2009). This tells us that the executive functions really are connected in some way, and that the other components of executive functions are dependent on inhibition. An example of this may be that working memory is affected if the child do have inhibitory deficits, because irrelevant information may disrupt the working memory.

3.2 The unity and diversity model

Executive functions have, at least traditionally, been mainly associated with the prefrontal cortex (PFC), initially based on observations of patients with damage in this area of the brain that often demonstrate struggles with goal-directed behaviour (Luria, 1966; Stuss, 2011, cited in Friedman & Miyake, 2016). Typically, these patients struggle in tasks that require controlled processing (Rabbitt, 1997, cited in Friedman & Miyake, 2016), that involves consciously paying attention to and put effort in to what we interpret. The literature has

discussed the relationship between the collection of processes that is included in the term executive functions. Meanwhile it has been argued that there are some similarities that have led researches to believe that the impairments in executive functions have something in common (Friedman & Miyake, 2016). Several researchers have noted that the low correlation between the executive functions may be caused by the low reliability, different strategies and task impurity (Burgess & Stuss, 2017; Shallice & Bugess, 1996). Reliability is whether there is a stability in what we measure, and if it is repeatable (Bryman, 2015). Executive functions will develop over time and it may not be reliable to the next assessment because of the rapid development in childhood and youth.

The definition of executive functions as related but separable abilities are captured in the unity and diversity model. To understand which parts of the executive functions that share similarities Friedman & Miyake (2016) used a latent variable analysis. This kind of analysis capture common variance across multiple measures and will exclude random measurement error. Using this analyse technique, they found that a battery of traditional simple executive function tasks clustered together in three domains, but also relations among these three types of executive functions; prepotent response inhibition, working memory updating and task-set shifting, and the common variance between these separate functions were high. The highest correlations were found between inhibition and shifting (0.79), as well as inhibition and updating (0.77). This could tell us that inhibition may have a close link to the other´s, while updating and shifting do have a correlation that is not as high as among the others (0.38). On the other hand, even this correlation could be interpreted as a medium to large effect size according to Cohen (Field, 2009). This may not come as a surprise, when a child´s ability to do any task requires the ability to shut out irrelevant information such as noise in the classroom or thoughts that are irrelevant in the task (Friedman & Miyake, 2016). These aspects of executive functions will further be presented, and I will use this delimitation to investigate whether posttraumatic stress reactions in children is associated with specific executive functions.

The model also gives an idea of the correlation between the assessment-tools used in assessing the three aspects of executive functioning. The tasks used to measure inhibition do correlate lowest with the assessment tools, while the correlations between shifting and the

task category got the highest correlation (0.71). Further, the correlations between tasks that is supposed to measure updating and shifting do have a moderate correlation to inhibition, which may suggest that all executive functioning measures are dependent on the inhibition index. In sum, the diversity and unity model suggest that these three executive functions correlated (showed unity) – but that they also were separable (showed diversity) (Friedman et al., 2008). We can say that they are separate executive functions, that do have a connection to one another. These specific executive functions will now be described in some more detail.

3.2.1 Inhibition

Inhibition refers to the individual´s ability to restrain inappropriate responses in both cognitive and socio-emotional settings. This can entail problems with turning off external stimuli and to restrain internal distractions that disrupt learning. This is one of the six executive functions that the ten experts on the field executive functioning agreed on (Barkley, 2012), and a central executive function in the unity and diversity model (Friedman & Miyake, 2016).

3.2.2 Shifting

Shifting require switching back and forth between subtasks according to a cue. Tasks that require shifting between these mental sets are for example the number task, the color-task and the category task (Miyake et al., 2000). The ability to easily shift between tasks have critical importance in children´s success in social and academic settings (MacDonald, Ellis, Pulsifer & Lyons, 2015). This is because we need the ability to shift between mental sets both during a school task or in a social setting, for example in change of topics.

3.2.3 Working memory updating

Updating is closely related to working memory, and requires coding information for relevance and replacing old, no longer relevant information with this updated information (Miyake et al., 2000). Updating is measured with tasks that requires working memory, such as tasks measuring the ability to remember a series of stimuli in order, which could be numbers, sentences or auditory stimuli. The working memory could be explained as kind of a workplace where we gather, attend to and actively process information. The working memory is important in regulation attention, planning and as well as action (Siegler et al., 2011).

3.2.4 Fluency

Fluency is not included in the unity and diversity model but is a domain of executive functioning that is often referred to when speaking about these functions. Fluency is typically referred to as spontaneous flexibility, and one of two categories of cognitive flexibility. Fluency requires that the child is producing responses within an often given category, either non-verbally or verbally (Spreen & Strauss, 1998).

3.2.5 Heritability

Later work on the unity-diversity model using twin-studies have documented that these specific executive functions (inhibition, shifting and updating) are highly heritable. Friedman and Miyake (2016) do stress that the high heritability does imply that these functions are not immune to changes. As they emphasize, changes in the environmental surroundings can lead to changes in heritability. There are also transactions between genes and environments, such that if a child for example has inherited genes associated with high executive functioning, the child will more likely also seek out activities that develop the executive functions (Plomin, Defries & Loehlin, 1977, cited in Friedman & Miyake, 2016).

3.3 Behavioural assessment of executive functions

To measure executive functions in a more complex context, as well as the specific executive functions, there are a large amount of available assessment tools. Wisconsin Card Sorting tasks (WCST) and Tower of London/Hanoi are assessment tools that are meant to measure more complex executive functioning. “Complex” here refers to that these tasks likely require involvement of several specific functions. For example, WCST requires strategic planning, organized searching, the ability to use environmental feedback to shift cognitive sets, goal-directed behaviour, and the ability to modulate impulsive responding, problem solving and some aspects of attention (Spreen & Strauss, 1998). The task is done by asking the child to sort the cards in a particular dimension, as colour or shape, then switching to another category when the examiner tell the child to (Friedman et al., 2008). Tower of London/Hanoi (including the different versions of this task, e.g. NEPSY Tower) is used to assess higher level problem-solving abilities, as well as working memory, inhibition and visual spatial memory. The task requires both planning and switching position of coloured balls to copy the

pattern of the solution (Samuelson, Krueger, Burnett & Wilson, 2010). While these latter tasks require involvement of several executive functions, there are other tests that aim to measure more specific functions.

3.3.1 Inhibition measures

***Stroop**:* One of the tasks often used to measure inhibition is the stroop test. The stroop test can for example be a test where the child is asked to name the ink colours of written colour words. This require attention to keep out irrelevant information and not read the word, but instead focus of the ink colour, which can be congruent or incongruent with the written word (Miyake, Friedman, Emerson, Witzki, Howerter & Wager, 2000).

Go/No-Go: The Go/No-go task is another task often used to assess inhibition, and the subjects are instructed to press a button in response to a specified target stimulus (Carrion, Garrett, Menon, Weems & Reiss, 2008). In this way, the task will measure the ability to overlook some information that is irrelevant and to in these cases withhold their response. A kind of inverse version of a Go/No-go task in which the no go stimuli, is especially rare and serve as the target to which participants is asked to inhibit their response, is the Continuous performance test (De Bellis, Hooper, Spratt & Woolley, 2009; De Bellis, Woolley & Hooper, 2013).

Flanker interference task: The task is designed to measure the child´s ability to ignore interfering stimuli and to only respond to the targeted stimulus. A set of visual stimuli is shown at the same time, and the child needs to respond to a certain stimulus (Park et al., 2014), and ignore the other stimuli. This can for example be a row of arrows, where the target stimulus is the one shown in the middle of participants are asked to indicate the direction of this arrow. The flanker stimuli can in this case either point in the same direction (congruent) or in the opposite direction (incongruent).

3.3.2 Shifting measures

Trail making task: This task is divided in to two parts. The Trail making test part A consists of 15 numbers for children between 9-14 years and 25 numbers for children over 15 years. The numbers are randomly located on a piece of paper, and the child is asked to draw a line with a pencil from the lowest to the highest number. On part B, the same amount of stimuli

are presented, but in this case both numbers and letters, and the child is asked to alternate by drawing a line from 1 to A to 2 to B and so forth. The task is meant to measure attention, speed and cognitive flexibility (Spreen & Strauss, 1998).

3.3.3 Working memory updating measures

Sentence repetition: In this task, the child is asked to repeat a difficult sentence. This is meant to measure the child´s working memory (Kavanaugh & Holler, 2014).

N-back: The task requires the child to press a button as possible when a previously presented stimulus is repeated. In the 1-back-condition, this is the immediately preceding stimuli, while in the 2-back condition, participants are to press the button when the stimuli presented is the same as the one presented two stimuli ago. The task is designed to measure the ability to attend to two or more stimuli at a time, an ability that is highly attention-demanding (Park et al., 2014).

Digit span: In this test the child is first asked to repeat the numbers presented forwards, and then backwards. The forwards repetition is designed to measure auditory short time memory, while backwards measures working memory and the child´s cognitive strategic abilities (Wechsler, 2003).

Spatial working memory: This task is similar to the Digit span, but the stimuli are for example spatial locations instead of digits, and the task measures the ability to process and remember a series of stimuli in order. The child is asked to press the boxes of stimuli in the same or opposite order as earlier presented (Park et al., 2014).

Letter number sequencing: This task is designed to measure auditory working memory, and the child is asked to read a series of number and letters and is asked to repeat them, saying the numbers first in ascending order and then the letters in alphabetical order (Samuelson et al., 2010).

3.3.4 Fluency measures

Controlled Oral Word Association: This task measures the verbal fluency, and the examiner is asking the child to produce words based on characteristics. This could be for example be letters starting with a specific letter (Letter fluency) or words belonging to a specific category such as "animals" (Semantic fluency) (Kavanaugh & Holler, 2014).

3.3.5 Validity of behavioural assessment tools of executive functioning

One of the most important validity questions in behavioural assessment tools aiming to measure several aspects of executive functioning, is their ecological validity. In comparison to systematic observations, structured interviews or ratings of daily self-care and adaptive functioning, there seems to be weak correlations to the behavioural assessment tools that measures executive functioning (Alderman et al., 2003; Bogod, Mateer & MacDonald, 2003; Burgess et al., 1998; Chaytor, Schmitter-edgecombe & Burr, 2006; Mitchell & Miller, 2008; Ready, Stierman & Paulsen, 2001; Wood & Liossi, 2006, cited in Barkley, 2012). Some tasks that measures executive functioning also lack normative data, and this makes it challenging to say for sure that there are deficits in executive functioning in a group of children with a disorder, unless it also has data from a control group or normative data from children and youth to compare with (Spreen & Strauss, 1998). In other words, behavioural assessment tools aiming to measure executive functioning may have a weak ecological validity, but on the other side structured interviews or questionnaires may not be as trustworthy when assessing executive functioning. They do however, often have a more adaptive validity in form of giving a better picture of how the challenges show in their everyday functioning.

Further research is needed to evaluate the reliability and validity of behavioural assessment tools of executive functioning (Spreen & Strauss, 1998), but something we often refer to in measuring validity and reliability of psychological tests, is the test-retest issue (Svartdal, 2009). It has been proposed that Wisconsin Card Sorting Task, that is the mostly used task to measure the cognitive aspects in this systematic review, do not measure problem solving in the same way if the child has been tested once before (Spreen & Strauss, 1998). This makes it difficult to explore the reliability of this test.

It has been argued that the test is measuring different aspects in "healthy" individuals than in individuals with deficits in prefrontal cortex and poorer executive functioning (Spreen &

Strauss, 1998). This could be difficult in psychological testing, which is why we often take use of more practical forms of validity: criteria validity and construct validity (Svartdal, 2009). If the test is measuring what it is supposed to measure under realistic conditions, we can say that the criteria validity is good. Further, we can say that the test has good construct validity if the test is measuring important sides of the phenomenon it is supposed to measure. This may be a challenge when it comes to several tasks of executive functioning, because the agreement of what the tasks are measuring is not that straightforward. This is the reason why Friedman & Miyake´s (2016) unity and diversity model is of importance. As earlier said, they looked at correlations between tasks of several separate executive functions, as well as the correlations between the functions.

The reliability of WCST was measured and found to be good with a correlation of 0.80 between test and re-test, but this may not be valid bearing in mind that the re-test does not measure problem-solving in the same way as the first assessment (Spreen & Strauss, 1998).

3.4 Relevance for daily functioning

Executive functions are important functions in daily life, both in social settings and in mastering the school (Hulme & Snowling, 2009). Well-developed inhibitory skills may for example help the child override impulses. This is required in the classroom when working on tasks, and with inhibitory skills the child is able to maintain the behaviour until the task is completed (Roebers, 2017). In a study done by Friedman et al. (2007) they explored the pattern in relations between attention problems rated by the teachers and executive functioning. They found that the amount of reported attention problems correlated with inhibition ($r = 0.40$), even after controlling for intelligence. The children with lower levels of attention problems at all ages (7-14 years old) significantly predicted better inhibition and updating abilities at an older age, as well as IQ, but this was not the case in correlations between measurements of shifting and attention problems. On the other hand, good working memory capacity is required to keep the overarching goal in mind (Roebers, 2017). Some researchers have argued that executive functions explain 22-30% of the variance in children´s school achievement (Roebers, Röthlisberger, Neuenschwander, Cimeli, Michel & Jäger, 2014).

Memory is central in both academic and social settings. We need the memory in solving tasks, the language we use when writing and speaking, as well as the emotions we feel on a given occasion. They all depend on our memory of past experiences and knowledge we gained from them (Siegler, DeLoache & Eisenberg, 2011). Working memory is one of the components of the memory system (Siegler et al., 2011), and also an executive function (Friedman & Miyake, 2016). The child or adolescent may struggle with solving tasks because of missing focus or memories of ideas or goals. There could further be an issue when it comes to setting something in context of what is already known, for example new knowledge in the context of existing knowledge. Another issue may be distraction by internal and external disruptions, such as sounds and thoughts (Fallmyr, 2017).

If a child has poor executive functioning, it could seem like the child is missing social rules. Take for example poor inhibition and poor working memory, that could lead the child to struggle with keeping information in a conversation with other kids and have irrelevant information disrupting. The other children could easily interpret this as rude, and the child could for the environment around seem like a child with poor social competence.

3.5 Summary

The term executive functions are an umbrella term that describes functions that are responsible for regulating the thoughts, emotions and actions during goal-directed behaviour (Barkley, 2012). Barkley (2012) claim that the lack of agreement when it comes to what underlying cognitive functions that should be included, results in vague definitions, and in challenges in the assessment of the functions. Using an empirical approach, Friedman and Miyake (2016) identified three distinct, yet associated specific executive functions; inhibition, working memory updating and shifting. These three domains are, together with fluency, used in the present systematic review as a framework for synthesis and interpretation of findings in the existing empirical literature.

Specifically, I will perform a systematic review to shed light on the following research questions: 1) Is there a connection between posttraumatic stress reactions and executive functioning in children and adolescents? 2) Are specific executive functions particularly affected in youth with posttraumatic stress reactions? and 3) Do children and adolescents

with posttraumatic stress reactions show deficits in executive functioning compared to children and adolescents exposed to traumatic events without posttraumatic stress disorder? I will then discuss theoretical questions and clinical implications of these possible associations.

4 Executive functioning and posttraumatic stress reactions

In this chapter, the aim is to discuss the connection between executive functioning and the disorder PTSD. The second chapter introduced some cognitive theories about experiencing traumatic events and the development of posttraumatic stress disorder. Further, the chapter of executive functions introduced the unity and diversity model, and four separate parts of executive functioning that will be used as a framework in this systematic review. But what could we say about the connection? Could it be that weak executive functioning could be a risk factor for developing posttraumatic stress symptoms, and even maintain the disorder? And what impact do emotions have on development and maintaining PTSD? These are questions that will be discussed in this chapter.

4.1 Prefrontal areas of the brain

As earlier presented, executive functioning is related mainly to prefrontal areas of the brain. These brain regions show especially protracted developmental trajectories (Tamnes, 2010), and do not reach full maturity until early adult age (Holmes, Kim-Spoon & Deater-Deckard, 2016, cited in Barrera-Valencia, Valderón-Delgado, Trejos-Castillo & O´Boyle, 2017). Prefrontal areas of the brain are especially sensitive to early life stress such as maltreatment and abuse during these years (Holmes et al., 2016, cited in Barrera-Valencia et al., 2017; Teicher et al., 1997, cited in De Bellis et al., 2009). When children and youth are under stress, neuromodulators called catecholamines (such as dopamine and norepinephrine) are released in the central nervous system. These catecholamines makes the body and mind ready to fight, through "turning on" the heart and muscles, and the amygdala which is the brains alarm system is activated (Arnsten, 1998). The result is that these structures is allowed to control our behaviour (Arnsten, 1998) because they may be needed in situations that require us to be activated, such as fearful and threatening situations. On the other hand, this is mechanisms that could contribute to posttraumatic stress disorder, and leaves the individual in constant fright (Arnsten, 1998), and instead of development and growth, the system will more actively focus on preservation and survival (Teicher et al., 2003). The child will struggle with regulating the intense fight-flight response or react aggressively to challenges,

and these are not optimal when the child is not in an unhealthy environment any more (Teicher et al, 2003). Furthermore, the facilitative actions in this system may result in cognitive dysfunction (Arnsten, 1998). In light of this, we need a better understanding of associations between early experiences of traumatic events and cognition. Development and learning are especially dependent on executive functioning, which is central in social and academic achievement, as well as in behavioural control and risk avoidance (Park et al., 2013). The mechanisms underlying the executive functions develop more rapidly through puberty (Palmer, Armsworth & Swank, 1997, cited in Yang et al., 2014). If prefrontal areas of the brain are affected by traumatic experiences during this time of life, it could result in difficulty concerning tasks that require executive functioning, such as social settings and school tasks. Furthermore, suffering from PTSD during the adolescence could lead to long-lasting impairments in cognition, intellectual and emotional development delays in language and psychomotor defects (Palmer, Armsworth & Swank, 1997, cited in Yang et al., 2014), because the system focuses on survival rather than development and growth (Teicher et al., 2003).

4.2 Cognitive theories of PTSD and executive functioning

4.2.1 Horowitz theory related to inhibition?

As earlier said, Horowitz proposed that individuals that have experienced traumatic events always is in between two extremes, pushing away thoughts to protect the self against being overwhelmed by the traumatic memories, and the need to express and work through the experiences. Horowitz claims that if the individual does not get the opportunity to work through the memories and process the thoughts, it will result in the clinical condition of PTSD (Raundalen & Schultz, 2006). The diagnostic manual ICD-10 explains posttraumatic stress disorder as a condition where the individual will experience flashbacks, where the child among other symptoms experiences intrusive memories (WHO, 1999). Children with an experience of traumatic events will according to the theory by Horowitz become experts of either pushing the memories away or express the thoughts and memories. Inhibition refers to the individual's ability to restrain inappropriate responses in both cognitive and socio-

emotional settings. This can entail problems with turning off external stimuli and to restrain internal distractions that disrupt learning (Barkley, 2012).

The similarity between the description of children with PTSD that is trying to push away thoughts but fail in pushing them away and weak inhibition abilities is striking. If a child is expected to concentrate on a task in class, or in a conversation with a friend, the possibility of irrelevant stimuli in form of thoughts or flashbacks that will interfere with it, would be higher than in children without PTSD. This could seem obstructive on the child and affect their quality of life, as well as their ability to learn.

4.2.2 Dual representation theory

As earlier described, Brewin´s dual representation theory describes two types of memory systems. His theory describes that the traumatic memories are stored and remembered in a different way than ordinary, daily memories. The main point in his theory is that the traumatic memories are stored in a memory system that is not that accessible to us and needs to be transferred to the verbally accessible memory (VAM) system to process the memory in the best possible way. Similar to the VAM memory and the situationally accessible memory system (SAM), other studies have addressed that the memory consists of two forms, one in a perceptual code and one in a verbal code. Studies have suggested that these systems can interfere with each other, an effect called verbally overshadowing. More precise, the studies suggest that, when asking participants to verbalize information, it can interfere with the ability to use their perceptual memory of the event (Brewin, 2003).

A study done by Hellawell and Brewin (2002), aimed to test the single and dual representation theories specifically in people suffering from PTSD. One of the aspects the researchers wanted to explore, was the perceptual memory system, and to explore this they wanted to give a task that makes use of this same system to explore if it would interfere with the reliving experiences that they meant were in the same system. They used the trail making test, that requires visual searching and measures the executive function shifting and would in this theory be affected by reliving because of the common memory system. They compared two groups, one of them was asked to do the trail making test during a reliving phase while the other group were asked to do it in an ordinary memory phase. As predicted, the trail making performance was much worse in the participants that was asked to perform it in a

reliving phase of their narrative (Brewin, 2003). The explanation of the different memory systems and its connection to PTSD could in other words lead to a hypothesis that we will find poorer shifting abilities in the group of children and youth with posttraumatic stress reactions in this review. If the hypothesis is correct, poor performance could be explained by a system that consists of memories of the traumatic events that interfere with the abilities to perform on tasks that requires abilities from the same system.

4.3 Emotions

Amygdala and prefrontal areas of the brain is as we now have seen central in executive functioning and could be harmed by persistent stress such as traumatic experiences (Arnsten, 1998; Holmes et al., 2016, cited in Barrera-Valencia et al., 2017; Teicher et al., 1997, cited in De Bellis et al., 2009; Palmer, Armsworth & Swank, 1997, cited in Yang et al., 2014). These areas of the brain are also central in emotions, as well as in relations to others and in social interactions (Arnsten et al., 2015; Immordino-Yang, 2016). This could result in challenges with regulation of emotions, thoughts and actions. Stronger developed and optimal functioning prefrontal areas will help the children and youth to extinguish fear responses, because the amygdala will be regulated, and both calm them and reduce the flashbacks (Arnsten et al., 2015). If the child struggles with regulating thoughts and emotions, the child may also have challenges with ignoring irrelevant information (inhibition) during a task or during social interactions, as well as shifting between sets (shifting). The working memory may be affected because the child needs focus to replace new information to old knowledge, and the cognitive flexibility may be poor (fluency).

The literature about emotions often separates between primary and secondary emotions (Fallmyr, 2017). The primary emotions are the immediate, automatic feelings that is attached to the situation that triggers them. Healthy primary emotions are an expression of needs and are present in the purpose that the individual gets coverage of the physical, psychological or verbalised need (Fallmyr, 2017). On the other hand, a negative and inexpedient emotion often is characterised by traumatizing experiences in the past and will not function as well as a communication of needs to the environment around the individual (Fallmyr, 2017). Secondary emotions on the other hand are feelings that replace other feelings or feelings that

is activated attached to the primary emotions. An example of a secondary feeling is anger as a feeling attached to the shame or guilt an individual may have (Fallmyr, 2017).

Emotions such as shame and guilt are some of the symptoms of PTSD (APA, 2013). One can imagine an iceberg with a surface, where the top of the berg is visible and the largest part beneath the surface. It is important to work with the emotions beneath the surface to overcome issues in the long term. Ehlers and Clark (2000) are under the impression that posttraumatic stress symptoms are maintained by an amount of guilt, self-blame, negative thoughts and reduced self-confidence. According to them, the solution may be to process the emotions and replace them with more healthy ones. These emotions, such as guilt and shame, can have impact on the executive functioning. As an example, happiness will stimulate the presence in learning situations. Together with interest and pride, happiness can change our expectations about the future and strengthen the cognitive functions such as concentration, evaluation and capacity to accomplish goals (Fallmyr, 2017), while shame and guilt could overshadow the ability to focus on the task. On the other hand, according to the dual representation theory, feelings like shame, fear, helplessness and horror attached to the traumatic events are often accompanied by the SAM memory system, and may be less assessible as verbal memories (Brewin, 2003), which can make it more challenging to talk about and further process in conversations with an adult.

The shame or guilt that the child or adolescent may feel as a result of the traumatic event, should be transferred to external causes (such as the person that the molester or the situation), which could change the emotion from guilt and shame to anger. We should always validate the feelings the child or youth may have, as well as identify and meet the need the emotion is expressing. As we in chapter 8 with implications will see, this may have something to do with the effectiveness of cognitive behaviour therapy.

4.4 Could the elements of executive functioning have a significance for the development and maintenance of PTSD?

This review aims to explore the connection between children with posttraumatic stress reactions and weak executive functioning. Because it would be unethically to look at this research question through an experimental design, the existing literature is based on observational correlation studies. Thus, we cannot infer about the causal relationship between the variables, i.e. which variable leads to the other one. An assumption could be that the experience of a traumatic event leads to challenges in executive functioning, but it could also be the other way around.

Some researchers have argued that the dysregulation of the neurobiological system and the changes in the brain in the childhood and adolescence can result in dysregulating that contributes to the development of various psychiatric and neurocognitive impairments (Andersen et al., 2008; De Bellis et al., 2011; Hedges & Woon, 2011; Heim et al., 2010; Kearney et al., 2010; Pechtel & Pizzagalli, 2011; Teicher et al., 2003; Wilson et al., 2011, cited in Kavanaugh, Holler & Selke, 2013). If a child experiences maltreatment, it could lead to dysregulation in the neurobiological system, and further to development of the clinical condition PTSD. It has further been argued that certain higher-order cognitive functions, such as executive functioning, are at increased risk for maltreatment-related dysfunctions (De Bellis et al., 2011; Pachtel & Pizzagalli, 2011; Wilson et al., 2011, cited in Kavanaugh et al., 2013). This could be explained by the extreme stress exposure the child experiences through the critical development periods in childhood and youth (De Bellis et al., 2011; Pachtel & Pizzagalli, 2011; Wilson et al., 2011, cited in Kavanaugh et al., 2013).

If a child does have weak inhibitory skills, the child will have challenges with shutting out irrelevant stimuli. If the child has difficulty closing out this irrelevant stimulus, there would make it easier for the memories of the traumatic event to find place in a situation where the child is expected to focus on a given task, whether we talk about school related expectations or social expectations.

4.5 Summary

In this chapter, the aim has been to give some background on the possible links between PTSD and executive functions. The chapter started with an explanation of how the prefrontal areas are linked to the executive functions and may be harmed by persistent stress or experiences of traumatic events (Arnsten, 1998; Holmes et al., 2016, cited in Barrera-Valencia et al., 2017; Teicher et al., 1997, cited in De Bellis et al., 2009; Palmer, Armsworth & Swank, 1997, cited in Yang et al., 2014). Further, some of the cognitive theories of PTSD was discussed with thoughts about separate executive functions. Because of the shame and guilt that often are symptoms of PTSD (WHO, 1999), and the theory of Ehlers and Clark (2000) that says the maintenance of posttraumatic stress symptoms do have something to do with the emotions, we also discussed emotions and its meaning in posttraumatic stress reactions. The final part discussed whether the elements of executive functioning could have a significance when it comes to maintaining or development of PTSD.

5 Methods

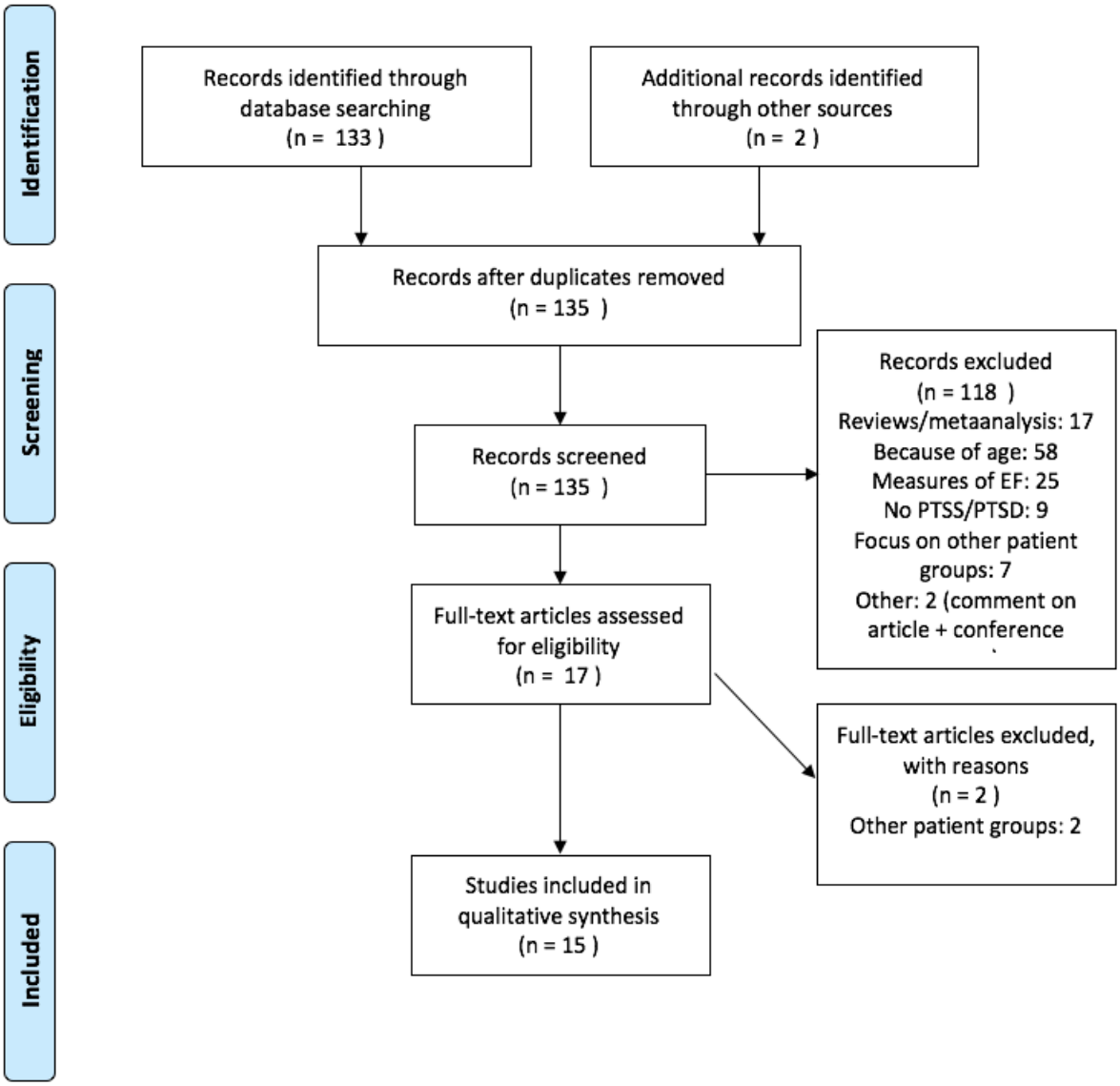
The aim of this chapter is to give a presentation of my method. The chapter includes a presentation of systematic review as a method, the systematic literature search done in this thesis, inclusion and exclusion criteria, as well as a flow diagram for the search. Furthermore, the chapter will present quality criteria in research, focusing particularly on aspects of validity, as well as on possible biases.

5.1 Systematic review

As the method for this master thesis, "systematic review" will be used. This means that I systematically will search for and review studies on the association between posttraumatic stress reactions in children and youth and executive functions. The purpose of the systematic review is to provide a systematic and transparent means for gathering, synthesising and appraising the findings of studies on a particular topic or question, while aiming to minimise the bias associated with single studies and non-systematic reviews (Jesson, Matheson & Lacey, 2011). The present systematic review is based on the Preferred reporting items for systematic reviews and meta-analyses (PRISMA) 27 item checklist and flow diagram (Moher et al., 2009), but will not present results of assessment of risk of bias for each study. In the discussion chapter, some risks of biases will be discussed on a more general level. The literature search was performed in January 2018 in Scopus with the search phrase ("ptsd" OR "ptss" OR "post traumatic stress" OR "post-traumatic stress" OR "posttraumatic stress") AND ("executive*" OR "cognitive control") AND ("child*" OR "adolescen*" OR "youth*" OR "pediatr*"). All abstracts were read for screening, and the eligibility criteria were: 1) original studies in English 2) using behavioural tasks to measure executive functions 3) in children (<18 years) 4) with PTSD or PTSS either diagnosed by a psychiatrist/psychologist or self - or parent-reported. Studies using only questionnaire to measure executive functions were excluded, as were studies focused on other patient groups or effects of an intervention, and reviews. Relevant references were cross-checked for further relevant studies. The screening and selection procedure is detailed in a flow diagram. All eligible studies were read in full by the author (ON) and inclusion was made in consensus with the main supervisor (CKT).

Because studies on both children with PTSD and children with PTSS are included as the sample in this review, I will refer to these groups together as children with posttraumatic stress reactions.

5.1.1 Flow diagram



5.2 Restrictions

A systematic review aims to minimize researcher bias and improve quality of the review. Reviewing articles in a narrative review could lead to more biases, for example the authors freedom of choice when it comes to picking out articles (Petticrew & Roberts, 2006). While

the systematic review will minimize such biases, there are some other threats to the method. A key challenge of this methodology is publication bias (Petticrew & Roberts, 2006). It has been pointed out that negative findings (statistically non-significant findings) may be under-presented in psychological journals, and this could be a serious source of bias in literature reviews. Even though this may be a bias in this systematic review, the review does not consist of intervention studies (Petticrew & Roberts, 2006). There may be a bigger issue when it comes to treatment and/or intervention studies because it is important to publish positive effect of these, but will also be discussed in chapter 6 for this review. Further, the discussion is based on the author´s (ON) interpretation of the studies included and could lead to biases in the review. There is an advantage that there was used an acknowledged database in the review, but it could be beneficially to include the search in more of the databases accessible.

It is common that the studies included in a systematic review differ in research designs. The systematic review aims to synthesize and compare these different studies, which could be challenging. On the other hand, this does it possible to illuminate the research questions from several perspectives (Petticrew & Roberts, 2006). As we will see, most of the research in this review uses the same research design, which makes it less challenging to compare them to each other.

Some of the studies included groups of both children and youth with a history of traumatic events with and without PTSD. When reading the means and standard deviations to calculate effect sizes, they were not in all cases divided in two groups, which made it impossible to separate them. Because some of the studies may have included children both with and without PTSD, and the results will not be as trustworthy as we wish for.

5.3 Quality criteria in research

In order to critically evaluate research, some central terms need to be defined.

Reliability is important when evaluating the quality of the research because we want to have results that could be replicated at a later time (Bryman, 2015). If we at a later time can find the same results, for example in assessing the executive functions with one year in between,

there is reliability in the results. The development that takes place in childhood and youth could be crucial to the assessment of these functions, because the children´s executive functioning could have developed a lot within a year. Is this fact influencing the reliability in a negative way? This is a common misunderstanding of the psychometric concept of reliability. If the individual changed from one assessment to another, reliable measurement should of course be able to capture those changes (Kleven, 2008). The reliability of this review could be understood as high, because if a researcher later wants to explore the same associations in the next year, the results in the database used will be the same (there would probably have been published some new articles on the topic). However, several researchers have noted the low reliability in tasks that measure executive functions (Burgess & Stuss, 2017; Shallice & Bugess, 1996).

The term reliability is closely related to another term; replication. Sometimes researches replicate the findings of earlier research, to figure out if they get the same results at a later time. The ability to replicate a study is dependent on details on the procedures of the specific research (Bryman, 2015).

Validity could be explained as in what degree the conclusions from a research is true or not (Bryman, 2015). There are several aspects of validity, and this is captured in Cook and Campbell´s validity system. Their system consists of four types of validity; construct validity, internal validity, external validity and statistical validity. Ecological validity is included as well, because of its importance in this review.

5.3.1 Construct validity

Quantitative research often studies constructs that needs to be operationalized to be available for empirical research. In educational and psychological research, we often search to analyse behaviour. Behaviour is not necessary easy to measure in the same way as more firmly constructs in other fields. This makes construct validity extra challenging (Kleven, 2008). For studies to measure constructs in the same way as other studies, to be able to say something about the connection between different research, we will need to have an operationalization of the terms in order to understand the same phenomenon through different research. This is why construct validity is important.

When we want to figure out if executive functions and posttraumatic stress reactions are associated with each other, construct validity is crucial. If every article that have as a goal to explore this area has different meanings of what both "executive function" and "posttraumatic stress disorder" entails, the research would have little value, because they would not necessary have studied the same constructs. The advantage of PTSD, is that it is characterized by diagnostic criteria, although, the reliability and validity of these can also be questioned. On the other hand, PTSS is also included in this review, and this construct is dependent on how many symptoms the study includes how many and which symptoms and at which level. The challenge with the term PTSD is on the other hand that there are two diagnostic manuals without identical criteria for the disorder.

Regarding executive functions, we will need to have a critical view on the notion, because it could include dissimilar functions. This will have a crucial impact if one study for example sees executive functions as working memory and planning while another one uses the same term including inhibition, shifting and updating. There will in this example be challenging to compare those two studies and claim that they support each other if they in reality measure somewhat dissimilar constructs. This is in this review resolved by categorizing the tasks used in the existing literature as either complex measures of executive functioning, or according to the Friedman and Miyake (2016) empirically derived specific executive functions inhibition, shifting and working memory updating, with the addition of fluency. All the included literature includes one or more of these domains in their studies.

5.3.2 Internal validity

Internal validity is by quantitative methodologists defined as the validity of assumptions from an observed covariation to a causal interpretation (Kleven, 2008). A correlation coefficient gives us a statistical value of how high or low a correlation between two variables are, but this correlation tells us nothing about the causal relationship between the variables (e.g. which variable that has an impact on the other one). The common variance could also be a result of a third variable affecting the other ones. If this is the fact, we call it a spurious relationship. In other words, internal validity is about the quality of the effect one variable has on another variable. Experimental designs eliminate a lot of possible threats to internal validity (Kleven, 2008). As I will discuss later, the internal validity of studies using cross

sectional designs are often weak, which makes it challenging to conclude that posttraumatic stress reactions cause deficits in executive functions.

5.3.3 External validity

External validity is the validity of inferences from the context of the study to a wider or to other contexts. This is in another words the issue of generalization. Findings can reflect the facts for one group of people, but could we also generalize the findings from the group we measure to a larger population? One can talk about generalization over persons, but also over situations or contexts and over time (Kleven, 2008). If a research has findings of the effectiveness of an intervention in one classroom in a village in Norway, it may be challenging to generalize the findings to a bigger population. One may say that the intervention has resulted in promising findings in this classroom, but we could not interpret these results for other classrooms, whether in Norway or internationally. This is also a consideration that could be important in research done in different countries, because different countries often have different systems. These are considerations one need to take when talking about validity of a study.

5.3.4. Statistical validity

In quantitative research we have to do with statistics. Quantitative research does often include statistical methods like tests of significance and estimates of effect sizes to make decisions about the tendencies value (Kleven, 2008). Statistics could further give us sizes of correlation between two variables (e.g. pearsons *r*). The studies do often present the statistics in different forms of statistical analyses, as for example *t*-test (that is a measure of statistical significance within one group or between two groups), linear regression (that shows us the correlation on a straight line) etc. Statistical significance is an important concept in this review. Significance gives an estimate of the extent to which we can be confident that our findings are not artefacts of the particular sample and makes us able to generalize from our sample to a wider context. The significance tells us how likely it is that we dismiss the null hypothesis even when it is true. The null hypothesis tells us that it is no relationship between two variables. In other words, statistical significance tells us that the statistical findings are unlikely to be the results of chance factors (Howitt & Cramer, 2014).

Threats against statistical validity could be summed up in two parts: violation of statistical

assumptions *and* low statistical power (Murnane & Willett, 2011). Statistical power is affected both by the size of the effect (Cohens *d*) and the size of the sample (Murnane & Willett, 2011), as well as how strict we are in claiming the effect are significant (Field, 2009). There is no straightforward answer to the decision of sample size (Bryman, 2015), but the absolute size has more importance than the relative size (Bryman, 2015). This is by Bryman (2015) explained with an example that 1000 individuals in UK has much more validity than a sample of 1000 individuals in the USA. In my interpretation this means that when we study children and youth exposed to traumatic events with posttraumatic stress reactions, a smaller sample is needed to get a good validity compared to a study aiming to explore individuals opinions about a political subject, because the population between these two will differ highly. The effect size is divided in to small, medium or large effect size, and give us information about the relation between two variables (Murnane & Willett, 2011). The larger an effect size is, the lesser is the probability that it has occurred as pure coincidence (Kleven, 2013). Either way, both effect size and sample size have an impact on the statistical power (Murnane & Willett, 2011). The statistical power is the ability of a test to find an effect (Field, 2009). Last but not least, this has an impact on the statistical validity (Murnane & Willett, 2011).

5.3.5 Ecological validity

Ecological validity is not one of the four validity-types in Cook and Campbell´s validity system but could be central in the analyse of the articles in this review. Ecological validity is concerned about whether scientific findings are relevant and applicable to people´s natural social settings (Bryman, 2015). Research do often takes place in settings separated from the children´s natural environment, and it is possible child acts differently, or that the environment could influence the child in different ways from the research-situation. The child could for example have improved concentration in the research setting because there is no one else around.

5.4 Effect size

While statistical significance tells us whether we could generalize from a sample to a population, effect size means the size of the effect of one variable on a second (Howitt &

Cramer, 2014), or as a measure of the differences in means between two groups (Howitt & Cramer, 2014). If we study a large sample, the smallest connection could result in statistical significance, but this may not have a practical meaning (Kleven, 2013). The most convenient measure of effect size is Pearson correlation coefficient between the two variables. Pearsons *r* in our case tells us whether the number of symptoms of PTSD correlates with the separate executive functions. The correlation coefficient can tell us about the relationship between two variables, and whether the correlation is positive or negative.

Cohen´s *d* is the most common measure of effect size. This measure is the difference between the means of the groups divided on the standard deviation of the scores (Howitt & Cramer, 2014). Cohen suggested as a rule that 0.2 can be interpreted as a small effect, 0.5 can be understood as a medium effect and 0.8 as a large effect (Murnane & Willett, 2011). This effect tells us about the strength of the relationship between two variables but should be interpreted with caution (Howitt & Cramer, 2014). To reduce the possibility of misunderstanding when it comes to the construct effect size, Lund (2002) introduces the concept effect difference. Effect difference is the difference between the means for two groups.

We can use the correlation coefficient as a measure of effect size, as well. Pearson´s *r* is the most familiar correlation coefficient and is a measure of the strength of a relationship between two variables (Field, 2009). Like with *d*, Cohen suggested some sizes for *r*. $r = 0.10$ is a small effect, $r = 0.30$ is a medium effect while $r = 0.50$ is a large effect (Cohen, 1988, 1992, cited in Field, 2009).

In this review, the aim is to explore the difference between the PTSD-group and the control-group in several measures of executive functioning. With effect size, we could compare the results of each study and look at the strength of the differences between the variables. We can in this case also look at confidence interval of effect size, which means that we could say in a chosen confidence interval (for example 95%), within which effect size the scores will be with a 95% safety (Howitt & Cramer, 2014). The confidence intervals could be explained as boundaries within which we believe the population will fall (Field, 2009). To calculate effect size, confidence interval and *p*-value, an effect size calculator from Centre for Evaluation & Monitoring were used (https://www.cem.org/effect-size-calculator). This was done on both

complex measures of executive functioning, inhibition, shifting, working memory updating and fluency. Some of the measures in each study were excluded because of the irrelevance of the research questions. Because the hypothesis is that the executive functioning will be weaker in the PTSD group, the formula was:

$$\frac{\text{Mean of control group} - \text{mean of PTSD group}}{\text{Pooled standard deviation}}$$

An explanation of positive and negative numbers will be that positive effect size tells us that the group of children with posttraumatic stress reactions score lower in the variables measured. Negative numbers will on the other hand be interpreted the group of children with posttraumatic stress symptoms have better scores on the variable. Because the negative effect sizes could mean that the PTSD group had lower scores on the variables if the measure was on for example errors, these scores were calculated in a different direction so that the negative scores had the same meaning. The studies that did not provide enough information to calculate effect size, will be presented with the numbers the studies provided us with.

5.5 Statistical significance

The null hypothesis always states that there is no relationship between the variables that are measured. When we speak about statistically significant findings, we use a significance level and search to state that we decline the null hypothesis (Howitt & Cramer, 2014). In this case, with a chosen significance level choose how big the risk of declining it with a possible fault. In the calculation of the effect sizes the significance level 5% were chosen. This means that the results that have a *p*-value under 0.05 will be considered statistically significant with a safety of 95%. If we say that the null hypothesis is declined, we would at the same time accept the alternative hypothesis, that conveys that there is a relationship between the two variables measured (Howitt & Cramer, 2014). The choice in this systematic review is to look at the *p*-value that is two-tailed. This means that the sample have a normal distribution, and that the majority of the sample will be in the middle (Howitt & Cramer, 2014). The choice of a significance level of 5% strengthens the statistical validity because it has an impact on the statistical power (Field, 2009). Because *p*-values depend on sample size, it is advisable to report effect sizes as well as *p*-values (Field, 2009). A non-significant result tells us that we

don’t have the basis to toss the null hypothesis. If it looks like the connection between two variables is the same in a larger sample, the connection may be significant even when the connection is non-significant. On the other hand, the small sample does it difficult to trust results that expresses something that is not random (Kleven, 2013).

5.6 Summary

This chapter have presented the method systematic review, that will be used in this thesis. Both advantages and disadvantages have been discussed. Further, some quality criteria have been presented, with the emphasis were validity. Internal validity is described as the validity of the causal connection between variables and are often weak in cross sectional designs and strong in experimental designs (Kleven, 2008; Bryman, 2015). External validity is the validity of inferences from the context of the study to a wider or to other contexts (Kleven, 2008). Whether the results could be used to say whether executive functioning have a connection with PTSD or not in the wider context, not only in the sample drawn in the study, are meaningful and of desire. Threats against statistical validity could be summed up in two parts: violation of statistical assumptions *and* low statistical power (Bryman, 2015). When we want to figure out if executive functions and posttraumatic stress reactions are associated with each other, construct validity is crucial. The constructs could be described in different ways and this could influence the validity. Effect size is a measure that tells us how large effect one variable has on another one, and is a more practical measure than statistical significance that are widely used (Kleven, 2013). The basis of this chapter will further be used in the discussion chapter.

6 Results

In this chapter, the primary goal is to review and summarize the existing literature in order to answer the following research questions:

1. *Is there a connection between posttraumatic stress reactions and executive functions?*
2. *Which parts of the executive functions are affected by posttraumatic stress disorder?*
3. *Is there a difference between executive functions in children and youth with PTSD compared to children and youth exposed to trauma that do not develop PTSD?*

As described in the methods section, 15 studies were included in the systematic review. These studies are presented in Table 1 and Table 2.

Table 1: Presentation of the included literature of differences between PTSD/PTSS and HC

	Year	Design relevant for current review	Journal	Subjects (n)	Executive function domain and measure	Findings *d* (95% CI), *p*-value
Barrera-Valencia et al.	2017	Cross sectional case-control	International Journal of Clinical and Health Psychology	PTSD=23 Depression=23 HC=24	Complex: WCST	Correct: PTSD: 40 (12) HC: 48 (12.25), p = 0.008*[a] Categories: PTSD: 2 (2) HC: 3 (1.75), p = 0.01*[a] Perseverative: PTSD: 14 (8), 7.5 (7.75), p = 0.001*[a]
					Inhibition: Stroop	Reading time: PTSD: 29 (7) HC: 25 (7.75), p = 0.05*[a] Reading errors: PTSD: 0 (0) HC: 0 (0), p = 0.06[a] Color time: PTSD: 45 (10) HC: 38.5 (18.5), p = 0.12[a] Color errors: PTSD: 1 (2), HC: 0 (0), p = 0.09[a] Conflict time: PTSD: 90 (48) HC: 71.5 (31.5), p = 0.06[a] Conflict errors: PTSD: 5 (3) HC: 3 (3.75), p = 0.04*[a]
Beers & De Bellis	2002	Cross sectional case-control	American Journal of Psychiatry	PTSD=14 HC=15	Complex: WCST Inhibition: Stroop Shifting: Trail Making Fluency: Controlled Oral Word Association	1.28 (0.45 -2.04), p < 0.001* 1.09 (0.28 – 1.83), p = 0.007* 0.07 (-0.66 – 0.80), p = 0.842 0.91 (0.31-1.49), p = 0.002*
Carrion et al.	2008	Cross sectional case-control	Depression and Anxiety	PTSS=16 HC=14	Inhibition: Go/No-Go	0.44 (-0.30 – 1.15), p = 0.238
Crozier et al.	2014	Cross sectional case-control	Development and Psychopathology	PTSD=16 TE=13 HC=45	Inhibition: Emotional oddball task	RT fear targets: 0.14 (-0.33 – 0.60), p =0.572[b] OE fear targets: 0.11 (-0.36 – 0.58), p = 0.637[b] RT calm targets: 0.27 (-0.21 – 0.73), p = 0.269[b] OE calm targets: 0.22 (-0.25 – 0.69), p = 0.358[b]

De Bellis, Hooper, Spratt & Woolley	2009	Cross sectional case-control	Journal of the International Neuropsychological Society	PTSD=22 TE=39 HC=45	Complex: NEPSY tower Inhibition: CPT	1.06 (0.51 – 1.59), p < 0.001* 0.03 (-0.48 – 0.54), p = 0.921
De Bellis, Woolley & Hooper	2013	Cross sectional case-control	Child Maltreatment	PTSD=60 TE=38 HC=104	Complex: WCST Inhibition: CPT, stroop Working memory updating: Numbers reversed	0.85 (0.52 – 1.18), p < 0.001* 0.44 (0.12 – 0.76), p < 0.008* 0.77 (0.44 – 1.09), p < 0.001*
Gindt et al.	2016	Cross sectional case-control	Perceptual and Motor Skills	PTSS=50%/Ap.10 TE=21 HC=25	Inhibition: emotional Go/No-Go	The study did not divide the sample in to groups but conducted a regression analysis to test the effect of PTSS and anxiety. Fearful faces: F (2.42) = 4.3, p = 0.05*[a] Neutral faces: F (1.43) = 2.7, p = 0.11[a] Angry faces: F (1.43) = 1.3, p = 0.25[a] Happy faces: F (1.43) = 1.4, p = 0.26[a]
Kavanaugh & Holler	2014	Cross sectional case-control	Journal of Child and Adolescent Trauma	PTSD=17 TE=18 HC=18	Complex: WCST Inhibition: Stroop Working memory: sentence repetition Shifting: Trail Making Fluency: The controlled oral word association test	1.41 (0.64 – 2.12), p = 0.001* - 0.04 (-0.70 – 0.63), p = 0.911 1.08 (0.34 – 1.76), p = 0.003* 1.14 (0.41 – 1.83), p = 0.002* 1.12 (0.38 – 1.80), p =0.002*
Kavanaugh, Holler & Selke	2013	Cross sectional case-control	Applied Neuropsychology: Child	TE= 49 PTSD=25% of TE HC=73	Complex: WCST Inhibition: Stroop Shifting: Trail Making Fluency: The controlled oral word association test	0.68 (0.30 – 1.04), p < 0.001* -0.26 (-0.62-0.10), p = 0.159 0.73 (0.35-1.09) p < 0.001* 0.43 (0.06 – 0.80), p = 0.021*
MacDonald et al.	2015	Correlation	Journal of Child and Adolescent Trauma	PTSD=55	Complex: WCST Shifting: Trail Making	r = -0.14, p > 0.05[a] r = 0.34, p < 0.05*[a]

					Fluency: Controlled Oral Word association test	r = -0.03, p > 0.05[a]
Park et al	2014	Cross sectional case-control	Anxiety, Stress & Coping	PTSS=36 TE=25 HC=30	Inhibition: Sustained attention, Flanker Working memory: Divided attention, Spatial working memory Total EF	0.18 (-0.34 – 0.71), p = 0.493 0.99 (0.42 – 1.53), p < 0.001* 0.04 (-0.48 – 0.57), p = 0.869 0.69 (0.14 – 1.22), p = 0.012* 0.73 (0.18 – 1.26), p = 0.009*
Samuelson et al.	2010	Cross sectional case-control	Child Neuropsychology	PTSD=27 PTSS=9 HC=35	Complex: WCST, Tower of London Inhibition: Stroop Working memory: Digit Span, Letter number sequencing	-0.14 (-0.64-0.37), p = 0.489 -0.35 (-0.85-0.16), p = 0.183 0.13 (-0.37-0.63), p = 0.607 0.19 (-0.32 – 0.69), p = 0.464 0.20 (-0.30 – 0.70), p = 0.432
Thomaes et al.	2012	Randomized controlled trial	Psychological Medicine	PTSD=29 HC=22	Inhibition: Stroop, Emotional stroop	Congruent: 0.01 (-0.54 – 0.57), p = 0.62 Reaction time: 0.77 (0.19 – 1.34), p < 0.008*[b] Negative: 0.46 (-0.11 – 1.01), p = 0.114 Neutral: 0.43 (-0.13 – 0.99), p = 0.130 RT negative: 0.67 (0.09 – 1.23), p = 0.021*[b] RT neutral: 0.95 (0.35 – 1.52), p = 0.002*[b]
Wu et al.	2010	Cross sectional case-control	Neuroscience Letters	PTSD=16 HC=9	Inhibition: Go/No-Go	RT: PTSD: 336 (QD: 21) HC: 378 (QD 34), p = 0.013*[a] CE: PTSD: 10.0 (QD 5.3) HC: 4.0 (QD 2.4), p 0.036*[a] OE: PTSD 8.7 (QD 3.3) HC: 2.3 (QD 1.7), p = 0.072[a]
Yang et al.	2014	Cross sectional case-control	Journal of Child Psychology and Psychiatry and Allied Disciplines	PTSD=34 TE=66	Inhibition: Stroop Working memory: Digit Span Shifting: Trail Making Fluency: Controlled Oral Word Association test	Results given in table 2 with comparisons between PTSD and TE

*Abbreviations: PTSD – Posttraumatic stress disorder; PTSS – Posttraumatic stress symptoms; HC – Healthy controls; WCST – Wisconsin Card Sorting Task; TE; Traumatic events; CPT: Continoous Performance Test-II, CI: Confidence interval, SD: Standard deviation. * Significant on 5% level. [a]: Effect size could not be calculated*

due to missing information, the statistics used in the study are given. RT: Reaction time. OE: omission error., [b]: The effect size used PTSD mean – HC mean to get a positive effect size for easier comparisons to other measures. r: Pearsons r correlation coefficient. QD: quartile deviation. CE: rate of commission error.

6.1 Complex executive functioning in children with posttraumatic stress reactions versus unexposed controls

Several of the studies included tasks that is supposed to measure complex executive functions.

The calculated effect sizes in complex measures was found to be between d = -0.14 and d = 1.41 (Beers & De Bellis, 2002; De Bellis et al., 2009; De Bellis et al., 2013; Kavanaugh & Holler, 2014; Kavanaugh et al., 2013; Samuelson et al., 2010). MacDonald, Ellis, Pulsifer & Lyons (2015) presented correlations between PTSD and executive functions in Pearsons r and found a correlation coefficient of r = 0.14, counted as a small effect size (Cohen, 1988, 1992, cited in Field, 2009). The study consisted of 55 children with PTSD, which is a large sample (MacDonald et al., 2015). The reason why this measure may be different compared to the other studies, may be explained by the study design, because the study did use a correlation design to explore the correlations between symptoms of PTSD and variables within executive functioning, without a control group. Not using a control group could be a threat against validity (Bryman, 2015). The median of the calculated effect sizes is d = 0.77, a medium effect size. When we calculate the distribution of scores, some of the scores could be somewhat extreme. A solution to this may be to exclude these outliers and look at the interquartile range. The interquartile range is the middle 50% of the scores in the sample (Field, 2009). If we exclude 25% of the effect sizes on each side of the median, we will find that the interquartile range is between d = 0.68 and d = 1.06.

The three largest studies if counted with the sample of PTSD and the unexposed controls, found medium to large effect size and were statistically significant (d = 0.85, d = 0.68, d = 1.06) (De Bellis et al., 2009; De Bellis et al., 2013; Kavanaugh et al., 2013). The only study that did not provide enough information to calculate effect size, reported statistically significant differences between the PTSD group and the control group in measures of complex executive functioning, where the PTSD group showed weaker complex executive functioning. The study showed significant differences between median of 40 correct answers on WCST in the PTSD group and a median of 48 correct answers for the control group. The

scores on both categories and perseverative scores did go in the direction of weaker scores in the PTSD group compared to unexposed controls, as well, all with statistical significant differences (Barrera-Valencia et al., 2017). Park et al. (2014) did not measure complex executive functioning, but gave total scores for the groups, which could be calculated to d = 0.73, a medium effect size. This could validate the median medium effect size found.

The only study that did not find medium or large effect size, actually found a negative effect size, which means that the group with posttraumatic stress reactions scored better than the control group on measures of complex executive functioning (Samuelson et al., 2010). A reason for this may be that the sample consisted of both children with PTSD and PTSS, while most of the studies had stricter limits on the sampling of this group. On the other hand, another study did not have separations between the group with PTSD and the group with children exposed to traumatic events without PTSD but did find a medium effect size either way (Kavanaugh et al., 2013).

A number of the studies in this review did find that children and youth with posttraumatic stress reactions did show poorer executive functions than the control groups. De Bellis et al. (2013) had a lot bigger sample than the other studies and did show a large effect size (d = 0.85), and the median of all effect sizes were d = 0.77.

6.2 Which parts of the executive functions seems to be especially affected in children with posttraumatic stress reactions?

The assessment of executive functioning varies in the included studies. Some of the tasks are used in most of the studies, as well as some not as well-known tasks. If we divide the tasks in to different aspects of executive functions they are meant to measure, we may be able to say which aspects of executive functioning that may be most affected by posttraumatic stress disorder. Friedman and Miyake separated between three related aspects of executive functions; inhibition, shifting and working memory updating (Friedman & Miyake, 2009). In the next part the measurement in the included studies of these parts will be discussed, as well

as the domain fluency, which is an additional well established specific executive function.

6.2.1 Inhibition

Inhibition refers to the individual´s ability to restrain inappropriate responses in both cognitive and social settings (Barkley, 2012). Most of the studies included inhibition as a measure of executive functioning. Twelve of the studies included measured inhibition as an executive function and compared a group of children with either PTSD or PTSS to a control group (Barrera-Valencia et al.,2017; Beers & De Bellis, 2002; Carrion et al., 2008; De Bellis et al., 2009; De Bellis et al., 2013; Gindt et al., 2016; Kavanaugh & Holler, 2014; Kavanaugh et al., 2013; Park et al., 2014; Samuelson et al., 2010; Thomaes et al., 2012; Wu et al., 2010). The largest study that included measures of inhibition were De Bellis et al. (2013), with a sample of 164 children in the PTSD group and the control group. The differences between the groups were found to be between d = -0.26 and d =1.19. In other words, the studies included found effect sizes in both directions, meaning that the group with posttraumatic stress reactions scored both weaker and higher than the control group in measures of inhibition.

The median of the effect sizes of inhibition were d = 0.18, which is not even a small effect size according to Cohen (Murnane & Willett, 2011). The range between the effect sizes calculated is high. The interquartile range with the 50% of effect sizes around the median were from d = 0.03 to d = 0.44, where the largest value is counted as a small effect size. The three largest studies found effect sizes of d = 0.44, d = -0.26 and d = 0.03 (De Bellis et al., 2009; De Bellis et al., 2013; Kavanaugh et al., 2013).

Some of the studies measuring inhibition had missing information that did it impossible to calculate effect sizes. Barrera-Valencia et al. (2017) found that the group with PTSD used more time on the stroop task with a mean of 29 compared to 25 in the control group (p = 0.05). The PTSD group did also show more conflict errors on the task, with a mean of 5 compared to 3 (p = 0.04) (Barrera-Valencia et al., 2017). Wu et al. (2010) found results indicating that adolescent participants with PTSD respond faster on the inhibition task but make more errors.

Some of the studies including inhibition as a measure, looked at emotional inhibition. They

wanted to see if children and youth with posttraumatic stress reactions inhibited fearful or negative targets different from calm or neutral targets (Crozier et al., 2014; Thomaes et al., 2012). The effect sizes in measuring inhibition of fearful or negative targets ranged from d = 0.14 to d = 0.67. On the other hand, the effect sizes when it came to neutral or calm targets ranged from d = 0.22 to d = 0.95 (Crozier et al., 2014; Thomaes et al., 2012). The median of fear/negative targets were calculated to be d = 0.3, a small effect size, while the median of neutral and calm targets was calculated to d = 0.35, a somewhat larger effect size that still is counted as a small effect. Because of the small differences, as well as few studies, this does not lead to a conclusion of differences in groups considering emotional inhibition.

6.2.2 Shifting

Shifting require switching back and forth between subtasks according to a cue (Miyake et al., 2000). Four studies that compared a group with PTSD to unexposed controls, explored shifting abilities. The effect sizes were between d = 0.07 and d = 1.14 (Beers & De Bellis, 2002; Kavanaugh & Holler, 2014; Kavanaugh et al., 2013). The correlation study that explored correlations between symptoms of PTSD and shifting abilities, found r = 0.34 (MacDonald, 2015). The median of the effect sizes is d = 0.73, a medium effect size. Because MacDonald et al. (2015) did use correlation coefficient to measure, this were not included in the median calculation. In regard to the correlation coefficient in MacDonald´s et al. (2015) study, an r over 0.30 is considered a medium effect size (Cohen, 1988, 1992, cited in Field, 2009). The largest studies found effect sizes of d = 0.73 (Kavanaugh et al., 2013), r = 0.34 (MacDonald et al., 2015) and d = 1.14 (Kavanaugh & Holler, 2014). Effect sizes of shifting did go in just one direction (the direction of poorer scores in the PTSD-group) and had no negative effects. This leaves us with the conclusion that deficits in shifting may be associated with posttraumatic stress reactions, and that children and youth with posttraumatic stress reactions often struggles with switching back and forth between subtasks. Relatively few studies have however included specific measures on shifting.

6.2.3 Working memory updating

Working memory updating refers to the ability to code information for relevance and replace old, no longer relevant information with this updated information (Miyake et al., 2000). Working memory is the structures and processes used in temporary storage and manipulation

of information. This includes the ability to keep information in the memory while solving a challenge or performing a task (Sattler, 2008). Of four studies that compared working memory updating measures in both a group of children with posttraumatic stress reactions and a control group, six effect sizes were calculated. The effect sizes were between $d = 0.04$ and $d = 1.08$ (De Bellis et al., 2013; Kavanaugh & Holler, 2014; Park et al., 2014; Samuelson et al., 2010). The median of all effect sizes of working memory updating were $d = 0.45$, a small effect size. The three largest studies, with five effect sizes on shifting, found effect sizes from $d = 0.04$ to $d = 0.77$ (De Bellis et al., 2013; Park et al., 2014; Samuelson et al., 2010). The interquartile range was from $d = 0.20$ to $d = 0.44$.

6.2.4 Fluency

Fluency is one of the categories in cognitive flexibility and is often referred to as spontaneous flexibility. This is a good description with the task in mind, because the children are asked to mention as many words as possible within a given category (Spreen & Strauss, 1998). Four of the studies included in this review assessed fluency, and they all measured it using "The controlled oral word association test". The studies compared fluency between a group of children with PTSD and a group of unexposed controls in the same age (Beers & De Bellis, 2002; Kavanaugh & Holler, 2014; Kavanaugh et al., 2013; MacDonald et al., 2015).

The effect size was calculated to be between $d = 0.43$ and $d = 1.12$ (Beers & De Bellis, 2002; Kavanaugh & Holler, 2014; Kavanaugh et al., 2013). The Pearsons correlation coefficient was $r = -0.03$ (MacDonald et al., 2015). The median of the effect sizes was $d = 0.91$. The three largest studies found following: $d = 0.43$ (Kavanaugh et al., 2013), $r = -0.03$ (MacDonald et al., 2015) and $d = 1.12$ (Kavanaugh & Holler, 2014). All effect sizes were medium to large, but on the other hand, MacDonald et al. (2015) found a negative correlation coefficient, which tells us that more symptoms of PTSD did not cause poorer fluency abilities. This did have a different research design compared to the other studies that measured fluency, and could have had an impact on the results, as well as it makes it more challenging to compare when it is missing a control group. This indicates that children and youth with posttraumatic stress reactions seem to differ with a medium to large effect from unexposed controls (Beers & De Bellis, 2002; Kavanaugh & Holler, 2014; Kavanaugh et al., 2013), but on the other hand, MacDonald et al. (2015) found no significant differences

between the groups and the correlation coefficient were low and the number of studies measuring fluency were low compared to other measures.

Table 2: Presentation of the included literature of differences between PTSD/PTSS and TE

	Year	Design relevant for current review	Journal	Subjects (n)	Executive function domain and measure	Findings *d* (95% CI), p-value
Crozier et al.	2014	Cross sectional case-control	Development and Psychopathology	PTSD=16 TE=13 HC=45	Inhibition: Emotional oddball task	Significant differences on fear targets, but not on the calm targets. Mean and SD missing in comparisons between PTSD and TE. PTSD and TE was in the same group in the assessments.
De Bellis, Hooper, Spratt & Woolley	2009	Cross sectional case-control	Journal of the International Neuropsychological Society	PTSD=22 TE=39 HC=45	Complex: NEPSY tower Inhibition: CPT	0.33 (-0.20 – 0.86), $p = 0.216$ Omissions: 0.14 (-0.39 – 0.66) $p = 0.602$ Variability: 0.37 (-0.16 – 0.89) $p = 0.171$
De Bellis, Woolley & Hooper	2013	Cross sectional case-control	Child Maltreatment	PTSD=60 TE=38 HC=104	Complex: WCST Inhibition: CPT, stroop Working memory updating: Numbers reversed	0.08 (-0.33 – 0.48), $p = 0.715$ 0.17 (-0.24 – 0.58), $p = 0.414$ -0.39 (-0.80 – 0.02), $p = 0.054$ 0.48 (0.07 – 0.89), $p = 0.022$*
Gindt et al.	2016	Cross sectional case-control	Perceptual and Motor Skills	PTSS=50%/Ap.10 TE=21 HC=25	Inhibition: emotional Go/No-Go	Impossible to separate between the group of children exposed to TE with and without PTSS. The study did not divide the sample in to groups but conducted a regression analysis to test the effect of PTSS and anxiety. Fearful faces: F (2.42) = 4.3, $p = 0.05$*[a] Neutral faces: F (1.43) = 2.7, $p = 0.11$[a] Angry faces: F (1.43) = 1.3, $p = 0.25$[a] Happy faces: F (1.43) = 1.4, $p = 0.26$[a]
Kavanaugh & Holler	2014	Cross sectional case-control	Journal of Child and Adolescent Trauma	PTSD=17 TE=18 HC=18	Complex: WCST Inhibition: Stroop Working memory: sentence repetition Shifting: Trail Making	0.93 (0.21 – 1.60), $p = 0.010$* -0.13 (-0.79 – 0.54), $p = 0.704$ 0.55 (-0.14 – 1.21), $p = 0.116$ 0.77 (0.07 -1.44), $p = 0.029$* 0.31 (-0.36 – 0.97), $p = 0.364$

					Fluency: The controlled oral word association test	
Kavanaugh, Holler & Selke	2013	Cross sectional case-control	Applied Neuropsychology: Child	TE= 49 PTSD=25% of TE HC=73	Complex: WCST Inhibition: Stroop Shifting: Trail Making Fluency: The controlled oral word association test	Mean and SD not separately given for TE and PTSD.
Park et al	2014	Cross sectional case-control	Anxiety, Stress & Coping	PTSS=36 TE=25 HC=30	Inhibition: Sustained attention, Flanker Working memory: Divided attention, Spatial working memory Total EF	0.32 (-0.23 – 0.87), p = 0.254 0.61 (0.04 – 1.16), p = 0.034* -0.04 (-0.59 – 0.51), p = 0.886 0.36 (-0.20 – 0.91), p =0.202 0.44 (-0.12 – 0.99), p = 0.121
Yang et al.	2014	Cross sectional case-control	Journal of Child Psychology and Psychiatry and Allied Disciplines	PTSD=34 TE=66	Inhibition: Stroop Working memory: Digit Span Shifting: Trail Making Fluency: Controlled Oral Word Association test	4 months: -0.20 (-0.62 – 0.21), p = 0.336 12 months: 0.34 (-0.08 – 0.76), p = 0.114 4 months: 0.09 (-0.32 – 0.51), p = 0.660 12 months: 0.09 (-0.42 – 0.42), p = 1.000 4 months (A): 0.21 (-0.21 – 0.62), p = 0.322 4 months (B): -0.26 (-0.68 – 0.15), p = 0.219 12 months (A): 0.06 (-0.35 – 0.48), p = 0.763 12 months (B): 0.03 (-0.39 – 0.45), p = 0.899 4 months: -0.02 (-0.43 – 0.40), p = 0.942 12 months: 0.11 (-0.31 -0.53), p = 0.604

*Abbreviations: PTSD – Posttraumatic stress disorder; PTSS – Posttraumatic stress symptoms; HC – Healthy controls; WCST – Wisconsin Card Sorting Task; TE; Traumatic events; CPT: Continoous Performance Test-II, CI: Confidence interval, SD: Standard deviation. * Significant on 5% level. [a]: Effect size could not be calculated due to missing information, the statistics used in the study are given. RT: Reaction time. OE: omission error., [b]: The effect size used PTSD mean – HC mean to get a positive effect size for easier comparisons to other measures. r: Pearsons r correlation coefficient. QD: quartile deviation. CE: rate of commission error*

6.3 Executive functions in posttraumatic stress disorder versus traumatic events

Eight of the studies in the systematic review included a group of subjects that were exposed to traumatic events but did not develop posttraumatic stress reactions. This is central in the understanding of whether the diagnose itself – or the traumatic event behind the diagnose – is the main factor that acts upon the executive functions. Four of the studies found that PTSD did not have any effect on the executive functions when controlled for, in other words that there is no significant differences in executive functioning between the group of children exposed to traumatic event with or without PTSD (Gindt et al., 2013; Kavanaugh et al., 2013; Kavanaugh & Holler, 2014; De Bellis et al., 2009). One of the studies found that PTSD mediated the relationship between children exposed to traumatic events at four months past the traumatic event and their executive functions, but this was not statistically significant at 12 months past the traumatic event (Yang et al., 2014). Park et al. (2014) found that the group of children exposed to traumatic event(s) with trauma overall scored weakest on the executive function tasks, but this was only statistically significant in impairment of interference control. Even if the differences in executive functioning in children exposed to trauma and children with PTSD in none of the studies were statistically significant, the group of children with PTSD overall scored weakest on the executive function tasks.

The calculated effect size was from $d = 0.08$ to $d = 0.93$ in the three studies that included a complex measure and had enough information to calculate the effect size (De Bellis et al., 2009; De Bellis et al., 2013; Kavanaugh & Holler, 2014). The median effect size when also including the total score calculated in Park et al. (2014), were $d = 0.39$. The only significant finding in this measure found an effect size of $d = 0.93$, an effect size that could be interpreted as a large effect (Kavanaugh & Holler, 2014). One of the studies gave a total score of executive functioning of the variables measured, and the calculated effect size were $d = 0.44$ between the groups exposed to traumatic events with and without PTSD. This study did also have a big sample when putting together the PTSD and TE groups, even the largest sample of these ones (n = 102) (Park et al., 2014). This could be interpreted as between a small to a medium effect size (Murnane & Willett, 2011).

In measures of inhibition, a few studies included two groups exposed to traumatic events with

and without PTSD. The effect sizes ranged from d = -0.39 to d = 0.37. Compared to the range of effect sizes in the PTSD versus the control group, these effect sizes are a bit lower. The median effect size in inhibition were d = 0.16, which does not even count as a small effect size (Murnane & Willett, 2011). The largest study that explored inhibition in these two groups found effect sizes of d = -0.20 at four months past the traumatic event and d = 0.34 12 months after (Yang et al., 2014). This means that the PTSD-group scored poorer on inhibition tasks than the TE group 12 months after the traumatic event, than 4 months after. This could be explained as the group without PTSD that may not have struggled with reactions at the time of the last assessment 12 months after, but that they had poorer inhibitory skills at the four month-assessment because it was closer in time. The other large studies that assessed inhibition found effect sizes between d = -0.13 and d = 0.37 (De Bellis et al., 2009; Kavanaugh & Holler, 2014). The effect sizes go in both directions, which makes it difficult to make a conclusion of the differences between groups exposed to traumatic events with and without PTSD concerning inhibition.

Only two of the studies included measures of shifting abilities when assessing the two groups with and without PTSD. The effect sizes ranged from d = -0.26 to d = 0.77 (Kavanaugh & Holler, 2014; Yang et al., 2014). In other words, the range between effect sizes were high and in both directions. The median effect size of shifting was d = 0.06. The only statistically significant effect size was d = 0.77. A contrast were found when calculating effect sizes of working memory updating, where the median effect size was d = 0.48. The effect sizes ranged from d = 0.09 to d = 0.61 (De Bellis et al., 2013; Kavanaugh & Holler, 2014; Park et al., 2014; Yang et al., 2014). The two statistically significant effect sizes were d = 0.48 and d = 0.61 (De Bellis et al., 2013; Park et al., 2014). Because of effect sizes only in one directions and that three of five were medium effect sizes, this could point in the direction that children and youth with PTSD may have poorer working memory updating compared to children and youth that have experienced traumatic events without PTSD.

Fluency were assessed in only two studies comparing the two groups exposed to traumatic events with and without PTSD and had effect sizes between d = -0.02 and d = 0.31 (Kavanaugh & Holler, 2014; Yang et al., 2014). None of the effect sizes were statistically significant and could with advantage have been researched more closely.

6.4 Summary

In this chapter, the studies included in the systematic review have been presented in light of the research questions of the thesis. Most of the studies found an association between posttraumatic stress reactions and lower executive functioning compared to a control group. According to this literature this leaves us with a conclusion there is an association, and that this group of children show poorer executive functioning (median effect size: $d = 0.77$). The interquartile range in measures of complex executive functioning were $d = 0.68$ to $d = 1.06$. The median effect scores of the separate executive functions differed somewhat, with less than a small effect size in inhibition ($d = 0.18$), with an interquartile range of between $d = 0.03$ and $d = 0.44$. We found a small effect size in working memory updating (median $d = 0.45$). On the other hand, shifting had a medium to large median effect size ($d = 0.73$) while fluency had a median effect size explained as large ($d = 0.91$).

The calculated effect sizes when comparing the groups exposed to traumatic events with and without PTSD were a bit smaller. This begs the question of whether the deficits are due to the diagnose itself, or a result of the children´s experiences. Effect sizes of complex executive functioning and total scores in measures of executive functioning, had a small effect size ($d = 0.39$). Calculations of median effect sizes in inhibition ($d = 0.16$), shifting ($d = 0.06$) and fluency ($d = 0.11$) show that these separate executive functions may not be due to the diagnose itself, but to the experience of a traumatic event. One of the interesting findings of the findings in comparisons of these groups, were that working memory updating had a small to medium median effect size ($d = 0.48$) and had effect sizes in only one direction of poorer scores in the PTSD group. Because of the small amount of studies in this review studying the separate executive functions in these groups, we should be cautious in making any conclusions, but it may seem like working memory updating is poorer when the children that have experienced traumatic event(s) and also develops the disorder PTSD.

7 Discussion

The goals of this thesis were to explore the associations between children and youth with posttraumatic stress disorder and their executive functioning. Further, the aim was to figure out whether separate executive functions seemed to be weaker in this group compared to a control group. The conclusion of an association between children and adolescents with posttraumatic stress reactions and weak executive functioning were concluded with in the last chapter. The effect sizes were calculated, and could show different effect sizes between different measures, that leads us to a better picture of which executive functions that differ more between the groups than others. This will now be summed up in median effect sizes. The median complex effect size was calculated to $d = 0.77$, a medium to large effect size. Fluency had the largest effect size of all measures and was calculated to a median effect size of $d = 0.91$. On the other hand calculated effect sizes of inhibition went in both directions, and the PTSD group scored both higher and lower than the control groups. The median effect size of inhibition was $d = 0.18$ and does not count for even a small effect size. Working memory updating had a small to medium median effect size of $d = 0.45$ and shifting had a medium to large median effect size of $d = 0.73$.

In comparisons between the groups of children and youth exposed to traumatic events with and without PTSD, the complex measures had a small median effect size of $d = 0.39$. In other words, the effect size between the group of children and youth with PTSD and the control group is a bit larger compared to when we calculated effect sizes for the comparisons between these groups. There was still a small effect size on complex measures, that tell us that the children and youth with PTSD may have poorer executive functioning than children with traumatic exposure that has not developed PTSD. Inhibition, shifting and fluency were executive functions that seemed to not have any large differences in these groups, with median effect sizes between $d = 0.06$ and $d = 0.16$. An interesting finding were that working memory updating had a small to medium median effect size between the groups of $d = 0.48$.

First, the discussion of quality criteria will find place. Are the results trustworthy? Can we generalize the results to a bigger population? Could it be a causal relationship between posttraumatic stress reactions and weak executive functions? Could it be that other variables

have an effect on the results? Does the type of traumatic event influence the associations? These are some of the questions that further will be discussed.

7.1 Quality of the studies – are they trustworthy?

7.1.1 Bias

When analysing data, we could be led to the wrong conclusions. When the test statistic is inaccurate, or biased, then our conclusions will be to. If the standard deviation is biased then the confidence interval and effect sizes will be too, because it is based on the standard deviation. If the test statistic is biased, then the *p*-value will be biased too (Field, 2009).

In consideration of biases in the research articles included in this systematic review, both the quality of the measure instrument, the studies focus on other possible factors that could have influenced the results and the presentation of the results are central.

One of the inclusion criteria was that the assessment of the executive functions was done with behavioural assessment tools. Tools such as Behaviour Rating Inventory of Executive Function (BRIEF) – a questionnaire that is supposed to measure the impact the executive functions have in daily life, have been said to have better ecological validity than behavioural assessment tools (Barkley, 2012). On the other hand, behavioural assessment tools may be better to explore the executive functioning more accurate (Løvstad et al., 2016). One of the reasons this was done, is with thought of biases. Interviews or questionnaires are more vulnerable to biases because there are people that could have an impact on the results. An example is that the child could hold back information because of the interviewer. The way that the questions get asked (e.g. leading questions) could also have an impact on the answers that is given (Bryman, 2015). This could lead to less biases in regard to measure instruments.

The majority of the studies considered possible factors that could have had an impact on the results. An example of this, is that most of them explored intelligence and socioeconomic status as possible mediating variables. As an example, Barrera-Valencia et al. (2017) found that the PTSD group had significant lower IQ-scores than the control group. This could give us a biased picture, because the poorer executive functioning in this group may be explained by the intelligence-variable. As the authors highlights, it is important to clarify if lower IQ is

a predisposing factor or a consequence of traumatic experience (Barrera-Valencia et al., 2017).

While some of the studies excluded children with a comorbid diagnose such as ADHD, others did not. For example, Kavanaugh et al. (2013) assessed how big percentage of the sample that did have comorbid diagnosis, where as much as 46% had comorbid ADHD. This could be problematic in the results, because the poor executive functioning could be a result of ADHD and not PTSD, and could lead to biases in the results, especially bearing in mind that this study found the largest effect size (d = 1.41) in complex measures of executive functioning.

Some of the studies did not provide us with means and standard deviations, which could lead to a biased picture of this review. All of the studies included was peer reviewed, which is a quality stamp itself. MacDonald et al. (2015) made a hierarchical multiple regression to determine whether the PTSD symptoms significantly improved the performance on the shifting variable after controlling for variables such as intelligence, socioeconomic status and level of prenatal alcohol exposure. They found that 26.5% of the variability in the performance on the Trail making task were predicted by the mentioned variables (MacDonald et al., 2015).

7.1.2 Outcome reporting bias

The largest amount of studies seems to agree that there is poorer executive functioning among children with PTSD compared to control groups. This is also the case when we look at the studies with the most participants. A large number of participants in one study could have a positive effect on the validity. The size of the sample is used to estimate if the findings are statistically significant or not, and while in big samples quite small relationships could be statistically significant, and the smaller the sample is, the bigger percent of correlation is needed to make it significant. This type of measure is widely used in research, but the difference does not really say something about the relationship itself, but only whether the results are big enough to say that it is generalizable to a population (Howitt & Cramer, 2014).

A smaller number of participants may enhance the possibility of bias (Bryman, 2015). Type

II-errors, is when we decide that there is no relationship between two variables, when the reality is that there is, and that the null hypothesis is false (Howitt & Cramer, 2014). The possibility of doing this type II error, increases if the sample is smaller (Kleven, 2013). When there are small samples, the risk of concluding with not significant differences is bigger, when there actually are significant differences in the population. The sample in most of the studies included in this review were small. This could have an impact on the results.

Even though significance testing is widely used in educational and psychological research, effect size is a better measure when it comes to the practical significance (Kleven, 2013). When we look at effect sizes for the differences between the groups in different executive functioning variables, we also get a *p*-value that tells us how likely it is that that the effect size is random. In the result chapter, the statistically significant results are presented by itself in addition to all effect sizes. This is done because when we exclusively look at the statistically significant effect sizes we know with more safety that the results are not caused by random effects. When the chances of random connections are high, it is not worth to give an interpretation (Kleven, 2013), but on the other hand, a primary focus on only statistically significant findings would give a biased picture of the results.

When it comes to evaluate the internal validity of the included literature in this review, there is a couple of challenges. Experimental design is strong considering internal validity, but only one of the studies in this review use this design, and this because it aims to investigate the effects of treatment. The most used design of the studies in this review, uses cross sectional design. This type of design typically has weak internal validity (Bryman, 2015). This makes it difficult to assume that there is a causal relationship between posttraumatic stress reactions and executive functions even when the findings could give a picture of a connection. On the other hand, we could say that there are associations between posttraumatic stress reactions and weak executive functions, but maybe not that posttraumatic stress reactions lead to deficits in executive functioning. A use of experimental design would be unethical, because we would have to inflict the children and youth with a high amount of stress and posttraumatic stress reactions. In other words, we could say that there is a connection, but we do not know in which direction, or which of the variables that is affecting the other.

A control group is strong considering internal validity because it makes it possible to exclude

possible effects of other explanation of the causal findings. The largest amount of the studies included in this review, uses a control group to compare scores. One of the included studies used an experimental design (Thomaes et al., 2012), but this was because the study also explored treatment effects of an intervention.

External validity is typically strong in cross sectional designs, if the sample is randomly selected. When the external validity is strong, this means that there is a big chance that we could generalize the findings to a bigger population – like all the children with posttraumatic stress reactions (Bryman, 2015). *P*-values that is statistically significant tells us a lot about the external validity, because when something is statistically significant, the results may with more safety be generalized to the population. On the other side, the samples in most of the studies were quite small, which does it more difficult to generalize to the population.

The issue of ecological validity in these kinds of studies is an important discussion point. Since the cross-sectional research often use research instruments like self-administered questionnaires and structured observation schedules, the ecological validity may be threatened (Bryman, 2015). This is also the case in tasks measuring executive functions, they have little or no ecological validity. The behavioral measures of executive functioning do not correlate well with more ecologically valid means of assessing EF in everyday life circumstances (Barkley, 2012). The issue when the ecological validity is weak, is that the reality may not be the same as in the studies. The children may for example have weak shifting abilities in the situation of the research – but does it also apply for the daily life of the child?

An important discussion-point in the validity of the studies in this review are the construct validity. When we aim to explore the connection between posttraumatic stress reactions and executive functions, there may be a couple of challenges in construct validity. Because posttraumatic stress disorder is a diagnose described in two diagnostic manuals, the construct validity may be of good quality there. On the other hand it could be a threat to construct validity that there is used different diagnostic manuals, with different definitions of PTSD. But the crucial point in this discussion is whether the studies used these manuals in their studies. Some of the studies uses a clinical sample drawn from different hospitals. This may

lead to good construct validity because a psychiatrist/psychologist most likely have used a diagnostic manual when assessing for PTSD. A bigger amount of the included studies used interviews based on the diagnostic manual in the inclusion process of the study. The cut-off line is though important here, in whether they say it is PTSD when the child/youth have 17 of the symptoms or in 7 of the symptoms. Other studies included in this review used self-administered schemes. These schemes were in most of the studies were based on the diagnostic manual(s), but the fact that the child itself or the parent filled it out, may be a threat to the construct validity. Either way, this review also includes PTSS as an inclusion criteria.This may be a restriction for the construct validity, because the boundaries of inclusion are not that clear. In other words, this review includes both PTSD as a diagnose and PTSS as symptoms of the diagnose. As a result of this, the participants may have 7 symptoms of PTSD or 17.

An even bigger challenge in construct validity of this review, is the definition of executive functions. As said in the chapter three, executive functions are a construct that is defined in a number of different ways. In this review, Friedman & Miyake (2009) are central in the choice of definition of the term. They include inhibition, shifting and updating as related executive functions. Exactly because of the relation between these three functions, one may conclude with that these three aspects are central executive functions. The studies included, measured executive functions in different ways. This is affecting the construct validity, because there are not clear definitions of what the term executive functions really includes. Some tasks may as an example have higher correlations to the part of executive functioning it is supposed to measure, than other tasks.

7.1.3 Publication bias

A key challenge of this methodology is publication bias. It has been pointed out that negative findings (statistically non-significant findings) may be under-presented in psychological journals, and this could be a serious source of bias in literature reviews (Petticrew & Roberts, 2006). While this could be the case in this systematic review, some of the studies published had none significant findings (Samuelson et al., 2010), a sign that this may not be the case. The significant findings seem to be given the most attention in reporting of results and was often given the most focus in the discussion. This may give a biased picture of the findings. On the other side, all the results were presented in tables in most of the studies, even if they

were non-significant.

7.2 Causality

A possible explanation of the weak executive functions in the children with PTSD could be their executive functions before the traumatic event took place. The executive functions vary among individuals – some have a weaker executive functioning while others have good executive functioning. The development of these functions could also be of importance. Is the time the trauma takes place of importance when it comes to the executive functions? But – back to the discussion of the starting point of the executive functions. They are affected by heritability. If the executive functions are inherited, could it be that the children that "inherited" weak executive functions are less resilient after traumatic events and will have a bigger risk at developing PTSD? In that case, could we conclude that posttraumatic stress reactions will affect the executive functions or give deficits in executive functioning? If we wanted to have an answer to this question, we would have to follow a group of children and assess their executive functioning over a longer period – and if some of them are exposed to trauma – or develop PTSD – look at their executive functioning *before* the trauma and see if there is a pattern.

We can speak about a causal relationship between variables when we know for sure that one variable influences another one. A causal relationship in this systematic review would mean that PTSD would lead to deficits in executive functions. The challenge when it comes to talking about this causal relationship between two or more variables is that the variables needs to be measured before and after the traumatic event found place, which is difficult in the issue brought up in this review. In other words, the optimal research design to explore a causal relationship would be experimental research design. This design is often used in measuring interventions. Two groups are included – and while one of the groups get the intervention, the other one gets no, or another treatment/intervention. This makes it easier to talk about whether the treatment or intervention is effective. In measuring executive functioning in children with posttraumatic stress disorder, this research design is both time-consuming and may cost a lot of money.

We would have to include a big sample of children from early in their life, measure their executive functioning several times, and only if, some children experience traumatic events

and develop PTSD one could talk about a causal relationship between PTSD and deficits in executive functioning. Because of this fact, one could not speak about a causal relationship, in other words that PTSD leads to deficits in executive functioning, in this thesis. What we could do, is speak about an association between the variables. We do not know if the traumatic event or the disorder PTSD is the variable that has the impact on the executive functioning. The children could for example have weaker executive functions to begin with, even before the traumatic event found place. There could even be a connection between weak executive functioning and the vulnerability to develop the disorder PTSD. The discussion will further include some variables that could have had an impact on the results in this systematic review.

7.3 Variables that could have had a mediating effect

The variability when it comes to results of whether poor executive functioning is associated with PTSD in children in youth, could be explained by a number of other variables. Both the age of the sample, type of traumatic events, intelligence, the criteria in sampling, the assessment tools used and the time from the traumatic event had happened. Some of these variables will here be discussed.

7.3.1 Type of traumatic event

There could be an explanation of the difference of the findings in the studies when we look at what type of traumatic events the children have been exposed to. The results from a study that explored the effects that familial and non-familial traumatic events had on cognitive functioning, showed that children who were exposed to familial maltreatment trauma performed weaker on working memory, inhibition, auditory attention and information-processing, than the children who had experienced non-familial trauma (DePrince, Weinzierl & Combs, 2009), and was not included in this systematic review because the children did not have PTSD. The poorer working memory, inhibition and information-processing this study found in children exposed to familial traumatic events may be explained by that a secure attachment seems to be an important factor in coping with the traumatic event. When a child or adolescent experiences traumatic exposure within the family, this secure attachment may not be present or harmed (Herrman et al., 2011). Is this the case in this review? Some of the studies have a group with children that have been exposed to one single event trauma like an

earthquake, while other studies look at children exposed to repeating traumatic events like maltreatment. The issue when exploring if one type of traumatic event has more impact on the other in this case, is that the total number of studies exploring children and youth exposed to single events or non-familial type of traumatic events are few compared to studies exploring children and youth exposed to maltreatment. In this case, could this be explained by Terr´s (1991) separation between type I and II trauma and their differential reactions? According to Terr, repeated traumas could lead to more massive denials, psychic numbing and personality problems (Terr, 1991). With more of these issues, one could think that this also would lead to bigger difficulty concerning executive functioning.

The findings of the study comparing executive functions among two groups exposed to an earthquake (Yang et al., 2014), found no significant differences with poorer executive functioning in the children with PTSD. They assessed the executive functions both 4 months and 12 months after traumatic event and compared the results to results of children exposed to the earthquake without PTSD. The difference among earlier studies and this current study could be explained by different characteristics of the traumatic experience (Yang et al., 2014).

Familial traumatic events are in this review understood as a traumatic experience within the family environment. Examples of this type of traumatic events could sexual maltreatment within the family, neglect, physical abuse and emotional abuse. All these is by the world health organization defined as maltreatment (Thapar et al., 2015). Non-familial trauma is on the other hand understood as traumatic events outside the family, such as earthquakes or some form of disaster like a fire or an accident. While it not necessarily would be this way, one could assume that familial traumatic events often are repeated, and ongoing for some time. On the other hand, non-familial traumatic event may often arise as a surprise, and more in form of a single incident.

If we divide the literature in to these categories, we may have a clearer picture of whether there is a different in executive function between the types of traumatic events the children are exposed to. While three of the studies included in this review did not have clear boundaries when it came to types of traumatic events (MacDonald et al., 2015; Gindt et al.,

2016; Samuelson et al., 2010), or other facts that made it impossible to look at the types of events, the other eleven were possible to divide in to the following categories: Repeated events, single event, familial traumatic events and non-familial traumatic event(s). This could have made it possible to look at the findings of the differences within these groups both in executive functioning in the more complex way, as well as the several domains included in the review. When trying to separate the studies in to the two groups, the studies both looking at complex measures and groups with and without PTSD was not enough to make a conclusion. Only one effect size on single events or non-familial events were calculated in complex measures due to missing means and standard deviations. The median effect size in the familial and repeated types of traumatic events were $d = 1.06$, a very large effect size.

7.3.2 Intelligence

"Intelligence is the ability to acquire knowledge, to think and reason effectively, and to deal adaptively with the environment. Because cultural environments differ in the skills most important for adaption, cultural conceptions of intelligence may differ markedly" (Passer et al., 2009, p. 437). Cattell & Horn suggested two types of intelligence – fluid and crystallized intelligence. Fluid intelligence refers to nonverbal, relatively cultural free mental activity. The crystalized intelligence entails obtained skills and knowledge that is developmentally dependent of exposure to the culture (Sattler, 2008). Friedman et al. (2006) found that fluid intelligence showed correlations with updating, but there were non-signifcant correlations between fluid intelligence and inhibition, as well as shifting and inhibition. Crystallized intelligence correlated with inhibiting, updating and shifting variables. When they controlled for intercorrelations between inhibiting, updating and shifting, on the other hand, they found that only updating was significantly related to intelligence (Friedman & Miyake, 2006). In other words, they found an interaction between both fluid and crystallized intelligence and the ability to replace old irrelevant information with new updated information (e.g. updating). Updating is closely linked to working memory, and working memory is used as a measure in intelligence testing (e.g. WISC-IV). A study by Roebers et al. (2014) found that the common variance between executive functioning and intelligence was between 13% and 25%. Do the children with PTSD have lower IQ than the unexposed controls?

De Bellis et al. (2009) found that the PTSD group in their study had lower IQ scores than the control group. There is no clear understanding if lower IQ is a predisposing factor or a

consequence of the traumatic events the children had been exposed to. Barrera-Valencia et al. (2017) also found that the group with PTSD had statistically significant lower IQ than the unexposed controls. This was done in DeBellis et al. (2009) as well, and they found a significant group difference between the groups in IQ, with the PTSD group with the lowest scores, the maltreated children somewhat better scores and the control group with the highest scores. This study did not control for IQ, given its potential association with the neuropsychological variables in the study. MacDonald et al. (2015) included IQ in the regression analysis to figure out if this variable mediated the connection between executive functioning and PTSD – and found that the results after controlling for IQ still was significant. On the other hand, Yang et al (2014) looked at differences in the PTSD group and the control group concerning IQ and found that there were no significant differences between the groups.

Among the other included studies that included IQ as a measure, Crozier et al. (2014) and Samuelson et al. (2010) found that the results maintained significant after controlling for IQ. If there is a connection both between intelligence and executive functions as well as between intelligence and PTSD, this could be a spurious connection – a common variable that influences both PTSD and executive functions (Bryman, 2015). This could be solved by including IQ as a variable and control for it in the analysis to explore its effect on the findings. This is done in some of the studies – and overall leads to the results that IQ is not playing a mediating role in the connection. In summary, there seems like the studies are in agreement when they look at significant differences in IQ between the PTSD and the group of children exposed to traumatic event(s) without PTSD compared to the unexposed controls, but when included in the analysis as a potential mediating variable, it looks like IQ do not have a mediating role in the association between posttraumatic stress reactions and weak executive functioning.

7.3.3 Age

Dividing the groups into “children” and “adolescents” could give us answers to whether the age could have an effect on the results in executive functioning. If we draw the line between childhood and adolescence at the age of thirteen, only two of the studies had a sample with a mean age counting as adolescents (Kavanaugh & Holler, 2014; Kavanaugh et al., 2013). This

may give a wrong picture bearing in mind that there is a larger number of studies with samples with mean age beneath thirteen years old. On the other side, looking at the effect sizes, it does not look like the differences are of significance, with an interquartile range between $d = 0.73$ and $d = 1.06$ in the groups with mean age beneath thirteen (De Bellis et al., 2009; De Bellis et al., 2013; Park et al., 2014) and effect sizes from $d = 0.68$ and $d = 1.41$ in the studies with mean age over thirteen (Kavanaugh & Holler, 2014; Kavanaugh et al., 2013).

7.4 Summary

In the studies included in this review it looks like the results indicate a significant difference between the group of children with posttraumatic stress reactions and the control-group. This leads us to the conclusion that there is a connection between posttraumatic stress reactions and executive functions. Further, the studies included in the review that looked at the differences between a group of children with posttraumatic stress reactions and a group of children exposed to trauma that did not have posttraumatic stress reactions did find a smaller effect size of $d = 0.39$ on complex measures of executive functions compared to comparisons between the PTSD group and the control group ($d = 0.77$). It can seem like the association between posttraumatic stress disorder and deficits in executive functioning is not due to the diagnosis itself, but to the traumatic events the child or adolescent has experienced, but we need more research to make a conclusion.

In this chapter, the quality of the included literature has been discussed with validity in focus. The research design used in the majority of studies included in this review do often have a weak internal validity and does it impossible to say anything about a causal relationship between the variables measured. Because of this, we could only refer to the findings of the connection between weak executive functioning and posttraumatic stress reactions as an association. There is some challenges in construct validity as well, especially when it comes to measurements of executive functioning. External validity is typically good in cross sectional designs, but the size of the sample is also crucial in the ability to generalize results to a bigger population.

There is a possibility of mediating variables that could have affected the findings in the association in the studies included in the review. Which type of traumatic event the child is

exposed to could be of significance when measuring the association between executive functioning and posttraumatic stress disorder. Intelligence were further discussed as a possible mediating variable. Intelligence could have a big impact on the executive functions.

8 Implications

8.1 Implications for the educational psychology counsellor

Educational psychology counsellors are in a unique position when it comes to working with the children and youth that are exposed to traumatic events, whether there is due to catastrophes or maltreatment. Some of these children have developed posttraumatic stress disorder, but as the findings in this review showed us, this do not necessary have an isolated effect on these children and adolescent's possible weak executive functions. Knowledge about both their challenges socially and academically is important and may lead to knowledge that could be used for giving advice to the people that is close to the child every day. Knowledge about their cognition and executive functioning are crucial in their ability to learn and to best contribute to the best development of children in this position. The findings of this review should make us aware of children exposed to traumatic events challenges in executive functioning, as well as executive functions effect on the children´s social life, academics and behaviour. The results also point in the direction of early prevention of children in risk of maltreatment or at risk of developing posttraumatic stress disorder, because we know the possible negative sequelae (Davis, Moss, Nogin & Webb, 2015).

There has been limited research in the area of the executive functioning in children with posttraumatic stress reactions, even though the executive functioning is crucial to perform in academics, extra-curricular activities and social settings (MacDonald et al., 2015). Bearing in mind the high prevalence of children and youth exposed to maltreatment, as well as the children and adolescents that experiences different sorts of catastrophes, the need for knowledge about the impact it has on cognition is high. The knowledge could lead to better assessment abilities in the services aiming to give advice to the people surrounding children and youth with traumatic experiences in the past. It could lead to better understanding of their functioning, and an explanation of the cognitive deficits some of them may show.

The comorbidity between experience of traumatic event is high to psychiatric disorders (Yule & Smith, 2015), and with focus on prevention for the children experiencing such, we get the opportunity to act preventively. Children with PTSD have higher rates when it comes to

drop-out from school (Broberg et al., 2005; Morton, 2018), which make it even more important to understand the cognition of children and youth with posttraumatic stress reactions.

As an educational psychology counsellor and as a teacher, one should be aware about the possibility of weak executive functioning and its impact on both school-related achievement and the children's social life. One should always assess the executive functioning in cases with children and youth that struggles with posttraumatic stress reactions. Adaption in schools needs to be done for the children with weak executive functioning.

One of the interesting findings in this systematic review were that the median effect size in working memory updating were the only median small to medium effect size ($d = 0.48$) in the comparisons between children and youth exposed to traumatic events with and without PTSD in separate executive functions. The working memory is important in regulation of attention, in planning and action (Siegler et al., 2011). This result may be used in both assessing and adaption for children with posttraumatic stress reactions. This will also be connected to intelligence testing, especially if the Wechsler intelligence Scale for Children (WISC-IV) is used, because one of the indexes in this are especially assessing working memory, as well as other parts that are dependent on working memory (Wechsler, 2003). Maybe there is something in the argument that PTSD should be classified as a disorder of memory instead of an anxiety disorder that it is today (O´Donohue & Elliot, 1992, cited in Yule & Smith, 2015). Issues that arises from a weak working memory the child or youth may be challenges in solving a task because he or she loses focus, forgets ideas and does not remember the goal. Another challenge may be to attach old theory to new knowledge. The child or adolescent may be distracted by inner associations, thoughts or ideas, as well as external distractions (Fallmyr, 2017). The advice to teachers with students that struggles with a poor working memory, may be to shade the child from competing impressions and give frequent breaks. The child may need the message both written and verbally. Another tip may be time management, for example in form of calendars or notes of tasks (Fallmyr, 2017).

A survey indicates that BRIEF has become a quite popular used questionnaire used to assess executive functioning, with 43% of the neuropsychologists saying that they use this on a

regular basis (Løvstad et al., 2016). A survey of psychologists in the specialist health service showed that 30% of the sample used BRIEF (Psykologiforeningen, 2009, cited in Fallmyr & Egeland, 2011). This is also used by educational psychology counsellors. While behavioral tasks measuring executive functions often have a weak ecological validity, there is also some challenges when it comes to using BRIEF. A study done by Løvstad et al. (2016) explored the relationship between neuropsychological test performance and self-reported emotional distress and found that there were strong associations between BRIEF and emotional distress in both the healthy group and in neurological groups. This leads to the conclusion that BRIEF scores should be interpreted with caution (Løvstad et al., 2016). Other studies have shown that the correspondence between measures of executive functions (like those measures in this review) and questionnaires of executive functioning like BRIEF is low (Barkley, 2012; Topak, West & Stanovich, 2013, cited in Løvstad et al., 2016). If questionnaires like BRIEF actually measures emotional distress, and not the executive functions, and if this do not correlate with measures used in the studies in this review, one could think that BRIEF may not be a good measure in assessing these functions. This may especially be challenging because it also captures emotional distress in healthy samples (Løvstad et al., 2016). On the other side, the measures in this review often do have a weak ecological validity, which means that the results do not necessary connect with the children´s daily life. Implications for the educational psychology counsellor may be that both behavioural tasks measuring executive functioning as well as BRIEF should be combined in assessment of the executive functions. It is extremely important that observation of the child or adolescent is a part of the assessment and conclusions about the challenges.

Connections between deficits in executive functioning and a variety of different forms of psychopathology have been reported (Snyder, Miyake, et al., 2015, cited in Friedman & Miyake, 2016). It is important to separate the challenges of PTSD from other psychopathology in executive functioning, because it could have an impact on the assessment results. Among these related disorders, attention deficit hyperactivity disorder (ADHD) and autism spectre disorder (ASD) have been discussed (Hulme & Snowling, 2009; Friedman et al., 2007; Friedman et al., 2008). It is important to separate these disorders and their challenges in executive functioning. Based on this review, children with posttraumatic stress reactions do differ compared to unexposed controls in the executive functioning, perhaps especially with regards to fluency (median $d = 0.91$) and working memory updating with the

largest median effect size when the PTSD group was compared to children and youth exposed to traumatic events without PTSD (d = 0.48), as well as on the more complex measures (median d = 0.77) and shifting (median d = 0.73). Earlier studies have purposed that children with PTSD has inhibitory dysfunction (Aupperle et al., 2012; Hulme & Snowling, 2009), but this was the smallest median effect size (d = 0.18) in this review, with effect sizes in both directions that make it difficult to have a clear picture of whether inhibition is poorer in the group with PTSD or not. Further research is needed to look at this connection, but this could be a difference among the disorders. Patterns in assessment of children when it comes to executive functioning could with bigger safety reveal the children´s possible disorders, and one should be aware that deficits in executive functioning do not belong to one disorder. This could have an impact on the assessment results.

Deficits in executive functioning have also been proposed as a possible explanation for some of the deficits seen in children with autism. It is striking that 67% of children with autism spectre disorder have weak scores on Tower of London, that is a measure of more complex executive functioning (Hulme & Snowling, 2009). In a review of studies exploring the connection between separate executive functioning in children with ASD they found that shifting was impaired in the included research, as well as in working memory. The only study that compared the group with ASD to controls in inhibition found no significant differences (Visser, Rommelse, Greven & Buitelaar, 2016). The same review explored executive functioning in children with ADHD and found that the included studies did not find any deficits in working memory in the group of children with ADHD, while they found that children with ADHD had clear deficits in inhibition in all of the research included. Shifting deficits is according to this review also impaired in children with ADHD (Visser et al., 2016). To summarize, it looks like children with ADHD has deficits when it comes to inhibition and shifting, while children with ASD often has deficits in the domain of shifting and working memory. Children with posttraumatic stress reactions on the other hand, has with the most evidence deficits in the domain of fluency, working memory updating and shifting according to this review. The pattern is in other words different among these disorders, while it looks like all of them have deficits in executive functioning.

In a meta-analysis done by Alvarez-Bueno et al. (2017) looking at the effect of physical

activity interventions effect on children´s cognition and metacognition, they found that physical activation interventions have been useful for the development of inhibitory functions. This could be useful as an advice to prevent deficits in executive functioning in the classroom, especially for inhibition. One could also use this as an advice for helping the children with weak executive functioning to develop these functions. An example could be to include short pauses with physical activity when the children are working with school activities. On the other side, Howie, Schatz & Pate (2015) explored the effect of Brain breaks, short pauses of physical activities had on executive functioning, and found no effect.

Two of the large number of studies finding trauma-focused cognitive behavioural therapy as an effective treatment-form for children with posttraumatic stress disorder, are Sachser et al. (2017) and Jensen et al. (2014). These studies both found that the treatment form was effective for these children´s challenges. This is both useful with treatment in mind but could be transferred to thinking advice to schools when teaching children with trauma-related challenges as well as PTSD. Among the components of trauma-focused cognitive behavioural therapy, we find that learning relaxation techniques is a part of it (Jensen et al., 2014; Sachser et al., 2017). This could be used in counselling the teachers dealing with these children and youth. The teacher could include breaks including several relaxation techniques while working with tasks at school. This were the theme in a systematic review of interventions for executive function as well. Mak, Whittingham, Cunnington & Boyd (2017) explored mindfulness-based interventions and its influence on executive functions and found that five of the 13 included studies found at least one significant intervention effect on interventions for executive functioning with medium to large effect size (Felver et al., 2014; Haffner et al., 2006; Leonard et al., 2013; Purohit & Pradhan, 2016; Sidhy, 2013, cited in Mak et al., 2017). Mindfulness interventions was described as meditations involving selecting a point of focus, such as the breath, or a physical action as raising and lowering arms, as well as regulating and directing attention to that point with sustained focused attention (Mak et al., 2017). This could be understood as relaxation techniques that have shown effect on PTSD, as well, and could be effective to bring in to the child´s school environment. Group-based cognitive behaviour therapy (CBT) in schools have been showed to be effective (Yule & Smith, 2015). One study that implemented group-based CBT with the support of the school´s educational psychologist, found improvement in symptoms of anxiety and depression (O´Callaghan & Cunningham, 2015).

Psycho-education is a part of trauma-focused cognitive behavioural therapy and could be used in schools to educate the children and youth about traumatic events and the reactions. This entails talking to the child about what posttraumatic stress disorder is and teaching the child what it would mean. It could be expedient to educate the whole class about the disorder, as well as what it entails. This could lead to more understanding and would benefit them all. A safe environment and a safe relation to the child are important in these cases.

8.2 Implications for further research

It would have been interesting to look at the difference in executive functioning among the different causes of traumatic events. Is the executive functioning weaker in sexual maltreatment compared to children that experienced war for example? There would have been especially interesting to look at the children with posttraumatic stress disorder before and after the traumatic event, to explore their executive functioning and their development earlier in their life. This could also have contributed to a better understanding of both resilience, development and the connection between executive functions and PTSD. It would furthermore have given us a better picture of risk factors, and the causal relationship between the variables. This could have been done by including a large group of children and testing their executive functioning over years and look at children with different psychopathology and their development from early on and afterwards.

8.3 Summary and conclusion

Educational psychology counsellors have a unique position for working with children that needs adaption to in the best possible way master the tasks in school, as well as their social life. The high rates of children exposed to traumatic events and their possibility of developing PTSD, makes it important to have knowledge about the disorder and its outcomes to give the best advice possible to the people surrounding the children every day, like teachers and parents. This review found that executive functioning was poorer in children and youth with posttraumatic stress reactions than unexposed controls, and that some of the separate functions seemed to be weaker than others. Compared to children and youth exposed to a traumatic event, it seems like children and youth with posttraumatic stress disorder especially perform poorer in working memory tasks. This could have a connection to intelligence, as

well as an impact on academic performance and in social settings.

BRIEF is often used in assessing executive functioning but should be interpreted with caution (Løvstad et al., 2016). As it may have better ecological validity than behavioural tasks measuring executive functioning, it could be used in combination with other measures. It is important to include an observation of the child or adolescent in addition to the assessment with behavioural tasks, to in the best possible way see the impact the challenges may have on the child in school activities and social settings.

Some research has found physical activity interventions to be effective in children´s cognition and metacognition (Alvarez-Bueno et al., 2017). An example of advice to teachers may in regard to this be to include short pauses with physical activity when the children are working with school activities. Further, the trauma-focused cognitive behavioural therapy has in a number of studies been found as an effective treatment form for children and youth with PTSD (Sachser et al., 2018; Jensen et al., 2014), and some of the aspects of the treatment form may be used as advice of teachers working with children with PTSD. Relaxation techniques and psychoeducation is two of them. Some advice that could be given to teachers that have students that struggles with working memory were also given. We looked at some advice that could be given to teachers that have student with issues of working memory. Shading the child or youth from competing impressions and give frequent breaks, both written and verbally messages as well as a time management in form of a calendar or notes, could be effective (Fallmyr, 2017).

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