

# Bachelor Degree Project



## **RESILIENCE IN COGNITIVE NEUROSCIENCE**

The 'Ordinary Magic' of Human  
Recovery

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**Abstract**

Resilience is a dynamic process that reflect individual ability to successfully recover and positively adapt to severe circumstances. In this essay, attachment, social support, self-regulation and affective processing, taken from the “shortlist of resilience” provided by Masten, are further analyzed and connected to findings within neuroscience. The result suggest that brain areas originated from the prefrontal cortex, such as orbitofrontal and dorsolateral cortex, are two major neural correlates to attachment and stress- and self-regulation. The amygdala is also an area of interest, because of its’ connection to emotions and affective memories. Research on affective style suggest that the functions associated with the prefrontal cortex are dampening the effect of the amygdala, which later supports resilience and recovery. The area of resilience is suffering from a lacking general definition, measurement and operationalization, which is argued to be the major challenge of this research area. Prominent researchers prospect that resilience research will continue to flourish within the area of neuroscience, and that further discoveries will be made concerning how this cognitive ability is related to structural and functional differences in the brain.

*Keywords:* resilience, recovery, stress, positive psychology, affective style, emotion regulation.

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## Introduction

The beginning of the 21<sup>st</sup> century has witnessed a sequence of global calamities such as natural disasters, political conflicts, virus outbreaks, economic crises, and industrial accidents (Masten, 2015). Most people are going to experience at least one violent or life threatening event during their life, with burnout and depression being plausible consequences (Bonanno, 2004). The European Parliamentary Research Service Blog estimates that around 300 million people worldwide suffer from depression (Members' Research Service, N. S. (2017, April 06). World Health Day 2017 – 'Depression: Let's talk'. Retrieved April 6, 2018, from <https://epthinktank.eu/2017/04/06/world-health-day-2017-depression-lets-talk/>), and the direct and indirect costs related to depression are estimated to be around €300 billion per year (Olesen et al, 2012). Some argue that the promotion of mental health is the greatest challenge faced by developed countries today (Kalisch, Müller & Tüscher, 2015).

Retrospectively, research has dominantly focused on investigating the psychopathological side of depression, thus how to diagnose and treat the disorder and “fix the problem” when the harm is already done (Boniwell, 2012). Later, the interest to study people whom showed the ability to recover and handle these traumatic experiences started to expand. Researchers observed tremendous variability in how the lives of these people unfolded, and how some showed the surprising ability to thrive even in the face of formidable odds (Masten, 2015). These individuals showed an ability to “bounce back” and recover to their normal level of mood and behavior in a rapid and successful way (Cohn, Fredrickson, Brown, Mikels & Conway, 2009). This ability was later coined “resilience”, originating from the latin word *resiliere* which means “to rebound” (Masten, 2015).

Along human history, tales have been told about individuals from humble backgrounds that have overcome difficulties and achieved personal success. Fairytales are commonly portrayed by themes such as struggles, persistence, heroic deeds and transformations, which have fascinated humans for decades. Therefore, there is no surprise that resilience has gained increased interest and is one of the core domains of developmental psychology (Masten, 2015). Resilience has, through history, been defined in many ways. For example, as a personality domain that some people have and others don't (Luther, Cicchetti & Becker, 2000). Some researchers argue that former theorists have underestimated and misunderstood resilience, viewing it as rare and as something exceptional. Subsequent research has made it evident however that resilience is nothing extraordinary (Bonanno, 2004). It has rather been proven to be a common phenomenon originated from humans inherent adaptational systems (Masten, 2001), and been defined as “ordinary magic” (Masten, 2015) to reflect individual ability to maintain a positive adaption when faced with adverse circumstances (Luthar,

Cicchetti & Becker, 2000).

Another transformation in resilience research is the shift from deficit- based models of treatment to models focusing on healthy and protective factors such as positive goals and outcomes, as well as available resources for the individual. This shift does not mean that problems, risk and vulnerabilities are ignored, instead it provides a more balanced perspective on strategies and interventions to promote and boost resilience (Bonanno, 2004). An example of a successful intervention program is the Nurse- Family Partnership for low- income mothers with children under the age of 2, that combine support and education within health care, parenting skills, emotional support and links to resources in the community. This program has been proven to improve the mothers' mental health and result in better emotional and language development for the infants (Olds, 2006). Also, findings in neuroscience have highlighted the brains capacity to change, known as neuroplasticity. This raises the possibility for humans to enhance neural capability and strengthen cognitive skills needed for resilience (Davidson, Jackson & Kalin, 2000), such as emotion regulation and self- direction. Resilience is, in other words, not a fixed state but rather something that can be learned and promoted within all humans, and a skill that changes both the structural and functional aspects of the brain (Masten, 2015). A skill that has been argued to be of great importance for happiness and overall well- being (Fredrickson, 2000).

The aim of this essay is to map out what current research say about resilience, different scientific models, challenges in this area and how it connects to the emerging field of positive psychology. Structural and functional neural correlates to resilience will be presented in contrast with the "short list of resilience" provided by Masten (2015; 2018). Presented data will be based on studies conducted with human subjects, thus excluding animal research. Resilience is a broad concept that has been linked to several different aspects on human nature such as behavior, personality and emotion. This essay will focus on the affective aspect of resilience, in other words how a person adapts to adversity in an emotionally constructive way, and cognitive skills that support resilience after traumatic circumstances. The brains capacity to recover after injury and regain its' normal level of skills and capacity, known as cognitive resilience, will not be covered.

The disposition of this essay will be as follows. First, the history of resilience as a scientific subject will be presented together with a description of the term and how it is usually applied in matter of research. Second, a presentation of positive psychology, and the broaden- and build theory in particular, will be concerned and how this relates to resilience. After that, neural correlates of resilience based on the adaptive skills in the "shortlist of resilience" (see Table 1) provided by Masten (2015; 2018) will be addressed. Findings

concerning resilience and cognitive neuroscience will be highlighted and compared with known functions of the concerned brain areas and circuits. Lastly, the overall challenges of this research area will be revised in the discussion, together with prominent researchers' thoughts about future directions.

### **History of Resilience**

The World War II had a profound influence on the pioneering studies of resilience. Researchers set attention on children that had been exposed to severe life traumas, such as homelessness, war and separation from caregivers (Nichols, 2013). Longitudinal studies and case- studies were motivated and financially founded to identify relevant risk factors associated with negative outcomes, such as mental health and behavioral problems (Masten, 2015). Researchers first focused on risk factors that lead to illness (Nichols, 2013). This constituted the first wave of resilience research (Masten, 2015), which was of a descriptive nature, focusing on the predictors of psychopathology and maladaptive behaviors resulting from adversity (Lavretsky, 2014). During this time, several researchers studied children whom had showed extraordinary ability to develop well and avoid psychopathology, despite traumas or severe adversity early in life (Masten, 2001). It was implied that individual outcome after exposure to risk would be absolute and unchanging, and outside of personal control. Were subsequent research has showed that the ability to adapt and recover comes from a developmental progression, and can thus be learnt. The term resilience was adopted because it reflected the relative nature of the concept, rather than indicating that it would be of a fixed nature (Luthar, Cicchetti & Becker, 2000).

The second wave focused more on the processes that lead to resilience and how protective influences effect the outcome (Masten, 2015). Vulnerability and coping patterns in children with parents whom suffered from schizophrenia were studied by prominent scientists. They studied children whom showed the capacity to resist becoming engulfed with their parents' psychopathology, whilst also maintaining compassion towards them (Luthar, 2006). Personal qualities were the scope of attention at that time, qualities such as autonomy, self- esteem (Masten, 2001), as well as high creativity and effectiveness. Subsequent findings indicated that resilience was developed dependent on a child's personality attributes, characteristics of their social environment and aspects of their family conditions (Luthar, 2006). It was implied that some children had a remarkable or special ability to handle difficult experiences in life, and stay mentally healthy despite the circumstances (Masten, 2001). As earlier mentioned, resilient children were considered to be extraordinary and rare (Luthar, 2006; Bonanno, 2004), but the term were later discarded when it became evident that

resilience is nothing extraordinary.

The third wave put attention to the promotion of resilience through interventions as well as testing the theories originating from earlier research (Masten, 2015). A shift from disease-oriented inquiry to inquiry towards wellness and prevention started to take form, where personal strengths, adaption and coping skills were studied, and interventions started to take form (Lavretsky, 2014). Until this point, research generally encompassed psychological variables connected to resilience (Cicchetti, 2003).

Finally the fourth wave, which is the phase that resilience research is currently in, is characterized by neuroimaging. Advancements in neuroimaging technology have made major leaps forward, allowing scientist to study the genetic and neurobiological side of resilience in more detail. Today's research is thus more dynamic and system-oriented, focusing on how genes and environment co-operate, and how trauma-induced stress effects hormones and the brain on both a functional and structural level (Masten, 2015). Hundreds of studies have indicated that the environment has a great impact. Empirical evidence support that a complex, stimulating, and enriched environment has positive advantages on both a neurochemical, neuroanatomical and behavioral level (Curtis & Nelson, 2003). Maltreatment during childhood has been shown to effect the brain both on a structural and functional level. More specifically, it has been linked to neurobiological effects on brain areas such as corpus callusum, amygdala and hippocampus (Teicher, Andersen, Polcari, Anderson, Navalta & Kim, 2003). The orbitofrontal cortex, which is part of the prefrontal cortex, has been linked to social reward (O'Doherty, Winston, Critchley, Perrett, Burt & Dolan, 2003) and affiliative behavior (DePue & Morrone-Strupinsky, 2005), which might promote close social relationships which in turn support resilience (Masten, 2015).

Despite the contributions made to date, the field of resilience is currently faced with a limitation that needs to be addressed for this research area to flourish further. Resilience researchers needs to agree upon a general definition of what constitutes as being resilient (Cicchetti, 2003; Luthar, Cicchetti & Becker, 2000; Masten, 2018).

## **The Definition of Resilience**

### **General definition.**

Resilience has evoked interest in the scientific community during the last decades (Masten, 2018), and has gained widespread use in scholarship and practice. Vague contradictory definitions are a current problem within this research area (McCleary & Figley, 2017). Along history, resilience has been viewed and defined as a trait-like characteristic, a

process, competence to meet normative expectations, the outcome of a persons' life course, and as a combination of all the above factors (Masten, 2015). Competence to meet normative expectations could for example be a persons' ability to achieve good grades in school or success at work despite challenges at home, or traumas that had been experienced in the past. In todays' research, resilience is often defined in general terms as a construct that reflects individual ability to maintain a positive adaption to adverse circumstances (Luthar, Cicchetti & Becker, 2000). The American Psychological Association (APA) defines resilience as an ongoing process that support a person to "bounce back" from traumas or hardship in life. It is the ability to operate well and use the social, psychological and physical resources that one has in his/her surroundings to recover in a rapid and successful way. APA also argue that the strength of this intrapersonal ability varies depending on the following factors; having strong and supportive social relationships both inside and outside the family, the capacity to make realistic plans, self- confidence and trust in one's own ability, communications skills, problem- solving ability and cognitive control over affective responses (American Psychological Association, 2018). Research in this area aim to identify and understand the underlying processes that account for the good outcomes that some people gain spite of serious threats to adaption or development (Masten, 2001).

### **Resilience as a trait.**

As mentioned, resilience was historically linked to certain personality traits. Some researchers of today believe that this is inaccurate and misleading (Masten, 2015), whilst others supports this view (Block & Kremen, 1996). Studies have been conducted historically, but also during recent years, were measurements such as the "ego-resilience questionnaire" and Connor- Davidson Resilience Scale have been used. Both scales are assessing the individual characteristics that are related to being resilient (Oshio, Taku, Hirano & Saeed, 2018). Ego-resiliency is defined as central personality constructs that effect and regulate motivation, emotion and behavior in response to situational demands and affordances (Letzring, Block & Funder, 2005). According to this definition, resilience is a characteristic quality, that origin from the psychosocial environment from each persons' childhood, that either fosters the development of capabilities that supports regulation of impulses and enhance controllability or constrains it. The term "ego" refers to the psychoanalytical term that addresses the intraindividual personality structure that motivates avoidance to threats and enhances viability. This force has been argued to be a product of evolution and entails survival- enhancing aspects such as a tolerable anxiety levels, impulse expression and adaptive behavior towards stress (Block & Kremen, 1996). The ego-resiliency scale contain

statements such as “I like to take different paths to familiar places”, “Most of the people I meet are likeable” and “I would be willing to describe myself as a pretty ‘strong’ personality”. Answers are being recorded using the Likert- like scale (Letzring, Block & Funder, 2005).

The Connor- Davidson Resilience Scale comprises of 25 items, each rated on a 5- point scale with a higher score indicating a greater amount of resilience. The characteristics of resilience that the scale is based on are for example patience, sense of humor, self- efficacy and adaptability to change. The scale has demonstrated sound psychometric properties, such as good test- retest reliability and internal consistency and been applied to a wide variability of subjects and conditions (Connor & Davidson, 2003).

This discussion, whether resilience can be argued to be a trait or not, is one of the most enduring in the literature. The idea is likely connected to the term itself, referring to when rubber bands lose their resiliency, which is the flexibility and ability to “bounce back” to its’ ordinary form (Masten, 2015). Sympathizers to the view of resilience as a trait argue that early signs of ego- resiliency can have a major effect on competent adjustment and adaptive behaviors in the future (Causadias, Salvatore & Sroufe, 2012). Low levels of ego- resiliency has been shown to be linked to later behavioral problems such as high impulsivity, aggression (Caspi & Silva, 1995), low self- control and poorer quality social relationships (Caspi, 2000). Protective functions such as problem- solving ability and positive attitudes are argued to be lawfully related to personality structures that the ego- resiliency scale measure (Block & Block, 1980).

However, other researchers argue that the evidence to support this view has been few (Panter-Brick & Leckman, 2013) and studies exploring the connection between adaptive behavior and ego- resiliency have been scarce (Causadias et al, 2012). It has also been argued that there are considerable risks connected to the view of resilience as a trait. This theory can support the belief that some people don’t have “the right stuff”, and therefore can not handle adversities. Some people might be blessed with great resources, such as close family connections (Masten, 2015) and an enriched environment that have promoted the development of necessary cognitive skills (Luthar, 2003) that contribute to their ability to recover much more than selective traits would. Some researchers believe that the resources and systems of resilience are not “in” the child, and that the idea of resilience as a trait is misguided and unethical (Masten, 2015).

### **Defining factors of resilience.**

According to Schwager and Rothermund (2013) three major factors need to be present to

identify resilience. First, a severe adversity should be established. Second, the persons' level of functioning should be able to be measured and compared to the same individuals' baseline of functioning. Third, and most importantly, the cause of recovery need to be fully explained by resources of the individual, and never by external forces (such as changed circumstances, or medical treatment).

However, it has been discussed in the scientific community what constitutes as an "adverse situation". Study definitions have ranged between a single stressful life experience (such as exposure to war) or several negative events during a life period. There has also been a remarkable difference in defining positive adjustment among these high- risk individuals. Some studies have used several domains and measured how well the individual excels in these areas, whereas others have only required excellence in one area, for example study results among children (Luthar, Cicchetti & Becker, 2000). Developmental investigators have measured resilience by comparing individual track record with the major expectations of that given society or culture. Whilst other researchers within psychopathology have focused on the absence of mental disorders, or low levels of symptoms and impairments, among children whom have experienced a troubled childhood (Masten, 2001). In respect to the absence of a global and acknowledged definition of resilience, researchers need to clearly define the approaches they use and provide valid justifications to these choices, based on both a conceptual and empirical foundation (Luthar, Cicchetti & Becker, 2000).

Resilience is, in other words, a broad concept that is lacking a global definition within the scientific community. Researchers argue that this research area would benefit remarkably if a common definition would be agreed upon, to be able to separate resilience from other related areas in psychology (Luthar, Cicchetti & Becker, 2000; Masten, 2001). Despite the challenge to find a global definition, research within resilience has continued. To understand this developing process and the protective variables that affects resilience, different research models have been used.

### **Models and Application Areas**

Because of the growing interest in resilience, models and measures for statistical analyses became critical (Masten, 2015). The aim with these models is to investigate factors that might enable individuals to withstand stressors, avoid psychological distress and lead to more positive orientated approaches in life which promotes well-being and happiness (Johnson, Panagioti, Bass, Ramsey & Harrison, 2017). Resilience- studies can be categorized between person- focused and variable- focused (Masten, 2015).

**Person- focused studies.**

Person- focused studies are usually single- case based and focusing on single individuals with the aim to examine resources and protective variables that may explain their manifested resilience (Masten, 2015). The attempt is to capture the natural patterns that lead to positive adaption (Masten, 2001). Most of these studies consist of biographical information about single persons that have endured extraordinary adversities and still managed to succeed and flourish in important life domains such as school, job career, social relationships and mental health. The limitation with these kinds of studies is that the result has low causality and can not be generalized to a greater population. To overcome this, researches have turned to aggregated cases that study groups of people to examine factors that might account for their level of resilience. An example of an aggregated case- study is the Kauai Longitudinal Study of resilience, that has become a landmark in resilience research (Luthar, 2006). The researchers followed the life- course of 698 babies at the Hawaiian island Kauai. The participants were grouped into two subgroups, classified dependent on their exposure to risk factors such as poverty, chronic family discord, perinatal stress and mental illness. This study found several promotive and protective factors that might explain the level of resilience among participants, for example high- quality caregiving, positive and supportive relationships, better cognitive skills and high level of optimism (Werner, 1992).

**Variable- focused studies.**

The other model of resilience- studies are variable- focused, also known as multivariate or correlational analyses (Masten, 2001). These studies are capitalizing on the power of multivariate statistics, with the aim to understand patterns in variation, processes that explains covariation and thus help predict future outcome and adaption among high- risk individuals. A typical variable- focused resilience study aim to explore different models of direct, mediating or moderating effects that promote resilience or increase vulnerability (Masten, 2015). An example of a variable- focused study is one conducted by Dubow, Edwards and Ippolito (1997). They investigated how contribution of stressful events and neighborhood disadvantage could predict antisocial behavior, levels of self- worth and family support and how these protective factors in turn effected the participants' level of resilience. Here, they used a hierarchical regression analysis to analyze the different factors and its covariation. The researchers in this study concluded for example that high levels of self- worth and perceived family support had a lowering effect on antisocial behavior.

### **Resilience and Positive Psychology**

The scientific discipline of psychology has, during the latest decades, focused on risk, psychopathology and diagnostics of disorders. Thus neglecting the importance of adaptive factors and human capabilities that promotes well- being (Seligman & Csikszentmihalyi, 2000) and resilience (Masten, 2001). This is where positive psychology comes in. Positive psychology is a sub- field to psychology that focus on the positive aspects of human life, such as flourishing (Boniwell, 2012) and optimal functioning. The aim of this field is to explore and promote elements that makes societies and individuals thrive (Seligman & Csikszentmihalyi, 2000).

Positive psychology impose important questions for resilience investigators, for example what it is that undermine development and what promote adaption. Resilience research also poses questions about the nature and development of optimal functioning (Masten, 2001). The definition of resilience also resemble considerably with the characteristics of well- being presented by Ryff (Lavretsky, 2014). According to this model, the core dimensions of well-being are autonomy, self- acceptance, personal growth, positive relationships with others, environmental mastery and purpose in life (Ryff, 1989). All these components constitute human strengths that are necessary when facing adversity in life in a resilient way. A resilient person will show a stronger tendency to use personal strengths to overcome the adversity, seek support from close relationships, master a new skill, and find a purpose with the encountered challenge (Masten, 2015).

Positive psychology research has been able to show the importance of positive emotions and their adaptive function. Positive emotions have, for example, been shown to have a boosting effect on problem solving (Isen, Daubman & Nowicki, 1987), ability to organize ideas and access different cognitive perspectives (Ashby, Isen & Turken, 1999). Joy has been argued to serve as an antidote to stress, strengthen social bonds and contribute to affiliative behavior (Izard & Ackerman, 2000). Fredrickson (2001) has formulated a theoretical model to capture the effects of positive emotions, known as the broaden- and- build theory. According to this theory, positive emotions have the ability to broaden our thought- action repertoire, and build lasting cognitive and psychological resources (Cohn, Fredrickson, Brown, Mikels & Conway, 2009). It is argued that highly resilient persons experience more positive emotions during stressful times, which help them to recover and grow despite the circumstances (Tugade & Fredrickson, 2004).

#### **The broaden- and- build theory.**

Human emotions have been of interest in scientific communities for decades and this

scientific field has flourished in recent years. However, some emotions have been favored and researched upon more extensively than others. According to Fredrickson (1998) positive emotions such as joy, contentment, love and interest have been marginalized within science when compared to negative emotions such as fear. The reason for this, Fredrickson argues, is that positive emotions are fewer and less concrete. Also, negative emotions are believed to have evolutionary purposes and thus be more crucial for survival. Nesse (1990) suggests that natural selection has favored the development and retainment of negative emotions since they help identify threats and opportunities to survive, rather than pleasant emotions that make us feel good. However, empirical evidence increasingly support the broaden- and- build theory, which state that positive emotions broadens our though- action repertoire, and help build psychological resources (Fredrickson, 2001), such as resilience (Lavretsky, 2014).

The broaden- and- build theory provide a framework that demonstrate how positive emotions contribute to human well-being. Resilience is a central construct in this theory, proposed to play a crucial role in enhancing necessary coping resources that help protect and boost a persons' capacity to overcome negative events (Lavretsky, 2014), and lead to a higher amount of positive emotions during stressful times (Cohn et al, 2009).

In a study conducted by Cohn, Fredrickson, Brown, Mikels and Conway (2009) they examined the relationship between ego-resiliency, global life satisfaction and positive emotions. This study result confirmed the hypothesis that high scores on the ego-resiliency scale had a strong correlation with reported life satisfaction and accounted for a higher amount of positive emotions. The researchers argued that positive emotions help individuals to build resources to reach desirable outcomes and to deal with both moderate and severe stressors.

Positive emotions have also been shown to have correlation with functional brain activity. The basal ganglia has for example been linked to the feeling of happiness (Phan, Wager, Taylor & Liberzon, 2002) and reward (Rolls, 2004). In the next part of this essay, empirical evidence on how resilience can effect the brain on both a structural and functional level will be addressed.

### **Resilience in Cognitive Neuroscience**

Historically, the tools to study resilience on a neural level have been limited. The subsequent waves of resilience research have mostly focused on the behavioral and psychological aspects that are readily observed and easy to assess. Tremendous technological advances have been made during the last decades, allowing researchers of today to study the concept of resilience on a more neurobiological level, earlier referred to as the fourth wave of

resilience (Masten, 2015). The upcoming part of this essay will highlight findings within neuroscience, divided in sections based on cognitive skills that have been proven to be key components of resilience. These skills belong to “the short list” of protective systems (see Table 1) which represents converging findings in science regarding fundamental and adaptive systems that substantiate resilience (Masten, 2015; Masten, 2018). These systems are the product of cultural and biological evolution, shared between countries and societies, since humans tend to share comparative social functions, limitations, vulnerabilities and coping mechanisms (Masten, 2015).

Table 1. *The “shortlist of resilience”*

Resilience Factors	Adaptive systems
Effective caregiving and parenting quality	Attachment; family
Close relationships with other capable adults	Attachment; social networks
Close friends and romantic partners	Attachment; peer and family systems
Intelligence and problem- solving skills	Learning and thinking systems of the CNS
Self- control; emotion regulation; stress	Self- regulation systems of the CNS
Motivation to succeed	Mastery motivation, related reward systems
Self- efficacy	Mastery motivation
Faith, hope, belief life has meaning	Spiritual and cultural belief systems
Effective schools	Education systems
Effective neighborhoods; collective efficacy	Communities

In this essay, factors from the shortlist, provided by Masten, that will be highlighted and connected to findings in neuroscience are; attachment and social support (family, peers and social networks), emotion regulation and stress management. These parts of the shortlist were chosen based on the amount of current and high- quality research on human subjects in these areas. Lastly, research within affective style and its’ connection to resilience will also be considered.

**Attachment & social support.**

John Bowlby (1907- 1990) was a pioneering researcher in early attachment, and his well-established theory about the important role of the caregiver has been debated and further developed many years after his passing. Today, researchers still argue that attachment and support from close social relationships are fundamental for the establishment of resilience (Masten, 2015).

Close relationships are the single most strikingly noted resilience factor reported in review articles over the past half- century (Masten, 2015). Several studies within positive psychology have also shown that the perceived support and trust we have towards our friends and families are of great importance for our level of happiness and well- being (Diener & Seligman, 2002; Myers, 2000). The definition of resilience, provided by the American Psychological Association, also support this notion. Relationships characterized by love, trust, encouragement and reassurance helps booster individual ability to recover (Members' Research Service, N. S. (2017, April 06). World Health Day 2017 – 'Depression: Let's talk'. Retrieved April 17, 2018, from <https://epthinktank.eu/2017/04/06/world-health-day-2017-depression-lets-talk/>).

The closest relationship that we tend to have is the one with our primary caregivers, which in most cases are the parents. The quality of care that a child experiences from the mother, in combination with individual differences in biological makeup, has a strong impact on gene expression, stress response system and brain development (Masten, 2015). Neglect or maltreatment in early childhood or infancy have been shown to have both structural and functional neurobiological effects, such as reduced size of the corpus callosum and attenuated development of the left neocortex, amygdala and hippocampus (Teicher, Andersen, Polcari, Anderson, Navalta & Kim, 2003). In other words, environmental experiences and potential challenges can either enable or constrain the structure and function of the child's brain and the development of adaptive cognitive functions.

Studies have indicated that higher favorable disposition towards social relationships and attachment (known as social reward dependence) are strongly associated with increased gray matter density in the orbitofrontal cortex (OFC), basal ganglia and temporal lobes. To be cared for and to have a secure attachment to the parent is considered rewarding, which has major implications on circuits in the human brain connected to reward, such as the medial forebrain bundle (Masten, 2015), and the OFC (Lebreton et al, 2009). The OFC has earlier been associated with social reward information processing (for example when subjects are exposed to smiling faces) (O'Doherty, Winston, Critchley, Perrett, Burt & Dolan, 2003), and together with the basal ganglia it has been linked to the process of reward related information

(Schultz, 2002). Another study also indicated an association between high social reward dependence and strength of white matter tracts between the ventral striatum and OFC (Cohen et al, 2009). This interconnection between the striatum and OFC has earlier been argued to not only support the feeling of reward, but also affiliative behavior that enhances social bonding (DePue & Morrone- Strupinsky, 2005). These findings have lead other researchers to propose that this enhanced connectivity might promote temperament predisposed towards social interaction (Lebreton et al, 2009), thus promoting the protective resilience factor to form close supportive relationships. One might speculate that an early secure attachment can have implications on the brains structural development, which later might affect personality and affective style. Attractive social qualities, such as being warm, affectionate, and sociable, would promote high- quality social relationships, which in turn might act as a protective factor and boost resilience when times get tough.

Humans have a basic need to belong. The fear of social isolation is believed to be exclusive to mammals, since we have an extended need for maternal care to optimize our chance of survival (Hadland, Rutschworth & Passingham, 2003; Masten, 2015). Perceived social isolation has been shown to have correlation with poorer health status over the lifetime (Hawtorne, 2007) and increased all- cause mortality (Smith, Jackson, Kobayashi & Steptoe, 2018). Scientists within neuroimaging have studied the effects of social isolation and exclusion on our brains and have linked the anterior cingulate cortex (ACC) to the feeling of social pain. When ablating the ACC on animals, the consequence has been shown to be a significantly reduced need for social belonging (Hadland, Rutschworth & Passingham, 2003). In an fMRI study, conducted by Eisenberger, Lieberman and Williams (2003), they used a ball- tossing game to manipulate the participants feeling of social inclusion and exclusion. In this study, it was evident that the ACC was more active during exclusion than inclusion, and activity in the right ventral prefrontal cortex (RVPFC) correlated negatively with self- reported distress. It was concluded that RVPFC seems to regulate the distress of social exclusion by disrupting activity in the ACC (Eisenberger, Lieberman & Williams, 2003). Arguably, RVPFC could be an important neural correlate for resilience because of its' connection to distress regulation.

It's not only the attachment and approval from ones' parents that are important. During adulthood, other social relationships such as those with our peers, can have an impact on our well- being and how the brain develops (Sheffield Morris, Squeglia, Jacobus & Silk, 2018). Studies have indicated that a reduced activation in the dorsolateral prefrontal cortex (DLPFC), that is known to be involved in emotion regulation, in response to socially negative status words (such as *loser*) could help explain association between evaluated social risk and

depressive symptoms. A teenager that reports high anxiety for peer victimization and negative evaluation, showed a lower activity in DLPFC and researchers believe that this can be a neural correlate for depression (Lee, Oppenheimer, Siegle, Ladouceur, Dahl & Silk, 2018).

Social deviance has been shown to have linkage to activity in the subgenual anterior cingulate cortex, which is a neural area involved in social pain and susceptibility. Closeness to family members is an important resilience factor when it comes to handling social deviation early in life (Schriber, et al, 2018). Other researchers have hypothesized that family dysfunction or peer victimization can influence the development of neurological circuitry during childhood and adolescents, especially neural systems that are needed for effective emotional processing that prevent depressive symptoms (Lee et al, 2018). The absence of a stable, secure and loving caregiver or the lack of belonging to a social group can thus lead to negative cognitive consequences, such as a declined ability to learn and a decreased intellectual capacity. This argument has been supported in a recent longitudinal study which indicated that education, physical and emotional care play an important role in brain development (Fox, Almas, Degnan, Nelson, Zeanah, 2011).

To summarize, supportive and caring close relationships and a secure attachment to primary caregiver have been shown to be of decisive importance when it comes to the evolution of adaptive skills, such as resilience (Masten, 2015). High- quality relationships also have association to structural and functional changes in brain areas in several prefrontal areas, such as the orbitofrontal (Lebreton et al, 2009; Cohen et al, 2010), dorsolateral (Lee et al, 2018) and anterior cingulate cortex (Schriber et al, 2018). Early experience of neglect has been associated with shrinkage in areas related to memory and emotional processing such as the amygdala and hippocampus (Teicher et al, 2003), which may aggravate resilience functions such as having strong social relationships, emotional processing capability and stress- regulation (Masten, 2015).

### **Stress regulation.**

When a person is faced with a challenging situation which evokes strong negative emotions, the level of adaptive skill to manage the affective response and stress is associated with a better and more constructive outcome for the individual. Caregivers play an important role when it comes to learning the child the competence of stress- regulation and self- direction (Alink, Cicchetti, Kim & Rogosch, 2009). An early secure attachment to one's caregiver has implications on the child's development of social and cognitive skills. The caregiver teach the child to expand their adaptive ability to evaluate stressful encounters and

later form coherent responses to stressors (Schoore, 2001). This “co-regulation” is believed to be an important founding stone for the child’s future level of adaptive skills, such as problem solving and mastery motivation (Alink, Cicchetti, Kim & Rogosch, 2009), which are all important founding stones of resilience (Masten, 2015). Maltreating parents, whom might experience difficulties coping with stress or recover from set-backs themselves, may be unable to teach this ability to their children. This might in turn have an impact on the development of neurobiological systems involved in stress regulation and the ability to cope (Twardosz & Lutzker, 2010). Converging data point towards the involvement of specific brain circuits in the formation of cognitive, behavioral and emotional coping mechanisms to stress. These are the amygdala, insula, hypothalamus, hippocampus, and cortical areas such as medial prefrontal cortex (mPFC) and anterior cingulate cortex (ACC) (van der Werff, van den Berg, Pannekoek, Elzinga & van der Wee, 2013). The amygdala tend to be involved in encoding and consolidation of emotional memories, especially fearful encounters (Bremner, 2007), and is involved in modulation of the autonomic nervous system, together with the hypothalamus (Davis, 1992). The insula is believed to be involved in high-level cognitive processing, such as attention and control (Menon & Uddin, 2010). Together with the hippocampus, the insula is also important in processing potential threat. (Feder, Nestler & Charney, 2009). The hippocampus is believed to play a crucial role in declarative memory, and the hypothalamic-pituitary-adrenal axis activation (Bremner, 2007). A recent review study (van der Werff et al, 2013), argued that smaller hippocampal volume is a common consequence after severe life stress. Thus, structural variations in the hippocampus could contribute to resilience (Bremner, 2007), but there are still lacking evidence to confirm this hypothesis (van der Werff et al, 2013).

The research area of neural correlates and effects on the brain connected to stress has conducted many studies with PTSD victims. PTSD stands for Post Traumatic Stress Disorder, and is characterized by reliving the traumas through their memories of, for example, war and combat (Bremner, 2007). Studies, using fMRI have shown that PTSD individuals tend to have an exaggerated amygdala response when exposed to emotional stimuli when compared to the activity among healthy control subjects (Etkin & Wager, 2007). A smaller volume in the amygdala among PTSD victims was also found in an MRI study (Morey et al, 2012), but other studies did not find this difference (Rogers et al, 2009). Van der Werff et al (2013) argues that although the amygdala has a role in the neurocircuitry of stress, further research needs to be made to be able to state that amygdala volume is associated with vulnerability towards psychopathology or resilience to overcome traumatic events.

To outline the neural systems connected to stress regulation, important areas that underlie

this cognitive capacity seem to be amygdala, insula, hypothalamus, hippocampus, and cortical areas such as medial prefrontal cortex (mPFC) and anterior cingulate cortex (ACC) (van der Werff, van den Berg, Pannekoek, Elzinga & van der Wee, 2013). Several of these areas have earlier been linked to emotional processing, memory, attention and control, which are considered to be part of the brains “executive functions” (Masten, 2015).

### **Self- regulation & affective processing.**

It is not only stress management that is crucial for resilience. A resilient person also tend to have a better way of handling intense emotions and arousal connected to the traumatic experience, and use adaptive thinking and reasoning rather than acting on impulse (Masten, 2015). Recent research has linked effective self- regulation to the so called “executive functions” of the brain, which depend mostly on the prefrontal networks. The executive functions usually include working memory, inhibitory control, focus of attention and cognitive flexibility (Masten, 2015; Blair & Dennis, 2010). These advanced cognitive functions appear to be a key influence on resilience, indicating that self- regulation skills have a protective function against stress and trauma (Blair & Raver, 2012) and support competence and adjustment (Duckworth, 2011). Some researchers argue that deviance in resilience is due to a persons’ emotional flexibility, defined as the ability to use affective resources to successfully meet the demands of the current situation. A highly resilient person exhibit more appropriate and effective emotional and psychological responses when exposed to a situation that can be considered as threatening, and conserve these resources during innocuous events (Waugh, Wager, Fredrickson, Noll & Taylor, 2008).

Self- regulation support volitional control of emotional arousal and attention, which later supports goal- directed action in response to environmental contingencies (Blair & Raver, 2012). Strategies that resilient persons tend to use during self- regulation are talking to a friend, exercising, biofeedback, practicing mindfulness, meditating, making jokes and deliberately reframing the situation in a more positive and constructive way (Masten, 2015). These strategies have shown to be successful for reducing pain, anxiety and improving quality of life (Compas et al, 2014).

Self- regulation and stress- management are closely related, both on a conceptual level but also neurobiologically speaking. The prefrontal cortex is connected to the limbic system and brainstem structures associated with the stress response and emotional arousal (Blair & Raver, 2012). Lee et al (2018) claim that emotion processing is often associated with activation of prefrontal regions of the cortex, such as dorsolateral, ventrolateral and medial prefrontal cortex, and causal ACC. These areas of the brain have formerly been known to be

involved in emotion evaluation, appraisal and emotion regulation. Studies have shown that the PFC has an inhibitory effect on the amygdala, which supports emotional control (van der Werff et al, 2013). In a study using fMRI, the result indicated that fear inhibition was linked to increased activity in the amygdala and the vmPFC. Suggesting that these two brain regions cooperate to enable recovery and fear extinction (Phelps et al 2004).

Kalisch, Müller and Tüscher (2015) argue that the way an individual appraises a situation is essentially important for the subsequent emotional reaction, and thus how resilient a person is. They pose “reappraisal”, the ability to re-evaluate a stressing situation into a more positive and constructive one, to be a fundamental element of resilience. Reappraisal can for example be when an individual remembers past success in handling similar stressors or reduces the subjective importance of the threat. Neurobiologists have found that brain areas involved in reward valuation, such as vmPFC, helps the individual to experience safety during otherwise threatening situations (Raczka et al, 2011), which help the individual to cope with the situation and the associated emotions (Kalisch, Müller & Tüscher 2015). A large amount of scientific studies indicate that increased activity in dorsal and lateral regions of the PFC, together with a decreased activity in amygdala help to control negative affect (Masten, 2015). In a study by Urry et al (2006) a top- down inhibition of the amygdala and ventromedial PFC was evident, where vmPFC worked as a major mechanism for the cognitive ability of emotion regulation to negative stimulus. The subjects that demonstrated a successful way of decreasing negative emotions also exhibited a decreased amygdala activity and increased activity in the vmPFC. It is argued that cognitive therapy could be an adaptive way to identify destructive thought that evoke aversive emotions, examine and re- appraise those beliefs and later improving resilience (Urry et al, 2006). Cognitive therapy has been suggested to engage relevant neural circuits for resilience, inducing long- lasting plasticity and producing enduring positive effects (Maier, 2015).

The orbitofrontal cortex (OFC) has also been linked to emotion regulation, generating expectancies, and calculating risks and opportunities. In a study using fMRI, the result showed that the high- resilient participant recruited sub-regions of the lateral OFC, which the authors believed could be a sign of their coping mechanism to regulate expectations of threat and safety. This increased activity in the lateral OFC is consistent with earlier findings which indicate that high- resilient persons have a greater ability to co-activate both positive and negative appraisals of a negative event, which help them to recover more quickly from stress and thus experiencing a better mental health outcome (Waugh, Wager, Fredrickson, Noll & Taylor, 2008)

Several researchers argue, however, that cognitive control and self- regulation is not a

unitary process, with pinpointed neural mechanisms. Evidence suggest rather that these processes are linked to a “family of functions” which are closely entwined (Mischel, et al 2011). Cognitive regulatory functions likely require the coordination and management of several systems simultaneously (Masten, 2015).

The ability to regulate ones’ emotions, and thus cope better with the stressor and promote recovery, has been shown to have strong associations with several parts of the PFC and amygdala. These brain regions have also been linked to *affective style*, a research area pioneered by Richard Davidson, a prominent scientist in neuroscience. Davidson (2013; 2000) argue that the brain circuitry underlying emotion is heavily influences by activity in the PFC and amygdala. Individual differences in these circuits have a priming effect on emotional reactivity, self- regulation (Davidson, 2000) and thus how resilient a person is. One dimension of affective style is the so called “resilience style”, which consists of a continuum indicating how resilient a person is based on activity in certain circuits. Resilience is marked by greater left versus right activation in the PFC. In some cases, the amount of activation in the left PFC of a resilient person can be thirty times that in someone who is low- resilient (Davidson, 2012). Davidson (2012) infer that a greater activity in the left PFC has an inhibitory effect on the amygdala, which is involved in distress and negative emotions. In a nutshell, the PFC might shorten the period of amygdala activation, allowing the brain to bounce back from an upsetting experience.

In the next part of this paper, the research area of affective style, based on research conducted by Davidson and colleagues, will be briefly recaptured. Focus will be on the theoretical part regarding resilience- style.

### **Affective style.**

Davidson (2012) argue that instead of personality, research should be focused on affective style (also known as emotional style), which is defined as the natural way that a person tend to respond to experiences that is encountered. It is the constellation of every humans’ emotional reaction and way of coping that differs in kind, intensity and duration depending on their emotional profile. Emotional style differ from personality in the sense that it can be traced to a specific brain signature. This research area refer to the broad range of individual differences in neural subcomponents of affective reactivity and dispositional mood (Davidson, Jackson & Kalin, 2000). Affective style is meant to capture a broad range of cognitive processes that either individually, or when combined, modulate how a person react, feel, and recover from an emotionally challenging situation. The neural subcomponents underlying this concept can be measured through for example fMRI signal change, and

include tonic levels, peak of amplitude to response, threshold and time to respond, and recovery time after stimuli exposure (Davidson, Jackson & Kalin, 2000). A large number of studies have been conducted, designed to examine the location of affective processing in the brain, as well as how these identified areas instantiate processes that are essential for affective processing. Recent research has shown that several territories of the prefrontal cortex, the amygdala, hippocampus and anterior cingulate cortex are involved in these cognitive abilities and help form individual differences in affective style (Davidson, 2000). When it comes to individual resilience style, Davidson (2012) argue that the brain regions mostly involved are the left PFC and amygdala. Earlier research indicate that PFC plays an important role in the neural circuit that enable both negative and positive emotions (Davidson & Irwin, 1999). The PFC is not a homogenous zone of tissue (Davidson, Jackson & Kalin, 2000), rather it's inevitable to divide the PFC into sub- regions that have different roles in affective processing. First are the distinction between orbitofrontal cortex (OFC), ventromedial prefrontal cortex (vmPFC) and dorsolateral prefrontal cortex (DLPFC). Second, is the distinction between left and right- sided sectors within these regions (Davidson & Irwin, 1999). These research findings have emerged from three main sources; studies made on patients with discrete brain lesions, studies on patients with neurological and/or psychiatric disorders with following abnormalities in emotion processing, and finally subjects with normal function and without any disorders or lesions (Davidson, 2000).

In a study conducted by Davidson, Ekman, Saron, Senulis & Friesen, 1990), electrical brain activity shifted in a lawful fashion depending on the affective content of the video that the subjects were exposed to. Film- induced negative affect had an increasing impact on anterior temporal, and right-sided prefrontal regions, whilst films that had a more positive affect evoked the opposite pattern. This asymmetry was later confirmed, in another study using positron- emission tomography (PET) to measure regional glucose metabolism in the mentioned brain areas. When the subjects were exposed to the stimuli evoking negative affect, right-sided increase in metabolic rate were observed in the anterior orbital, inferior frontal, middle, and superior frontal gyri. The positive affecting stimuli showed a higher activity pattern in the left-sided pre- and postcentral gyri (Sutton, Davidson, Donzella, Irwin & Dottl, 1997). Recovery following a negative stimulus has also been linked to greater left-sided prefrontal activation, suggesting that the left PFC play a greater role in emotional responding and in the active inhibition of negative affect. These findings also imply that individuals with a greater left- sided activation might have an easier way of recovering from emotionally challenging situations, than their more right- sided counterparts (Davidson, Jackson & Kalin, 2000).

A study compared structural differences between patients with major depressive disorder (MDD), family members without a history of MDD, and families with a history of MDD but without depressive periods. The study was conducted with MRI, and showed that MDD patients had smaller gray matter volume in the dorsomedial prefrontal cortex (DMPFC), ACC and caudate nuclei in comparison with the participants without a history of MDD in their family. Smaller volumes of white matter were also evident in ACC and right dorsolateral PFC among MDD patients compared to participants whom had a history of MDD in their family, but no difference in contrast to those that did not have this in their family history. The researchers argue that this discrepancy between those participants that had developed MDD and those with a genetic risk of doing so, but had not, might be explained by protective neurobiological characteristics. Larger DMPFC might act as a protective function and thus supporting resilience, but this need to be confirmed by longitudinal studies on MDD and neurobiological differences (Amico, Meisenzahl, Koutsouleris, Reiser, Möller & Frodl, 2011).

Davidson (2000) argue that a damage to certain sectors of the PFC would influence the capacity to anticipate future positive outcomes, and consequently have an impact on the ability to guide behavior in an adaptive and constructive fashion. The orbitofrontal sector has been associated with the learning, and unlearning, of stimulus- incentive associations, which is one critical component of reversal learning (Rolls, 1999) and emotion regulation. The cognitive ability to regulate and decrease the duration of negative emotions are key components of affective style, and help to alter individual vulnerability towards stressors, and optimizing resilience (Davidson, 2000).

The amygdala is also believed to be an important component of individual resilience style and neural substrate of human emotional experience, particularly in fear and general negative affectivity (Andersson & Phelps, 2002). Traditionally, emphasis in literature has been on the amygdala being responsible for the subjective feeling of fear. LeDoux and Hofmann (2018) argue that this view is misleading and not supported by recent research. Studies have shown that subjects with bilateral amygdala damage can still experience fear (Feinstein et al, 2013), and that a person can be exposed to a threat without experiencing fear. Instead, the amygdala has been linked to the subjective experience of threat and controls behavioral responses connected to these threats (LeDoux & Hofmann, 2018). Recent studies have confirmed this, showing that patients suffering from bilateral damage to the amygdala also suffer from difficulties in negative emotional processing, for example the ability to recognize danger and threatening cues (Davidson, 2000). Studies have indicated that activity in the left and medial PFC have an inhibitory effect on the amygdala. In a study conducted by

Abercrombie et al (1996), glucose metabolism in the left medial and lateral PFC co- varied with metabolic activity in the amygdala, thus indicating that this neural circuit might have a dampening effect on negative stimuli and may play an important role in resilience (Davidson, Jackson & Kalin, 2000). As earlier mentioned, Davidson (2013) argues that this dampening effect from the PFC on the amygdala could be the neural explanation to resilience.

Activity in the right amygdala has also shown to predict results on dispositional negative affect reported in the Positive and Negative Affect Schedule (PANAS) (Davidson, Jackson & Kalin, 2000). This link between amygdala and the reported amount of positive and negative affect was evident in a study where subjects were exposed to negative film clips. The result showed that the participants with higher levels of activity in the right amygdala, measured through glucose metabolism, could recall significantly more negative film clips 3 weeks after the exposure (Cahill et al, 1996). A more recent study (Sanchez et al, 2015) the relationship between amygdala and positive affect was further investigated. Researchers used PANAS for measuring affect, and fMRI to investigate activity in the amygdala. The hypothesis was that individual differences in positive affect would modulate attention to negative stimuli. The result showed a significant inverse correlation ( $r = -0.51$ ,  $p < 0.01$ ) between left amygdala activation and positive affect. Participants that reported a higher amount of positive affect showed a lower amount of amygdala reactivity, and subjects with a lower score showed a higher activity, and thus having a harder time to disengage attention from unpleasant stimulus (Sanchez et al, 2015). Considering that positive affect (PA) involves high attention, alertness and pleasure (Watson, Clark & Tellegen, 1988), and has been linked to improved cognitive functions such as emotion regulation (Fredrickson, 2000), it is not far-fetched to believe that PA also reduces the neural resources to focus on negative and unpleasant characteristics in the environment (Sanchez et al, 2015). In other words, a person high in PA might use their attentional scope to focus on other things, leaving less resources to pay attention to things that are not so pleasant. As mentioned earlier, this tendency to reappraise the situation has been argued to be an important component of resilience (Kalisch, Müller & Tüscher, 2015).

However, this hypothesized relationship between amygdala activity and the affective experience of positive and negative feelings have been questioned. Anderson and Phelps (2002) conducted a study containing 10 left, and 10 right unilateral amygdala damaged subjects, one patient with bilateral amygdala damage and 20 control subjects. In this study, they used PANAS to investigate their overall emotional experience during the last year. No global difference was found in PANAS test scores between the patients and the control group, and neither was there evidence indicating a valence-specific difference between the groups. The results suggest that neither bilateral or unilateral damage to the amygdala lead to a

significant difference in the amount of negative and positive affect compared to normal healthy subjects. Amygdala might be involved in emotional processing, but it is not righteous to state that it is a necessary component for normal phenomenal affectivity (Anderson & Phelps, 2002). In a meta-analysis, comparing PTSD patients with healthy control subjects, no significant structural difference was found on amygdala volume between the two groups (Woon & Hedges, 2009). These research findings suggest that even though the amygdala is a key component in the neurocircuitry of stress, the volume does not seem to be closely related to vulnerability to stress or resilience (van der Werff et al, 2013). Davidson (2012) states that when amygdala activity is being dampened by the PFC, the brain can plan and act effectively without being distracted by negative emotions such as distress, thus supporting the individual to recover more quickly and “bounce back” from adversity.

### **Discussion**

In this essay, the importance of attachment, supportive relationships and the cognitive skills of stress- and self- regulation have been undertaken. These areas were taken from the “short list of resilience”, presented by Masten (2015; 2018). These fields were chosen based on the quality and amount of research in neuroscience that was available. The remaining areas from the shortlist of resilience that were not addressed in this essay was mastery motivation (agency), problem solving, hope (faith, optimism), routines and rituals and positive views on the self or identity (Masten, 2018). The author didn’t find as much material connected to neuroscience within these areas, and therefore chose to focus on those with accessible empirical data. The chosen data that this essay is based on indicate that resilience is supported by several factors, for example having close nurturing relationships, and developed cognitive skills such as emotion- and stress regulation (Masten, 2015). Neural structures and functions within the amygdala (van der Werff et al, 2013), orbitofrontal (Cohen et al, 2009), anterior cingulate (Eisenberger, Lieberman & Williams, 2003) and dorsolateral prefrontal cortex (e.g. Lee et al, 2018), have been linked to these factors and thus argued to be important determinants for individual level of resilience.

The result from this essay has amplified that the quality of close relationships is important, not only for our ability to recover and “bounce back” from adversity, but also for our overall level of well- being. The quality of our close relationships, with family members, spouse and friends, provided us with support, but also help to co- regulate negative feelings and process them in a more adaptive way. Interventions to support the development of positive adaptive skills among struggling families are important to foster resilience, both after a traumatic experience but also as proactive initiative. Scholars in multiple fields of science

concerned with human development and adaptation are coming together and integrating their findings and ideas, to achieve better solutions for struggling families and prepare for anticipated disasters such as terror and pandemics. This widespread collaboration between scholars and research areas will hopefully further integrate resilience research with positive psychology, and generate new application opportunities to promote human well-being and optimal functioning.

Neuroscience has shed light on how the brain support resilience, for example to regulate emotions, and turn something destructive into a more constructive matter, and turn attention to what the situation might bring. This essay has gathered research about how the brain support cognitive skills connected to resilience, and that it is a dynamic process that can be fostered and strengthened through interventions. An important area for future research is interventions to promote neural circuits proven to strengthen resilience. Interventions such as physical activity, increased social support, behavioral therapies including mindfulness and meditation or other activities increasing a sense of meaning and purpose with life have shown to promote resilience (Luthar, Cicchetti & Becker, 2000). Hopefully, it might be possible to use interventions that promote resilience as complement to pharmaceutical agents for individuals fighting psychopathological struggles after trauma (McEwens, Gray & Nasca, 2014). To further understand how stress effect the brain and hinders resilience, it has also been argued factors such as age and timing of stress are critical to consider. For example, when is it most damaging, neurobiological speaking, for a child to be exposed to maltreatment or a family- related trauma? These insights would be a good basis for developmentally- tailored interventions to strengthen the brains' biological state among children and younger adults (Gee & Casey, 2015).

It has been argued that the main limitations with resilience is the lack of clarification and threshold for what constitutes as a resilient outcome, and that most studies have not focused on natural observation of resilience. Instead it has usually been a top- down approach, where researchers have investigated associations and variables to test their hypothesis. This may be the reason to why many questions about the nature of resilience remains unanswered, such as exploring if different factors underlie recovery after different traumas or failures (Johnson, Panagioti, Bass, Ramsey & Harrison, 2017).

Other critical issues have been discussed, such as the variations when it comes to definition and terminology. Measurement of resilience, operationalization of studies, definition of adversity and what constitute as positive adjustments can differ fundamentally (Luthar, Cicchetti & Becker, 2000). It has also been discussed that the lacking objectivity regarding adversity is critical issue, and that this might be a major confounding variable in

resilience research. The same situation might be considered severely adverse to one person, but only slightly troublesome for another. There might also be a crucial difference between the subjective definition of what constitute as a severe life circumstance between the research subject and the researchers, which harm the quality of the study results considerably (Luthar, Cicchetti & Becker, 2000).

Another limitation of resilience is of theoretical concern. Majority of studies are empirically driven without a common theoretical foundation. Some scholars use a developmental framework, whilst others guide their research based on a more organizational or ecological perspective. A related issue is the delimitation of the construct as a whole. It has been argued that resilience can not be separated from other closely related research subjects (for example coping and positive adjustment), and that the distinctiveness of the construct is questionable. These constructs might overlap, but researchers argue that there are considerable value in retaining resilience as an independent and distinct construct. Resilience differs from other classical theories both in empirically tested correlations and contains other heuristics in developmental science that others are lacking (Luthar, Cicchetti & Becker, 2000).

Resilience research will continue to flourish as the importance of this process keep increasing (Masten, 2015). The fourth wave of resilience research will continue to discover systems that program resilience, together with individual sensitivity to experience. Since the interaction between body and mind are more tractable than ever, insights regarding the underlying factors of affective personality and resilience style will be further understood in the future (Davidson, Jackson & Kalin, 2000). Influential governments, policymakers and funders are requesting better- quality evidence to base societal initiatives and projects on, to be able to promote resilience within their population. Resilience is an important issue, both on a national and global scale. The complexity connected to resilience and human life can be considered daunting, but there is considerable progress being made that are improving the odds for positive development (Masten, 2015). There are reasons to be optimistic about the continued possibilities to promote optimal functioning and support people at risk due to adversity, both present, past and yet to come (Masten, 2018).

### **Conclusion**

Resilience research has flourished during the latest decades and will supposedly keep gaining in importance due to challenges faced by developing countries today. Researchers within neuroscience have begun to unfold how the brain is supporting individuals recovering from trauma and adversity. So far, several circuits in the prefrontal cortex and amygdala have

shown to be important to promote cognitive skills that support resilience, such as stress- and self- regulation and social connectedness. Interventions to promote resilience and strengthen neural circuits are a major priority in this research field today. Future research would benefit greatly from a global definition of resilience and what constitute as an adversity. Common operationalization and measurements also need to be established so that this research field can keep build a solid empirical foundation and support people at risk due to adversities.

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