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THE SUBJECTIVE EXPERIENCE OF ANXIETY AND ITS RELATION TO PERFORMANCE

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Abstract

There have been many attempts to explain the experience of anxiety during different types of performance situations. There are several different views on the brain mechanisms of anxiety. The traditional view has its focus on amygdala but recent research questions this view. In this essay the focus is on how two recent theories, namely the two-system model (LeDoux & Pine, 2016) and the attentional control theory (Eysenck, Derakshan, Santos & Calvo, 2007) has changed the theoretical landscape of the brain mechanisms behind the experience of anxiety. The two-system framework model claim that the subjective experience of anxiety uses the same cortical circuits as executive functions involved in attention and working memory. Whereas the attentional control theory argues, that due to the limited attentional capacity, increasing the subjective experience of anxiety would result in less capacity for executive functions involved in working memory and attention resulting in impaired performance. This review shows that research on the relationship between the subjective experience of anxiety and performance is inconsistent and researchers possess different views on what gives rise to the experience. Some data indicate that the amygdala is crucial for the subjective experience of anxiety while other data suggest that other cortical circuits have a much more prominent role. If the cortical circuits are strongly involved in the subjective experience of anxiety, this would be strong support for the attentional control theory and the two-system framework model.

Keywords: anxiety, the subjective experience of anxiety, amygdala, attention, working memory, performance

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Introduction

The game is tied, 30 seconds remaining, fans are screaming, family and friends are watching, coaches and players are silently reeling on her performance. The result of the season all comes down to this, the most important moment, the last penalty. The adrenaline is pumping through her veins, she is anxious, afraid to fail and the goalkeeper seems huge. She puts the ball in front of her, starts limping towards it, afraid and anxious, will she score? She shoots and misses. While crying in the locker room, the coach pats her on the shoulder, telling her "you had too much anxiety". This is only one in many examples were anxiety is argued to affect performance. Asking any player, coach, student or worker, the answer is the same, they all argue that anxiety affects performance. However, researchers are not equally convinced and the result from research has been inconsistent.

Anxiety is not a new field of study. Even Greek and Latin physicians could identify and separate anxiety from other types of negative affect, with Hippocrates as one of the first known to describe anxiety in writing (Crocq, 2015). Although the universal agreement of anxiety is that it is an emotion, closely related to fear, with most researchers suggesting that anxiety derives from fear. A shortcoming is that there is no universal agreement on how to describe and define anxiety. The term anxiety is used in many different domains and they include a variety of aspects (Eysenck et al., 2007; LeBow & Chen, 2016). Anxiety is both used to diagnose different mental illnesses including intense negative feelings during a longer period as well as in daily life to describe a feeling of nervousness or worry located to certain situations (American Psychiatric Association, 2013).

Today, experiencing anxiety is common in the community and it affects a large sample of the population. Up to 33,7% is estimated to be affected by an anxiety disorder during their lifetime and it is the most common mental illness and is mostly studied as a pathological problem (Bandelow & Michaelis, 2015). Thus, it is not just a problem for diagnostic psychology but multiple divisions in psychology. Anxiety and performance are a relatively new field of study. In 1949 Sherriffs (1949) was one of the first to study the relationship between anxiety and performance. He assumed that the level of tension and anxiety would affect academic performance (1949). As time progressed, research and models of anxiety and performance have developed. Evidence can be found in the attentional control theory (ACT; Derakshan & Eysenck, 2009; Eysenck et al., 2007). It was developed to study and present the effects of different types of anxiety on cognitive performance. In sport psychology, models like zones of optimal performance (Hanin, 1980), reversal theory (Kerr, 1987), psychic energy theory (Martens, 1987) and multidimensional anxiety theory (Marten, 1990) have all been practiced to study the relationship between anxiety and performance.

Despite many different views and components of anxiety, the basic understanding of anxiety is that it is related to fear (LeDoux & Pine, 2016). Anxiety is often associated with concepts like; worry, nervousness such as tingling sensation and increased blood pressure. For those definitions that provides a distinction between fear and anxiety, then fear is often described as a feeling that occur when a threat is immediate or imminent while anxiety is often described as a feeling of fear occurring in the absence of threat or future-oriented threat (LeDoux & Pine, 2016; Eysenck et al., 2007). In this essay I will use anxiety as the subjective experience of fear, nervousness, and worry thus in the absence of threat.

Most none pathological approaches to anxiety include different components, with some approaches suggesting that anxiety could be divided into trait and state anxiety (Eysenck et al., 2007). Continuing, trait anxiety is the tendency for a person to experience anxiety and state anxiety is the present feeling of anxiety and is determined interactively by trait and situation and divided into two components, worry, and emotionality. The concept of worry has many synonyms (Eysenck et al., 2007). Both cognitive anxiety and perceived anxiety are used in research although they are different names for the same thing, the subjective experience of anxiety. It is referred to as "negative expectations and cognitive concerns about oneself" (Morris, Davis, & Hutchings, 1981, p. 541) and describes the subjective experience of the cognitive components of anxiety such as performer's worry and concern of performance (Morris, Davis, & Hutchings, 1981). Emotionality and somatic anxiety are being used synonymously and are described as a person's perception of physiological distress and unpleasant feeling such as irritable, nervousness or tension (Morris et al., 1981). They are often described as the physical components of anxiety which include the behavioral and physiological responses to anxiety. This being said, the amygdala is often argued to be the central part of anxiety and the emotional system.

The brain mechanisms of emotion and anxiety is a widely studied area, however, it is still unclear which areas contribute to the subjective experience of anxiety. It’s been argued (Adolphs, 2008; Adolphs et al., 1995; Davis et al., 1994; Davis et al., 2009; Etkin, 2009; Gold et al., 2015; Pfleiderer et al., 2007; Sakai et al., 2005) that the subjective experience of anxiety is produced by the two almond shaped nuclei called amygdala. However, some researchers disagree to this statement and argue that the amygdala does not play such a prominent role in producing the subjective experience of anxiety (Anderson & Phelps, 2002; LeDoux & Pine, 2016; Panksepp, Fuchs, & Iacobucci, 2011). LeDoux and Pine (2016) have presented the two-system framework model to explain how the subjective experience of anxiety is produced. Also, the attentional control theory (Eysenck et al., 2007) provides an explanation of how the subjective experience of anxiety is related to performance. These two models together with recent research on consciousness, including attention and working memory provide a theoretical explanation of the relationship between anxiety and performance from a cognitive neuroscientific perspective (Cox et al., 2003; Eysenck et al., 2007; LeDoux & Pine, 2016).

This thesis aims to investigate the ongoing debate of what brain mechanisms produce the subjective experience of anxiety as well as its relation to performance. With this, comparing the traditional view that the amygdala produces all types of anxiety with recent cognitive neuroscientific research and including the two-system framework model and the attentional control theory. Importantly, this is a literature review and the primary focus is to present, describe and discuss theories, models, and research on anxiety, performance and its relationship and measurements used to study the relationship. This will be accomplished with the guidance and support of research in psychology and cognitive neuroscience. Although anxiety is primarily used and discussed in pathology, this review aims to focus on a none pathological approach to anxiety, specifically, the subjective experience of anxiety. Furthermore, it will be investigated using research and previously noted model and theory of how other cortical, as well as subcortical regions, provide a more satisfying explanation than the amygdala on how the subjective experience of anxiety is produced. The aim to study the relationship between the subjective experience of anxiety and performance is due to its body of research supporting its theoretical assumptions and extensive and detailed explanation. This literature review included search through the searching engine and database Google Scholar, including the keywords “amygdala”, “anxiety”, “attention”, “attentional control theory”, “cognitive anxiety”, “fear”, “performance”, “two-system model”, “worry” and “working memory”. During the search, models, and theories on anxiety and performance were identify and evaluated for its scientifically support and relevance. Articles where sorted into, two categories, one arguing for the amygdala as the producer of the subjective experience of anxiety one view arguing that other cortical areas produce the subjective experience of anxiety. In this research the two-system framework model and the attentional control theory was specifically included. Because they provide an explanation of how different cortical circuits are involved in producing the subjective experience of anxiety with a large body of research. It was also select because of its cognitive neuroscientific perspective. Also, multiple meta-analysis was included to maximize the inclusions of articles of the relationship between the subjective experience of anxiety and performance. Each relevant research article and study included were evaluated based on citations, publishing journal, authors and general validity.

The structure of this review is designed to firstly include a brief background and distinction of fear and anxiety. Followed by the cognitive neuroscience of fear and anxiety, discussing the role of the amygdala in fear and anxiety. Then, this review will provide the reader with the traditional view of anxiety as well as the inconsistent of research in the traditional view that the amygdala produces the subjective experience of anxiety. This will lead to a presentation of an alternative explanation, that the subjective experience of anxiety is produced by other cortical areas and how it is related as well as how it impairs executive functions involved in working memory and attention. Furthermore, the two-system framework model and ACT will be presented, providing support for the claim, that the subjective experience of anxiety impairs working memory and attention and therefore impairs performance. This will be followed up with research supporting and opposing this view, including critique against the research. This will be followed up by discussion, summary, future directions and lastly conclusion of the presented models, theories, research findings and measurement of anxiety and performance.

Fear and Anxiety

Although this literature review aims to research anxiety, one may find it hard to do so without including fear. Fear and anxiety are two negative emotions. It has been previously noted that fear and anxiety share striking resemblances in their definitions. Where the feeling of fear and anxiety both described as a worrying feeling, where fear is the presence of a threat whereas anxiety is in the absence of a threat (LeDoux & Pine, 2016). As one can tell, these terms are closely linked and may be hard to distinguish from each other and are sometimes used synonymously, although some researchers suggest they are kept apart (LeDoux & Pine, 2016). One of the strongest supports for this claim is provided by LeDoux and Pine (2016). They argued that fear and anxiety should be divided into two separate concepts. That there is one neural circuit involved in uncertain threat (anxiety) and another involved in obvious threat (fear). Recent studies support these claims. A study found that an electric stimulation of the bed nucleus of the stria terminal is located in the basal forebrain induced the feeling of anxiety in healthy subjects in similar ways that stimulation of the amygdala induced the feeling of fear (Davis & Walker, 2013; LaBar, Gatenby, Gore, LeDoux, & Phelps, 1998). These results suggest that different neural circuits are involved in uncertain threat (anxiety) and obvious threat (fear) and are an important side note due to the use of fear and anxiety as synonyms. Furthermore, the term fear often includes three other concepts; subjective experience of fear, behavioral response and physiological response to fear although some researcher and theorists question this separation (Anderson & Phelps, 2002; LeDoux & Pine, 2016; Panksepp, Fuchs, & Iacobucci, 2011). An important note is fear conditioning, often defined as the state where an organism is learned to predict threatful situation. It is a form of learning to experience threat although the threat is unattended. Conditioned fear is a feeling of anxiety and therefore sometimes used as synonyms in research (Adolphs, 2008; Davis, 1992 Zald, 2003).

The Cognitive Neuroscience of Fear and Anxiety

There is a body of research on the concept of fear, although a more limited sample on anxiety within the field of cognitive neuroscience and psychology and therefore important to include the concept of fear while studying anxiety (Derakshan & Eysenck, 2009; Miyake & Shah, 1999; LeDoux & Pine, 2016; Posner and Peterson, 1990; Smith and Jonides, 1999). The subjective experience of fear and anxiety is often described as an innate function of subcortical brain areas and the universal expressed emotion is often said to be a product of the brain's limbic system and especially the amygdala (Adolphs, 2008; Davis, Walker, Miles, & Grillon, 2009). This is seen as the traditional view, although this view has been heavily criticized by multiple authors but especially LeDoux (LeDoux & Pine, 2016; LeDoux, 2003). Anxiety derives from fear (Bishop, 2007) and it is widely thought and well established that the amygdala plays a crucial role in processing behavioral and physiological responses to negative emotions in both humans and animals (Robinson, Charney, Overstreet, Vytal &, Grillon, 2012; Sergerie, Chochol, & Armony, 2008). This will be further covered in the review, however, for further understanding of the relationship, one has to understand the neural basis of anxiety.

The Amygdala

The amygdala is a very small but complicated structure, it is an almond shaped group of neurons located in the medial temporal lobe in both hemispheres (LeDoux, 2007). On the input side, the amygdala receives information from a variety of sources. It receives information from all five cortical lobes as well as from multiple subcortical structures (Sergerie et al., 2008; LeDoux, 2007). Furthermore, the information derives from the sensory information with the various sensory systems that process the external world such as the olfactory system, the auditory system, and the visual system. On the output side of the amygdala, it is connected to all the systems involved in emotional reactivity such as the anterior cingulate cortex (ACC) and the ventromedial prefrontal cortex (vmPFC), which are also involved in the cognitive and attentional system (LeDoux, 2003, 2007). The amygdala is involved in many different processes associated with different emotions. According to Panksepp and colleagues (2011), it is commonly argued that fear is one of its primary areas to monitor. The amygdala is also argued to include many other functions of the brain; the subcortical regions are involved in a large variety of cognitive functions such as the modulation of attention and conditioning (LaBar & Phelps, 2005; Panksepp et al., 2011).

The role of the amygdala in producing fear and anxiety. Historically, the view has been that the amygdala produces negative emotions of fear and anxiety (Davis et al., 1994). Today, the debate is divided into two camps. One idea is that all types of anxiety are produced by the amygdala, referred to as the traditional view, multiple authors support this view (Adolphs, 2008; Adolphs et al., 1995; Davis et al., 1994; Davis et al., 2009; Etkin, 2009; Gold et al., 2015; Pfleiderer et al., 2007; Sakai et al., 2005). Whereas other argue that other cortical structures also are involved in the producing of different types of fear and anxiety (Anderson & Phelps, 2002; Damasio et al., 2000; Lang, 1968; LeDoux & Hofmaan, 2018; LeDoux & Pine, 2016; Panksepp et al., 2011; Rachman & Hodgson, 1974; Zald, 2003). Some researchers even describe it as a love-hate relationship (Panksepp et al., 2011).

It has long been argued that the amygdala is necessary for producing all types of nonpathological state anxiety, referred to as the traditional view of fear and anxiety. Several researchers have pursued the role of studying the role of the amygdala in negative emotions such as fear and anxiety (Bishop; 2004; Dolan & Vuilleumier, 2006; Etkin, 2009; LeDoux, 2003, LeDoux & Pine, 2016; Pfleiderer et al., 2007). Some things about the relationship are well established. For instance, the amygdala is involved in processing threatening stimuli (LeDoux, 2003; LeDoux & Pine, 2016). It is also well established that the amygdala plays a crucial role in behavioral and physiological responses to anxiety and especially fear. Continuing, no large body of research is questioning whether the amygdala is playing a role in processing negative emotions or its role in behavioral and physiological responses to threatful stimuli (Davis et al., 1994; Panksepp, Fusch, & Iacobucci, 2011). On the contrary, recent research from LeDoux and Pine (2016) as well as Panksepp et al. (2011) suggest that stimulation of the amygdala does not induce the subjective experience of anxiety but rather the physiological and behavioral responses to anxiety.

The traditional view on anxiety is based on the idea that humans have inherited basic universal emotions from animals and research support this claim with a strong relationship that has been found between negative emotions and the amygdala in animals (Davis et al., 1994; Davis et al., 2009). The general understanding of the relationship between the amygdala and fear can be explained by an immediate threat being observed by the sensory system, sending information to the brain (Sergerie et al., 2008; LeDoux, 2003, 2007; LeDoux & Pine, 2016). Which in turn activates the lateral nucleus of the amygdala and the idea is that it immediate activate the defensive responses of behavioral and physiological reactions as well as the subjective experience of threat. Through the connection of the lateral amygdala, information continuous to the basal amygdala and further through nucleus accumbens where certain defensive actions are controlled. The key components of these circuits are subcortical although certain cortical areas are responsible for controlling defense reactions (Sergerie, et al., 2008; LeDoux, 2003, 2007; LeDoux & Pine, 2016).

Historically, research has focused on the traditional view with especially animals' studies (Davis, Rainne, & Cassel, 1994; LaBar et a., 1996; Morris et al., 1996; Davis et al., 2009). These studies suggest that the amygdala plays an important role in producing the subjective experience of threat. Many of these animal studies have later been successfully replicated in both humans and animals. Studies have for instance shown that electrical stimulation of the amygdala has generated negative feelings. An example of this replication is LaBar et al. (1998), where electrical stimulation of the amygdala has been induced in healthy individuals. These subjects have reported through self-reports, perceived negative emotions, also known as the subjective experience of threat, such as fear and anxiety. Earlier, Morris and colleagues (1996) indicated the same thing, however, this study indirectly induced negative emotions through presenting the subject with fearful faces and measured the amygdala activation. The study found that both high-anxious and low-anxious healthy subjects showed an increased amygdala activity when showed faces with negative emotional expression in spatial attention. This has also been noted in unattended threat stimuli, meaning that the stimuli are out of the spatial attention, indicating that the amygdala is active in both consciously induced threat as well as nonconscious threats (Bishop, 2004). This would mean that although the subject is not aware of a threat, the amygdala seems to lighten up when stimuli are showed outside spatial attention. Also, other research has shown that some patients with amygdala damage do exhibit conditioned fear although no physiological responses noted (LaBar & Phelps, 2005). Although the number of patients with this condition is limited, this is an indication of that conditioned fear is related to other regions than the amygdala. Other compelling pieces of evidence has been supplied by different case studies. These case studies are often argued to provide key evidence for the amygdala's role in negative emotions (Adolphs, 2008). One of these patients is supplied by a rare genetic disorder resulting in focal bilateral destruction of the amygdala and it's said to provide compelling evidence for the amygdala's role in fear. The patient is reported in many different studies and reported to have an inability to experience fear and other negative emotions. This patient has provided one of the most compelling evidence and has led the researcher to believe that the amygdala seems to have a critical function producing fear and anxiety. This is because other emotions such as surprise, happiness or anger seems to be intact in the patient (Adolphs, 2008; Adolphs, Tranel, Damasio, & Damasio, 1995).

The traditional view is also relevant for recent research. Firstly, pathological research on anxiety, which has found amygdala activation in panic disorders and other types of anxiety disorders (Etkin, 2009; Sakai, Kumano, Nishikawa, Sakano, Kaiya, Imabayashi, & Diksic, 2005; Pfleiderer, Zinkirciran, Arolt, Heindel, Deckert, & Domschke, 2007). Also, in humans with bilateral amygdala lesion, it was found that these patients reported higher levels of anxiety during panic attacks compared to healthy individuals (Khalsa, Feinstein, Feusner, Adolphs, & Hurleman, 2016). Recent animals' studies also support the claim that the amygdala is crucial for producing anxiety (Davis et al., 2009). Also, a study found increased amygdala activation when participants reported perceived anxiety (Gold, Morey, & McCarthy, 2015). These studies show that the traditional view is relevant according to some researchers today.

There are some implications on the view that the amygdala plays a central and crucial role for producing the subjective experience of negative emotions. A large body of research suggests that the amygdala produce negative emotions, consisting of studies relying on subjects with rare genetic disorders and animals' studies including damages to specific brain regions (Adolphs, 2008; Adolphs et al., 1995; Davis et al., 1994; Davis et al., 2009; Etkin, 2009; Gold et al., 2015; Pfleiderer et al., 2007; Sakai et al., 2005). On the contrary, some researchers (Anderson & Phelps, 2002; Lang, 1968; LeDoux & Pine, 2016; Panksepp et al., 2011; Rachman & Hodgson, 1974) question this view and argues that the amygdala does not produce the subjective experience of negative emotions. Adolphs (2008) provided compelling evidence that people with amygdala damage fail to exhibit the subjective experience of fear. He argues that the amygdala does not produce the subjective experience of fear and instead the amygdala is mostly involved in producing behavioral and physiological responses. However, the behavioral and physiological responses of fear and anxiety are sometimes perceived as the same thing as the subjective experience of fear and anxiety. According to more studies such as LeDoux and Pine (2016), Anderson and Phelps (2002) and Panksepp et al. (2011), the amygdala circuits are directly responsible for behavioral and physiological responses to threat, whereas the subjective experience of fear and anxiety is not directly supplied by amygdala circuits. Atkinson, Heberlein, & Adolphs (2007) showed that the amygdala does not seem necessary for normal fear recognition from neither auditory or visual stimulus. Also, Anderson and Phelps study from 2002 presented that subjects with unilateral or bilateral amygdala damage did not report any different subjective experience of fear and anxiety compared to healthy individuals. This is a strong indication that the subjective experience of anxiety not necessarily produced by the amygdala. Early studies have shown that measures of behavioral as well as physiological responses of fear do not correlate well with self-reports of subjective experience (Lang, 1968; Rachman & Hodgson, 1974). This would according to LeDoux and Pine (2016) mean that different neural circuits are responsible for the subjective experience of fear than for behavioral and physiological responses to threat. There is a large sample of evidence supporting this claim (Anderson & Phelps, 2002; Lang, 1968; LeDoux & Pine, 2016; Panksepp et al., 2011; Rachman & Hodgson, 1974). Zald (2003) showed that negative emotional stimuli generate a short-lived activation of the amygdala. Only generating a generally short-lived signal would not be expected from a region that is supposed to be involved and central in generating an effect. In Damasio et al. (2000) research, where 41 subjects reported past emotional events, marked with happiness, sadness, anger, and fear, the result showed that the amygdala only lite up once and this was people reported the feeling of happiness. This is an indication that the amygdala does not seem necessary for generating negative emotions.

Evidence such as this had led the researcher to question the role of the amygdala. However, to clarify, although the role of the amygdala in the subjective experience of anxiety is being questioned, there is still compelling evidence that the amygdala plays a crucial role in behavioral and physiological reactions to threat. Also, previous studies have shown that subjects with amygdala damage may be unable to react to threats, although they still can perceive negative emotions such as pain, fear, and anxiety (Adolphs, 2008; Anderson & Phelps, 2002; LeDoux & Hofmaan, 2018; LeDoux & Pine, 2016). These findings, support the claim that the physical features of behavioral and physiological responses and subjective experiences are not products of the same cortical circuits in the brain. Also, this would debunk the idea that the amygdala is the fear center for subjective fear and anxiety as well as conclude that the physical features of behavioral and physiological responses and subjective experiences are not products of the same brain regions. So, when it comes to the role of the amygdala in the subjective experience of anxiety, there seems to be supported to question the role that the amygdala is the center for the experience of negative emotions such as fear and anxiety. However, it seems to be of importance to separate subjective experience from behavioral and physiological responses contrary to previous beliefs (Anderson & Phelps, 2002; LeDoux & Pine, 2016). Furthermore, it seems like emotional stimuli may engage in amygdala processing without reaching conscious awareness. It goes the other way as well, conscious feelings of emotions such as fear and anxiety does not require amygdala activation. Also, amygdala activation is associated with cognitive processes including attention and memory. These conclusions have led us to further investigate the subjective experience of anxiety. However, the amygdala is still a great mystery and which can be seen in the different views on the amygdala’s role in anxiety, there is no universal agreement on how the amygdala works.

The Subjective Experience of Anxiety

Research on the subjective experience of anxiety as a separate component from behavioral and physiological responses is a relatively new field of research. Previous research has, arguably, overlooked the subjective experience of emotions due to the inability of any objective measurement of it (LeDoux & Hofmaan, 2018). Measuring the subjective experience of anxiety is more challenging than both behavioral and physiological responses to anxiety, both are easier to measure and more reliable, although less valid. Previous research has indirectly measured negative emotions by measuring behavioral and physiological responses, suggesting that they do not provide a valid measure of anxiety. Although a person expresses fear and has increased pulse, it does not necessarily mean that they subjectively experience fear. Research has shown that the subjective experience of fear does not correlate well with behavioral and physiological responses to fear (Lang, 1968; Rachman & Hodgson, 1974; LeDoux & Hofmaan, 2018). This view comes with the support of a large sample of evidence as noted previously.

Before presenting the research, it is important to discuss the measurement of the subjective experience. Different studies have used different tools measuring the subjective experience of fear and anxiety. Most studies used behavioral and physiological responses as an indirect measure of subjective experience meanwhile some use self-rating scales, such as the Competitive State Anxiety Inventory-2 (Cox et al., 2003). One has to keep in mind that although someone’s reaction may be fearfully or angrily, the subjective experience may differ. However, other tools should be considered. Non-verbal and verbal communication is a more accurate tool for measuring subjective experience of fear and anxiety although they are less common (LeDoux & Hofmaan, 2018). The most accurate measurement is verbal communication. Non-human species use non-verbal communication. Therefore, studying animals subjective experience of fear and anxiety is a difficulty in research. (LeDoux, 2017). Studying humans subjective experience of anxiety is much more possible. Also, as previously noted, measuring behavioral and physiological responses is not a reliable measurement for the subjective experience of anxiety. Further investigation, has raised an indication that the subjective experience of emotions emergence from other subcortical and cortical circuits that of the traditional view that the amygdala is center in the experiencing negative emotions (LeDoux & Pine, 2016).

Recent neuroscientific research on the cognitive and neural underpinnings of subjective experience suggests that nonconsciousness processes give rise to cognitive processes (Bertini, Cercere, & Làdavas, 2013; Dehaene & Changeux, 2011). They propose that the subjective experiences of anxiety are produced by the same cortical circuits that underlie any type of consciousness instead of subcortical circuits specific for defensive responses. The parietal neocortex, lateral prefrontal cortex, and medial prefrontal cortex are some of these cortical areas. These circuits are argued to be responsible for executive functions involved in attention and working memory. This would mean that the subjective experience of anxiety operates in the attentional system and therefore an increase in the subjective experience of anxiety would increase the activity in working memory and the attentional system.

Working Memory and Attention

Researchers have long argued that attention is involved in managing with sensory, perceptual and memory systems and its limits (Marchetti, 2014). Attention allows the selecting of information enabling managing of the information from different inputs. Working memory is argued to be the continuation process after attention, involved in temporally holding information available for processing. The concept of working memory bears many similarities with and evolved from the concept of short-term memory and is sometimes used in different (Baddeley, 1983). Thus, it is important to not confuse these concepts with each other. It is being argued that working memory and attention are two cognitive constructs with a limited cognitive capacity. Meaning that increase involvement in one executive function involved in working memory and attention leave fewer resources for other executive functions involved in working memory and attention (LeDoux & Hofmaan, 2018; LeDoux & Pine, 2016; Marchetti, 2014). For over 60 years the terms of working memory and attention have been an area of theoretical interest for research and are still to this day (Baddeley, 1983; Marchetti). Although much research has been on these topics, much is still unknown (Baddeley, 1983; Engle & Kane, 2003; LeDoux & Hofmaan, 2018; Marchetti, 2014).

There are several models and theories to explain working memory and attention such as a two-factor theory of executive control (Engle & Kane, 2003) and the mind and brain model (Jonides, Lewis, Nee, Lustig, Berman & Moore, 2008). In the role of working memory and attention, there are a lot of disagreements. There have especially been huge leaps amongst theorists and researchers in the past on how information is selected and then processed to working memory. Some argue that attention selects, through executive functions, which stimuli and which information that should proceed to the working memory. Whereas, others propose a view that explains while others suggest a post-perceptual selection (LeDoux & Pine, 2016). Furthermore, other disagreements are whether the working memory is unitary or not (Engle & Kane, 2003; McMillian et al., 2005; Miyake & Shah, 1999; Miyake et al., 2000). However, most researchers suggest that the relationship between attention and working memory is mostly unified although some research provides strong evidence suggesting that it is a non-unitary system (Posner and Peterson, 1990; Smith and Jonides, 1999). Miyake and Shah (1999) have argued that as much as six different themes (widely generalized) on different models and theories between the relationship of attention and working memory commonly used in research. They suggested that the relationship between attention and working memory and the understanding of it might require mapping and sorting of the many different views (Miyake & Shah, 1999). Following this, Awh, Vogel, and Oh (2006) agree that this mapping and sorting is useful and that the many different views might not so different as they might seem. They imply that interaction between attention and working memory is dependent on the information encountered and what stage attention is involved in. This might explain why theorist and researchers' ideas are so divided and so many different models and theories exists (Miyake & Shah, 1999; Posner and Peterson, 1990; Smith and Jonides, 1999). However, there are some things theories and models seem to agree on. One of these things is that most researchers agree that executive functions are crucial for selecting and maintaining information (Engle & Kane, 2003; McMillan, Laird, & Bullmore, 2005; Miyake & Shah, 1999; Miyake, Friedman, Emerson, Witzki, & Howerter, 2000). The mind and brain model (Jonides et al., 2008) are a complex model and is strongly influenced by neuroscience. The theory argues that there is a distinction between short-term and long-term memory and argues for a limited attentional capacity together, evidence of this is based on the neuroimaging research (Cowan, 2008; Jonides et al. 2008; Miyake & Shah, 1999). Baddeley presented his ideas; he suggested a limited attentional capacity (1983; 2003; 2012). Although it differs in terminology and emphasis, it shares close similarities with other models and just like most models, they agree with limited attentional capacity (Baddeley, 2003, 2012; Jonides et al. 2008; Miyake & Shah, 1999). There are also Individual difference-based theories arguing for limited attentional capacity (Baddeley, 2012). Thus, there are many different theories and models with different views, in some terms, they seem to agree, although the use different terminology and the view on how information is perceived the general agreement is that the attentional system seems to be limited.

The two-system framework of fear and anxiety. The traditional fear center view on fear and anxiety suggests that one neural system is responsible for physiological response, behavioral response as well as a subjective experience. The traditional view of fear and anxiety derives from the idea that some basic, universal expressed emotions have been inherited from animals to humans and that this is controlled by the amygdala (Bishop; 2004; Darwin, 1872; Dolan, Vuilleumier, 2006; Etkin, 2009; LeDoux, 2003, LeDoux & Pine, 2016). Both animal and human research have shown that behavioral and physiological responses of fear and anxiety seem to be related to the limbic system, frequently said to be the fear center (Adolphs, 2008). A threat immediately activates the limbic system, primarily the amygdala and through activation of the lateral to the central nucleus of amygdala resulting in activating of defensive behavioral reactions (Adolphs, 2008; LeDoux & Pine, 2016). The problem with the fear center explanation is that it does not include the subjective experience of fear and anxiety, instead only the behavioral and physiological responses are used to measure fear and anxiety.

LeDoux and Pine (2016) provided an alternative explanation based on a large sample of data. They propose that there are two neural systems involved in the negative emotions of fear and anxiety. One system to describe the subjective experiences of fear and anxiety as the conscious feeling of fear and anxiety and according to the model should be referred to as fear or anxiety. The other system describes the bodily reactions of behavioral response and physiological responses in the brain, and should, therefore, be defined separately as defensive responses (physical component; LeDoux & Pine, 2016).

The idea of this model is supported by a large body of research as noted before with the evidence that there is a significant difference between self-reports of fear and anxiety and the measure of bodily reactions (Anderson & Phelps, 2002; LeDoux & Pine, 2016; Zald, 2003). Findings suggest that people with amygdala damage fail to display bodily responses to fear and anxiety (Adolphs, 2008; Anderson & Phelps, 2002). Also, research suggests that there may be bodily reactions indicating fear or anxiety although no subjective experience of fear or anxiety could be found in self-reports (LeDoux & Pine, 2016).

LeDoux and Pine (2016) propose that subjective experiences of anxiety are produced by the same cortical circuits that underlie any type of consciousness instead of subcortical circuits specific for defensive responses such as the amygdala. These circuits are responsible for executive functions in attention and working memory. Also, as previously noted, because working memory and attention have a limited cognitive capacity (Marchetti, 2014; LeDoux & Hofmaan, 2018) as well as the subjective experience of anxiety is produced by the same cortical circuits as working memory and attention according to LeDoux and Pine (2016). This would theoretically result in a relationship between the subjective experience of anxiety and executive functions involved in working memory and attention (LeDoux and Pine, 2016; Marchetti, 2014). Where an increase of the subjective experience of anxiety would “steal” space in attention and working memory leaving fewer resources for executive functions involved in attention and working memory. Therefore, impairing performance involved in these functions. The two-system framework model (LeDoux & Pine, 2016) together with research on working memory provide us with this assumption. However, it also relies on research on cognitive neuroscience which, as previously noted, argues that the subjective experience of anxiety is produced by the same cortical circuits as any type of consciousness, which is involved in attention and working memory. Because if the subjective experience of anxiety is produced by, as some argue (Adolphs, 2008; Davis et al., 2009; Etkin, 2009; Gold et al., 2015; Pfleiderer et al., 2007; Sakai et al., 2005), the amygdala, this would be strong support against the assumption that an increase in the subjective anxiety of anxiety leaves fewer resources for executive functions involved in working memory and attention.

The Relationship between Anxiety and Performance

Recent theories, models, and research studying the role of subjective anxiety on performance has its origin in previous ideas. There are models such as zones of optimal functioning (Hanin, 1980), reversal theory (Kerr, 1987), psychic energy theory (Martens, 1987), processing efficiency theory (Eysenck, 1979) and multidimensional anxiety theory (Martens, 1990), they are all examples of previous theories that recent research, theories, and model have used. Previous research on zones of optimal performance has from the early 80s till late 90s frequently been used in research, although poor predictive power has led the theory to decrease in the present research.

Although previous theories and models are rare in recent research, the ideas are still present, attentional control theory, as well as the two-system model, has used some of these ideas (Eysenck; 2009; LeDoux & Pine, 2016). Also, most recent theories and models on the relationship between anxiety and performance all have one thing in common, they separate the subjective experience of fear and anxiety (worry & cognitive anxiety) from physiological and behavioral responses to fear and anxiety. More importantly, research within working memory and attention as well as the two-system framework model provide us with information and knowledge of how fear and anxiety work. According to them, the subjective experience of fear and anxiety are centered, as argued previous, in separate cortical circuits than behavioral and physiological responses (Bertini et al., 2013; Dehaene & Changeux, 2011). Although this research together with the two-system framework model provides us with an explanation of how anxiety impairs the performance, it does not provide us with any evidence on performance being impaired. Attentional control theory studies the relationship between anxiety and cognitive performance and might provide us with further evidence and knowledge (Derakshan & Eysenck, 2009).

The Development of Attentional Control Theory

Eysenck et al. (2007) provide an extension of Eysenck and Calvo's previous theory, the processing efficiency theory (Eysenck & Calvo, 1992), called the attentional control theory. Which in turn derives from a variety of sources. Some of the ideas and assumptions of the processing efficiency theory have developed from Liebert and Morris ideas about anxiety while others from Eysenck's ideas about both performance and anxiety (Eysenck, 1979; Eysenck & Calvo, 1992). Liebert and Morris suggested that anxiety should be divided into two components (Eysenck, 1979). One of the components of anxiety, the physical components, commonly described as emotionality and somatic anxiety, including physiological and behavioral responses to anxiety. The other term includes the subjective experience of anxiety and is referred to as cognitive anxiety or worry. These two components were first presented in the cognitive inference theory and later as key components in developing the processing of efficiency theory and later in the attentional control theory (ACT; Derakshan & Eysenck, 2009; Eysenck et al., 2007; Morris et al., 1981).

Furthermore, the theory zones of optimal function (Hanin, 1980) have provided key predictions for theories and models on the relationship between anxiety and performance. It argues that increase worry (subjective experience of anxiety) would result in decreased performance by a negative linear relationship (Hanin, 1980). Whereas the relationship between emotionality and performance is illustrated by an inverted-U shape. Increased emotionality (behavioral and physiological responses) may lead to an increase or decrease in performance depending on the amount of emotionality (Hanin, 1980). Meaning that emotionality may increase as well as impair performance depending on the amount whereas worry always impairs performance. These ideas were first adopted in the cognitive inference theory (Morris et al., 1981) and the process efficiency theory (Eysenck, 1979), then finally adopted by the attentional control theory (Eysenck, 2007).

The process of efficiency was put forward to answer two major issues in a previous theory by Morris and colleagues, the cognitive inference theory (Derakshan & Eysenck, 2009; Morris et al., 1981). The first issue was to address the problem of how performance should be measured. The cognitive inference theory measured performance effectiveness, easily defined as the quality of performance, also known as the outcome of the performance. The problem with this measure of performance is that it was a bad predictor of performance. On the contrary, Eysenck and Calvo proposed in the process of efficacy theory that a more accurate way of measuring performance is to measure processing efficiency. It is defined as the quality of performance compared to the effort to put in and has also been adopted by the ACT. The second major issue was that the cognitive inference theory failed to put forward a satisfying explanation on why task-irrelevant processing such as worry (subjective experience of anxiety) impairs performance in the view of the cognitive system (Morris et al., 1981). Eysenck et al. (2007) argue that working memory has limited capacity and that worry takes place in the working memory system and therefore impairs cognitive performance. This is also supported by research, studies have successfully found a relationship between increased cognitive anxiety and impaired cognitive performance, although somewhat inconsistent (Blankstein, Flett, Boase, & Toner, 1990; Calvo, Alamo, & Ramos, 1990).

In addition to this idea, two assumptions were proposed in processing efficiency theory (Eysenck, 1979). The first assumption is the there should be a distinction between state and trait anxiety. State anxiety was described as the present state of anxiety and trait anxiety is the predisposition to experience anxiety. Together with the present perceived threat, trait anxiety provides current state anxiety. This assumption included that state anxiety, in turn, should be divided into two components: worry and emotionality. (Eysenck, 1979; Morris, Davis & Hitcdical, 1981). With this idea, Eysenck also proposed the prediction that state anxiety should be more reliable in predicting task performance than trait anxiety (1979). The other key assumption that was presented, was that worry as a component of state anxiety was assumed to affect performance in a negatively linear relationship following the zones of optimal functioning's ideas (Hanin, 1980). The idea behind this assumption is that as worry appears, it takes space in the limited attentional capacity and therefore decreasing performance (Eysenck & Calvo, 1992). As well as the position that worries in the context of anxiety always impair the quality of performance (Eysenck, 1979). Eysenck proposed that anxiety produces cognitive activities that are irrelevant to the set task such as worry and therefore impairs performance. All these ideas and assumptions came to be the basis for the processing efficiency theory.

The processing of efficiency theory was then developed in 1992 by Eysenck and Calvo. The new idea is that the working memory system plays a crucial role in the relationship between anxiety and performance. Continuing, the theory presented two major predictions. The first prediction was that subjects high in state anxiety (worry and emotionality) are more likely to perform at an inferior level in cognitive performance compared to those who provided low test results in state anxiety. It follows that individuals with high state anxiety, are also assumed to have a higher level of worry compared to low-level anxiety individuals. However, research sometimes fails to distinguished trait anxiety and state anxiety from each other because of a correlation as high as .70 or more (Eysenck & Calvo, 1992). The idea for this assumption was that state anxiety impairs the efficiency of the central executive in working memory (Eysenck & Calvo, 1992). The second prediction was that attentional resources necessary for the task and difficulty are based on the levels of the difficulty of the task. Increase in difficulty in task would lead to a greater negative effect of worry on performance (Eysenck & Calvo, 1992). The idea behind this prediction was that worry impairs the efficiency of the central executive, function located in the working memory.

However, worry also has motivational properties (George, 1994). Therefore, a person with higher levels of worry and with a task low in difficulty may compensate impaired executive functions with more attentional resources used because of the motivational properties of worry (Eysenck & Calvo, 1992). Therefore, processing efficiency theory proposed that although anxiety impairs cognitive performance it also increases motivation, as anxiety increase so does motivation. The result showed no significant difference in performance between high-anxious and low-anxious individuals in performance. The previous measurement of performance from cognitive inference theory, quality of performance, was therefore rejected. Contrary to this, Eysenck et al. (2007) proposed that a more reliable measurement would be to measure processing efficiency, quality of performance concerning effort (Derakshan & Eysenck, 2009; Eysenck et al., 2007). Later, Eysenck presented attentional control theory based on the strength of processing efficiency theory but also dealt with its limitations (2007).

Attentional Control Theory

The processing efficiency theory (Eysenck & Calvo, 1992) was extended by Eysenck et al. (2007). It is not a general theory of anxiety and performance as a previous theory but rather a theory of anxiety and cognitive performance (Eysenck et al., 2007). The theory aims to explain the relationship between anxiety and cognitive performance through the study of working memory and attention (Eysenck et al., 2007). There are several reasons for developing a new theory. At the time of the development of processing efficiency theory little was known about the specific functions of the central executive and much were imprecise (Eysenck & Calvo, 1992; Eysenck et al., 2007). Much information about the function of the central executive is still unknown. However attentional control theory aims to describe some of these functions of anxiety and how they affect cognitive performance (Derakshan & Eysenck, 2009; Eysenck et al., 2007). There is no consensus on how the executive functions work and how they affect performance, however attentional control theory aims to describe some of these based on empirical support. ACT assumes that the central executive includes a large sample of functions and argues that the focus should be on the three central executive functions: inhibition, shifting attention and updating function (Eysenck, 2009). This assumption is based on the research of working memory (Baddeley, 1983; Smith and Jonides, 1999) as well as empirical support from other neuroscientific anxiety research (Derrberry & Reed, 2002; Eysenck et al., 2007).

Before introducing these concepts, it is important to present the concept of attentional control. Attentional control is a central part of the theory, which is where the name of the theory derives from (Eysenck et al., 2007). There is no consensus on how to define attentional control (Derakshan & Eysenck, 2009). In the attentional control theory, it is being described as a person's capacity to select what stimuli in all the senses should to pay attention to and what they choose to ignore. The theory is based on Yantis (1998) ideas of a top-down stimulus and bottom-down stimulus-driven system which will be discussed later on. In this case, attentional control is the ability to control the executive functions of inhibition, shifting attention and updating function (Derakshan & Eysenck, 2009; Eysenck et al., 2007). As noted, there is no general agreement of how the executive functions work. The attentional control has adopted the view based on strong empirical support (Derakshan & Eysenck; 2009; Miyake et al., 2000; Friedman & Miyake, 2004). The empirical support consists of research on many different tasks, testing many different executive functions in various ways (Engle & Kane, 2003; McMillian et al., 2005; Miyake & Shah, 1999; Miyake et al., 2000).

According to the ACT, the function of inhibition uses attentional control to inhibit other stimuli to "steal" attention from a selected attentive stimulus (Derakshan & Eysenck, 2009; Eysenck 2007). This is a negative attentional control. Shifting attention is used to shift attention from one stimulus to another, through attentional control, enabling to stay focused on the task-relevant stimulus. There is also the updating function, it is involved in updating and changing the experience of different stimuli in working memory. This is in accordance with the view that the executive functions are crucial for selecting and maintaining attention on certain stimulus (Engle & Kane, 2003; McMillian et al., 2005; Miyake & Shah, 1999; Miyake et al., 2000). Positive attentional control consists of shifting attention to proper stimuli and updating and changing the experience of a different stimulus. Positive attentional control is necessary for good performance. This is consistent with current research on the relationship between anxiety and performance.

The most central assumption of attentional control theory is the understanding of attentional processes and anxiety's effect on the processes which allows an understanding of how anxiety affects performance. Power and Dalgeish (1997) proposed that anxiety is perceived when the current goal has threatened a claim consistent with the ACT which relies on the consistency of empirical support. For instance, the Egloff and Hock (2001) study, examined anxiety as a predictor of attentional bias with a threat related stimulus. The result showed as proposed, that the increase in anxiety in high anxious patients increased cognitive activation. The idea behind the central assumption is that anxiety reduces attentional focus and therefore impairs attentional control. This assumption has led to the name attentional control theory. Continuing, this key assumption derives from Corbetta and Schulman (2002) in the stimulus-driven attentional system as well as the posterior attentional system of Posner and Petersen (1990) (Eysenck et al., 2007).

The attentional control theory has accepted Yantis view (1998), which distinguish between top-down goal-driven or controlled processes and bottom-up stimulus-driven processes (Derkshan & Eysenck, 2009). These two attentional control systems are described by Corbetta and Shulmans (2002). One system referred to as a top-down goal-driven system involved in the selection of sensory information and responses, located centered in the dorsal posterior parietal and frontal cortex. The top-down system is controlled by cognitive factors including present goals and knowledge. The second system, a bottom-up stimulus-driven system, used during the detection of sensory events, especially the stimulus unattended and salient, centered in the temporoparietal and ventral frontal cortex in the right hemisphere. (Corbetta & Schulman, 2002). Attention is argued working in an interaction between cognitive (top-down system) and sensory influences (bottom-up system). The attentional control system assumes that due to this interaction, cognitive performance is impaired. It is associated with a decrease in the goal-directed attentional system (involved in the top-down system) and an increase in the stimulus-driven attentional system (involved in the bottom-up system). This would lead to an increase in the executive inhibiting function resulting in fewer resources for other executive functions such as updating function and shifting attention and therefore also as a consequence impaired performance (Corbetta & Schulman). This is following the assumptions of ACT (Eysenck et al., 2007).

Importantly, the model shares a striking resemblance with the ideas of the two-system framework model where both divided the traditional view of anxiety as and unified phenomenon. To separate anxiety into bodily responses (behavioral and physiological responses) and the subjective experience of anxiety (Eysenck et al., 2007; LeDoux & Pine, 2016). However, as mentioned before, the two-system model framework is a general model of fear and anxiety while the attentional control theory is a specific theory of anxiety and cognitive performance.

Research on the Relationship between Anxiety and Performance

On the topic of the relationship between anxiety and performance, there are four meta-analyses including over 200 different studies and more than 50 thousand subjects involved (Craft, Magyar, Beckar, & Feltz, 2003; Ma, 1999; Seipp, 1991; Woodman & Hardy, 2003). Two meta-analyses are studying the relationship between anxiety and academic performance (Ma, 1999; Seipp, 1991) whereas the other two include anxiety and sports performance (Craft et al., 2003; Woodman & Hardy, 2003). All studies included measured some form of the subjective experience of anxiety from questionnaires, with the Competitive State Anxiety Inventory-2 (Cox et al., 2003). Also, whether it was cognitive anxiety or worry they were both defined in the same way and used synonymously.

Seipp's meta-analysis (1991) studied previous research and measured the general type of anxiety. Meaning that the studies mostly did not measure the subjective experience of anxiety. But rather a general type of anxiety measured using questionnaires, also failing to separate the subjective experience and physical measure of anxiety. Although this meta-analysis provided none significant and inconsistent results between anxiety and academic performance. It did not provide us with any large sample measuring subjective components of anxiety. The result showed that worry provided us with a stronger negative correlation with academic performance in comparison to emotionally although yet insignificant.

Ma's meta-analysis studied anxiety and academic performance, however specifically math anxiety and performance (Ma, 1999). As argued previous, in different executive functions may be involved in different tasks and using a specific task may limit the possibility that the result from the different tasks may cancel out each other. The study examined the achievement in the subject math. Math anxiety was described as a general uncomforting when performing math, a feeling of tension and helplessness, quite similar to the concept of worry. This study showed a significant relationship between math anxiety and performance in math, however, purely correlational. Although this study only tells us that students who are anxious about performing math perform worse. This does not necessarily mean that anxiety has impaired their performance. Instead, one is likely to believe that people who are worse at math feel anxious when performing it or any third factor.

In 2003 two meta-analyses studied the relationship between anxiety and sports performance, also purely correlational and both studying cognitive anxiety (worry; Craft, et al., 2003; Woodman & Hardy, 2003). One study found no significant relationship between cognitive anxiety and sports performance with a positive correlation of .01 (Craft et al., 2003). However, the research questionnaire used to measure cognitive anxiety has been heavily criticized (Jones & Hanton, 2001; Lane et al., 1999; Woodman & Hardy, 2001). It might be that it does not measure anxiety and it might not access cognitive anxiety. Arguably, the biggest factor is that this study has not taken into account an important factor of worry (subjective experience of anxiety), the motivational properties worry is argued to include (Eysenck, et al., 2007; George, 1994). Also, it has not measured the different effects of high-anxious and low-anxious individuals. Which has been proposed by other research and argued for by the two-system framework model, ACT and relevant neuroscientific (Eysenck et al., 2007; Engle & Kane, 2003; Jonides et al. 2008; LeDoux & Pine, 2016; Marchetti, 2014; Miyake & Shah, 1999). They argue that high-anxious individuals provide a more efficient measure of anxiety when studying the relationship between anxiety and performance.

The second meta-analysis showed a significant negative relationship between cognitive anxiety and sports performance with a relationship of -.10 ($p>.05$: Woodman & Hardy, 2003). Which is in accordance with the ideas of the two-system framework model, attentional control theory as well as neuroscientific research. Importantly, it showed a stronger relationship in individuals competing in high standard competitions, such as a national or international level. This suggests that cognitive anxiety in higher demands which most likely are associated with more attentional focus impairs performance more. Also, this is previously discussed and following cognitive neuroscientific research and models like the two-system framework model and ACT (Eysenck et al., 2007; Engle & Kane, 2003; Jonides et al. 2008; LeDoux & Pine, 2016; Marchetti, 2014; Miyake & Shah, 1999).

Causality. So far, although research is inconsistent there seem to be some agreements that there at least is a correlation between the subjective experience of anxiety and performance as previously noted (Craft et al., 2003; Ma, 1999; Seipp, 1991; Woodman & Hardy, 2003). However, a causal relationship is less researched (Craft et al., 2003). Carey, Hill, Devine, and Szücs (2016) studied the relationship between math anxiety and math performance. They predicted that either math anxiety impairs math performance or may math performance elicit math anxiety. Although they claim that there is somewhat inconsistent research in the field, they argue that there have been some indications that math anxiety impairs math performance. Following this, a study showed a causal relationship between math anxiety and math performance (Park, Ramirez, & Beilock, 2014). It showed that by experimental lowering the subjective experience of anxiety, their math performance was significantly impaired. These results has also been supported by multiple other studies (Gerstenberg & Imhoff, 2012; Marx, Monroe, Cole, & Gilbert, 2013; Seitchik, Jamieson, & Harkins, 2012; Spencer, Steele, & Quinn, 1999) and also suggesting, in accordance with attentional control theory, that the subjective experience of anxiety inhibits working memory in high anxious individuals and therefore impairs performance. Another study, analyzed baseball players hitting performance during a game according to a path-analytic technique (George, 1994). 53 baseball players were studied in different groups divided to perform a questioner, one group in each wave (period of the game), therefore enabling studying the causal relationship of anxiety and performance. The result showed a strong causal relationship between cognitive anxiety and performance, although none significant.

Scale and measurement of anxiety. The Competitive State Anxiety Inventory-2 was developed to measure different subscales of anxiety (Cox et al., 2003). The questionnaire and scale used 27-items to measure the three subscales: cognitive anxiety, somatic anxiety, and self-confidence. This is the most common scale of measuring anxiety, including over 40 different studies (Craft et al., 2003). However, although the large sample, research has been shown inconsistent result and the questionnaire has been questioned (Craft et al., 2003; Woodman & Hardy, 2003). Instead, we propose that different questionnaire's and scales are being used.

In contrast to many other studies using the Competitive State Anxiety Inventory-2 (Cox et al., 2003), Cassady and Johnson (2002) proposed a new scale to test the subjective experience of anxiety called Cognitive Test Anxiety scale. It has been tested with strong support for its reliability and validity. In pilot studies used as a tool to develop this questionnaire had been found to have high internal consistency ($\alpha = .86$) and with over 400 participants the result seems to be reliable (Cassady & Johnson, 2002). Also, a comparison between this scale and the Reactions to Tests was used in measuring the subjective experience of anxiety (Sarason, 1984). This test relies on strong support and with total scale reliability of .78. Besides, two other scales (Spielberg's Test Anxiety Inventory, 1980; Benson, Moulin-Julian, Schwarzer, Seipp, & El-Zahhar's Revised Test Anxiety scale, 1992) were used to compare with the Cognitive Test Anxiety scale. This comparison showed a high correlation between the scales, confirming the quality in the shape of reliability and validity. Furthermore, the scale has also been tested later, confirming the validity and reliability of the scale (Furlan, Cassady, & Pérez, 2009). This scale has been used in research, providing strong support for the idea that the subjective experience of anxiety impairs performance. Cassady (2004) studied the correlational effects of the relationship between anxiety and performance, providing significant results. Upon higher levels of the subjective experience of anxiety, the performance was impaired. The scale seems to provide a more reliable and valid measurement of the subjective experience of anxiety compared to the commonly used Competitive State Anxiety Inventory-2 (Craft et al., 2003) which has been heavily criticized (Woodman & Hardy, 2003).

Discussion

The purpose of this thesis was to find out what produces the subjective experience of anxiety as well as how it is related to performance. This literature study has dealt with a debate among researchers in cognitive neuroscience. Where the traditional view argues that the subjective experience of anxiety is produced by the amygdala, supported by a large body of research (Adolphs, 2008; Adolphs et al., 1995; Davis et al., 1994; Davis et al., 2009; Etkin, 2009; Gold et al., 2015; Pfleiderer et al., 2007; Sakai et al., 2005).

The other view, relying on recent research on consciousness, working memory and attention argue that the subjective experience of anxiety is produced by the same regions involved in any type of consciousness also involved in executive functions (Anderson & Phelps, 2002; Damasio et al., 2000; Lang, 1968; LeDoux & Hofmaan, 2018; LeDoux & Pine, 2016; Panksepp et al., 2011; Rachman & Hodgson, 1974; Zald, 2003). The two-system framework model (LeDoux & Pine, 2016) and the ACT (Eysenck, et al., 2007) provides a thorough explanation of the relationship between the subjective experience of anxiety and performance. According to the two-system framework model and cognitive neuroscientific research, the subjective experience of anxiety seems to be generated by more regions than the amygdala to an extent that differs from the traditional view. Instead, the two-system models together with other researchers (Bertini et al., 2013; Dehaene & Changeux, 2011; LeDoux & Pine, 2016) argue that the subjective experience of anxiety is generated by the same cortical circuits as any conscious experience instead of as previously proposed, generated by defensive responses from the amygdala. A view that is supported by recent research. Furthermore, the ACT together with research on working memory and attention explains how the subjective experience of anxiety impair performance (Anderson & Phelps, 2002; Damasio et al., 2000; LeDoux & Pine, 2016; Panksepp et al., 2011).

Furthermore, the ACT (Eysenck et al., 2007) together with the two-system framework model (LeDoux & Pine, 2016) provides a theoretical explanation of the role of the subjective experience of anxiety and performance. However, failing to find a meta-analysis supporting ACT assumptions that increase in the subjective experience of anxiety would impair performance. These different meta-analyses (Craft et al., 2003; Ma, 1999; Seipp, 1991; Woodman & Hardy, 2003) result provided, are somewhat inconclusive and inconsistent. However, studies included in these meta-analyses are correlational research and further research should focus on experimental research on the relationship between anxiety and performance. Because it might be that performance neutralizes the effects of the subjective experience of anxiety, meaning that increase performance may decrease anxiety and therefore it is important to study the causal effects.

Also, correlational research is inconsistent and the four meta-analyses performed in the 2000s does not provide any significant result of the relationship between anxiety and performance (Craft et al., 2003; Ma, 1999; Seipp, 1991; Woodman & Hardy, 2003).

Nonetheless, although a large sample of studies, most research could be widely questioned due to its use of the Competitive State Anxiety Inventory-2 and the inability to count for anxiety's motivational properties. Competitive State Anxiety Inventory-2 has been heavily criticized and instead one may propose a more valid and reliable scale, the Cognitive Test Anxiety scale. This scale seems to provide a more reliable and valid measure of the subjective experience of anxiety compared to the commonly used scale of Competitive State Anxiety Inventory-2 (Craft et al., 2003). However, only a small body of research has been conducted, using this scale.

More importantly, one may argue that some research has failed to count for the subjective experience of anxiety's motivational properties which has been shown by George (1994) and argued for in the attentional control theory (Eysenck et al., 2003) and the two-system framework model (LeDoux & Pine, 2016).

Future Directions

The most important future goal of anxiety and performance research would be to use experimental research to find out the casual relationship between anxiety and performance. Focusing on how anxiety may affect different people and types of performances differently. As well as count for different effects of anxiety that may cancel out the impairing properties of anxiety on working memory and attention. One of these effects is as argued previously, the motivational properties of anxiety which also has to be further evaluated. Also, to evaluate what type of scale that should be used while studying the relationship between anxiety and performance, both in correlational and experimental research, to enable a valid and reliable measuring tool.

Also, we propose that anxiety should use when referring to the mental states of feelings of fear and anxiety when no threat is attending. Fear should be used when referring to the mental states of feelings of fear and anxiety in the presence of a threat. We further propose that the term anxiety should be used when referring to the subjective experience of anxiety and the uses of anxiety should be avoided when referring to behavioral and physiology. To achieve a more reliable and valid measuring of anxiety as well as to clarify the concept for further research.

Conclusion

The debate between the traditional view that the subjective experience of anxiety is produced by the amygdala and the view that it is produced by other cortical circuits is still active. The amygdala may or may not be involved and the center of the subjective experience for anxiety, although research somewhat suggests a strong involvement by other cortical circuits. Furthermore, the meta-analysis on the relationship between the subjective experience of anxiety and performance provides some support for the claim that anxiety impairs performance. At least some specific types of performance seem to provide compelling evidence such as math anxiety and math performance. While other fields of study fail to find any strong support for a relationship. Since the field of study includes a variety of different types of performance, it is hard to draw conclusions and connections whether the subjective experience of anxiety generally affects any type of performance. So, in conclusion, this thesis shows that although a large sample of studies, the result is inconclusive and further research needs to investigate the subjective experience of anxiety and its relation to performance.

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