Influence of social anxiety on social attention and corresponding changes in action patterns

Einfluss der sozialen Angst auf die soziale Aufmerksamkeit und korrespondierende Veränderungen im Bewegungsverhalten

Doctoral thesis for a doctoral degree

at the Graduate School of Life Sciences,

Julius-Maximilians-Universität Würzburg,

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„What You call the external world is as much You as your own body."

Alan Watts

„It's like everyone tells a story about themselves inside their own head. Always. All the time. That story makes you what you are. We build ourselves out of that story."

Patrick Rothfuss, 'The Name of the Wind'

Acknowledgements

Foremost, I would like to thank Prof. Dr. Paul Pauli for his supervision, his support, and for giving me the opportunity to complete this thesis. Furthermore, I would like to thank the other members of my thesis committee: Prof. Dr. Jürgen Deckert, Prof. Dr. Martin J. Herrmann, and Prof. Dr. Matthias Gamer. Thank you, for your advice, your ideas, and constructive criticism.

Thanks to, Anna-Lena, Abby, Vanessa, Lennert, Roswitha, Charlotte, for doing a great job in collecting data and to all my participants for kindly providing named data.

Many thanks to all my former colleagues, for your support, needed (coffee) breaks, good advice, and finally for creating a place where it was actually nice to go to work. Special thanks to Matthias, Markus, and Michael, for your continuous support during all my technical dilemmas and to Anna and Elena for the excellent collaboration.

A big thank you, to my friends and family, for your earnest interest in my work, for kindly refraining from asking how I am progressing with my thesis (at the later stages of my dissertation project), and above all for your moral support and believing in my ability to actually get this thing done.

Thank you, Miriam! As expected, I find no words which can get even close to describing the extent to which I am thankful to you. In short: Thank you for time, mind, and love!

Abstract

People who suffer Social Anxiety Disorder (SAD) are under substantial personal distress and endure impaired normal functioning in at least some parts of everyday life. Next, to the personal suffering, there are also the immense public health costs to consider, as SAD is the most common anxiety disorder and thereby one of the major psychiatric disorders in general. Over the last years, fundamental research found cognitive factors as essential components in the development and maintenance of social fears. Following leading cognitive models, avoidance behaviors are thought to be an important factor in maintaining the developed social anxieties. Therefore, this thesis aims to deepen the knowledge of avoidance behaviors exhibited in social anxiety, which allows to get a better understanding of how SAD is maintained.

To reach this goal three studies were conducted, each using a different research approach. In the first study cutting-edge Virtual Reality (VR) equipment was used to immerse participants in a virtual environment. In this virtual setting, High Socially Anxious (HSA) individuals and matched controls had to execute a social Approach-Avoidance Task (AAT). In the task, participants had to pass a virtual person displaying neutral or angry facial expressions. By using a highly immersive VR apparatus, the first described study took the initial step in establishing a new VR task for the implicit research on social approach-avoidance behaviors. By moving freely through a VR environment, participants experienced near real-life social situations. By tracking body and head movements, physical and attentional approach-avoidance processes were studied.

The second study looked at differences in attention shifts initiated by gaze-cues of neutral or emotional faces. Comparing HSA and controls, enabled a closer look at attention re-allocation with special focus on social stimuli. Further, context conditioning was used to compare task performance in a safe and in a threatening environment. Next to behavioral performance, the study also investigated neural activity

using Electroencephalography (EEG) primarily looking at the N2pc component.

In the third study, eye movements of HSA and Low Socially Anxious (LSA) were analyzed using an eye-tracking apparatus while participants executed a computer task. The participants' tasks consisted of the detection of either social or non-social stimuli in complex visual settings. The study intended to compare attention shifts towards social components between these two tasks and how high levels of social anxiety influence them. In other words, the measurements of eye movements enabled the investigation to what extent social attention is task-dependent and how it is influenced by social anxiety.

With the three described studies, three different approaches were used to get an in-depth understanding of what avoidance behaviors in SAD are and to which extent they are exhibited. Overall, the results showed that HSA individuals exhibited exaggerated physical and attentional avoidance behavior. Furthermore, the results highlighted that the task profoundly influences attention allocation. Finally, all evidence indicates that avoidance behaviors in SAD are exceedingly complex. They are not merely based on the fear of a particular stimulus, but rather involve highly compound cognitive processes, which surpass the simple avoidance of threatening stimuli. To conclude, it is essential that further research is conducted with special focus on SAD, its maintaining factors, and the influence of the chosen research task and method.

Zusammenfassung

Menschen, die unter einer sozialen Angststörung leiden, stehen unter erheblicher persönlicher Belastung und leiden teilweise unter Beeinträchtigung der normalen Funktionsfähigkeit. Neben den persönlichen Belastungen sind auch die immensen Kosten für das Gesundheitswesen zu berücksichtigen, da die soziale Angststörung eine der häufigsten psychiatrischen Störungen ist. Die Grundlagenforschung hat kognitive Faktoren als wesentliche Komponenten bei der Entwicklung und Aufrechterhaltung sozialer Ängste identifiziert. Nach führenden kognitiven Modellen wird angenommen, dass Vermeidungsverhalten ein wichtiger Faktor für die Aufrechterhaltung der entwickelten sozialen Ängste ist.

Die vorliegende Arbeit hatte als Ziel, einen tieferen Einblick in das Vermeidungsverhalten von sozial Ängstlichen zu bekommen, um ein umfangreicheres Verständnis für die Aufrechterhaltung von sozialen Angststörungen zu bekommen.

Um dieses Ziel zu erreichen, wurden drei Studien durchgeführt. In der ersten Studie wurde modernstes Virtual Reality (VR) Equipment eingesetzt, um die Versuchsteilnehmer in eine virtuelle Umgebung eintauchen zu lassen. In dieser virtuellen Realität mussten Hoch-Sozialängstliche (HSÄ) und Kontrollprobanden einen sozialen Approach-Avoidance Task (AAT) durchführen. In dieser Aufgabe mussten die Teilnehmer eine virtuelle Person passieren, welche einen neutralen oder wütenden Gesichtsausdruck zeigte. Mit der Verwendung eines hochgradig immersiven VR Systems, unternahm die Studie den ersten Schritt zur Etablierung einer neuartigen VR Aufgabe für die implizite Erforschung des Verhaltens bei sozialer Vermeidung. Mithilfe von nahezu unbeschränkter Bewegung, durch eine virtuelle Umgebung, erlebten die Teilnehmer realitätsnahe soziale Situationen.

Die zweite Studie untersuchte Unterschiede in der Aufmerksamkeitsverschiebung, die durch die Beobachtung von neutralen oder emotionalen Gesichtern ausgelöst wurde. Hierbei wurde das Verhalten von HSÄ und Niedrig-Sozialängstliche

(NSÄ) verglichen, um den Einfluss von sozialer Ängstlichkeit bei Neuzuweisung von Aufmerksamkeit in Bezug auf soziale Reize zu messen. Zusätzlich wurde Kontextkonditionierung verwendet, um die Aufmerksamkeitsverschiebung in einer sicheren und einer bedrohlichen Umgebung zu vergleichen. Neben dem Aufmerksamkeitsverhalten untersuchte die Studie auch die neuronale Aktivität mittels Electroencephalography (EEG), wobei vor allem die N2pc-Komponente untersucht wurde.

In der dritten Studie wurden die Augenbewegungen von HSÄ und NSÄ analysiert, während die Teilnehmer eine Computeraufgabe durchführten. Zu den Aufgaben, gehörte das Erkennen von sozialen oder nicht-sozialen Reizen in komplexen visuellen Darstellungen. Ziel der Studie war es, Aufmerksamkeitsverschiebungen in Richtung sozialer Komponenten zwischen den beiden Aufgaben zu vergleichen. Darüber hinaus wurde untersucht, welchen Einfluss die soziale Angst auf diesen Prozess hat. Mit anderen Worten, die Messungen der Augenbewegungen ermöglichte zu untersuchen, inwieweit die soziale Aufmerksamkeit aufgabenabhängig ist und wie diese Abhängigkeit von sozialer Angst beeinflusst wird.

Mit den drei Studien wurden drei unterschiedliche Ansätze verwendet, um besser zu verstehen, welches Vermeidungsverhalten Individuen mit sozialer Angststörung ausführen und wie ausgeprägt dieses ist. Insgesamt zeigen die Ergebnisse, dass HSÄ eine verstärkte Vermeidung im Verhalten und Aufmerksamkeit aufweisen. Darüber hinaus zeigen die Resultate, dass die instruierte Aufgabe einen wesentlichen Einfluss auf die Aufmerksamkeitsverteilung hat. Zusammenfassend deuten alle Ergebnisse darauf hin, dass das Vermeidungsverhalten in der sozialen Angststörung sehr komplex ist. Dieses basiert hierbei nicht einfach nur auf der Angst vor einem bestimmten Reiz, sondern beinhaltet hochkomplexe kognitive Prozesse, die über eine einfache Flucht-Reaktionen hinausgehen. Abschließend ist es unerlässlich, dass weitere Forschungen über die soziale Angststörung, ihre Erhaltungsfaktoren und den Einfluss der gewählten Forschungsaufgabe und -methode durchgeführt werden.

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Abbreviations

AAT Approach-Avoidance Task.

ANOVA Analyses of Variance.

BAT Behavioral Avoidance Test.

CAVE Cave Automatic Virtual Environment.

CBT Cognitive Behavior Therapy.

CTX+ Conditioned anxiety context.

CTX- Conditioned safety context.

EEG Electroencephalography.

ERP Event-Related Potentials.

FDR False Discovery Rate.

HMD Head Mounted Display.

HSA High Socially Anxious.

HSÄ Hoch-Sozialängstliche.

IPQ Igroup Presence Questionnaire.

ITI Intertrial interval.

LSA Low Socially Anxious.

LSAS Liebowitz Social Anxiety Scale.

NSÄ Niedrig-Sozialängstliche.

ROI Region Of Interest.

SAD Social Anxiety Disorder.

SAM Self-Assessment Manikin questionnaire.

SAS Social Anxiety Screening.

SIAS Social Interaction Anxiety Scale.

SOA Stimulus Onset Asynchrony.

SPAI Social Phobia and Anxiety Inventory.

SSQ Simulator Sickness Questionnaire.

STAI State-Trait Anxiety Inventory.

US Unconditioned stimulus.

VR Virtual Reality.

1. Introduction

We, humans, are highly social beings, which is present in the way we like being around others, sharing experiences and emotions. On the one hand, most of us enjoy social interaction. On the other hand, everyone knows the fear of social interactions or social situations. For example, fear of public speaking, as the most common feared social interaction (Furmark, 2002; Pollard and Henderson, 1988; Wittchen and Fehm, 2003). Other social situations include meeting new people, talking to people of authority, talking to people of the other gender, asking for a free seat in train or airplane, or return something in a store. Additionally, there are also, a lot of work-related fears, like a job interview or leading a meeting. Whereas for most people these fears are mild, there are some people with fear levels so high, that they show avoidance behaviors and are massively impaired in private and occupational life. These people suffer from Social Anxiety Disorder (SAD).

Fundamental research over the last years found cognitive factors as essential components in the development of social fears (Beck, Emery, and Greenberg, 1985; Clark and Wells, 1995; Eysenck et al., 2007; Mathews and Mackintosh, 1998; Rapee and Heimberg, 1997). Bad experiences in childhood and adolescence lead to negative basic beliefs, which support the development of SAD at a later point in time. Another important aspect is how SAD is maintained. Here models from Clark and Wells (1995) and Rapee and Heimberg (1997) are the most up to date and empirically supported. However, there is still some lack of information, and some parts remain unclear. Following those models, one crucial factor in maintaining SAD is avoidance behavior. On the contrary, another factor is hypervigilance towards socially threatening stimuli. This converse combination is what makes SAD special, compared to other anxiety disorders.

The above-mentioned avoidance behavior is not just the apparent act of not entering social situations at all but also contains more subtle behaviors. Socially anxious individuals engage in these subtle avoidance behaviors, to avoid the negative evaluation of others (Beidel, Turner, and Dancu, 1985; Clark and Wells, 1995; Rapee and Heimberg, 1997). These behaviors could be the avoidance of eye contact or avoidance of close body contact. The model by Rapee and Heimberg (1997) exemplifies, that this avoidance behavior directly leads to negative social evaluations by others, thereby fulfilling the greatest fears of the individual suffering SAD. Also, avoidance seems to temporarily follow initial hypervigilance towards social threats (Bögels and Mansell, 2004; Wieser et al., 2009). This observation of avoidance after initial hypervigilance lead to the formation of the hypervigilance-avoidance hypothesis (Bögels and Mansell, 2004; Heinrichs and Hofmann, 2001).

The main quest of this thesis is to get a better understanding of what those avoidance behaviors are, and to which extent they are exhibited. Getting a better understanding is essential, as people with SAD show severe personal suffering. For treatment of the disorder, it is important to understand the mechanisms that form unhealthy deviances and what keeps them going.

The thesis will start with a summary of the current understandings of social anxiety disorder, including an overview of the best-known cognitive models. Followed by a synopsis of how approach-avoidance behavior attention allocation has been researched in the course of the disorder.

In the second part of the thesis, the three studies are described which have been conducted for the doctoral thesis to investigate different aspects of avoidance behaviors of SAD.

In the first study cutting edge Virtual Reality (VR) equipment was used to immerse participants into a virtual environment. In this VR, socially anxious individuals and matched controls had to execute a social approach-avoidance task. In the task, participants had to pass a virtual person displaying neutral or angry facial expressions.

The second study looked at differences in attention shifts initiated by gaze-cues of neutral and emotional faces comparing High Socially Anxious (HSA) and Low Socially Anxious (LSA) individuals. In addition, context conditioning was used to compare task performance in a safe and in a threatening environment. Next to behavioral performance, the study also investigated neural activity using Electroencephalography (EEG), primarily looking at the N2pc component.

The third study investigated how attention shifts towards social components are affected by different tasks. Here participants had to perform a social and a non-social detection task, where targets were either people (social) or arrows (non-social). Moreover, the study looked at how high levels of social anxiety influence this task dependency. For the assessment of attention shifts, eye movements of socially anxious and matched controls were analyzed using an eye-tracking apparatus while participants executed a computer task.

Finally, all the results of the studies are discussed in light of the given theoretical background.

2. Theoretical Background

2.1 Social anxiety disorder

People who suffer from Social Anxiety Disorder (SAD), formerly known as social phobia, fear the negative evaluation of others. Alternatively, as the current DSM-5 definition puts it, they have a persistent fear of social situations and performance situations in which they are exposed to unfamiliar people or to the possibility of being scrutinized by others (American Psychiatric Association, 2013). More specifically people with SAD, have a fear of acting embarrassingly or are being humiliated by showing anxiety symptoms (American Psychiatric Association, 2013). Those physical anxiety symptoms typically include excessive blushing or sweating, trembling, and nausea. As well as rapid speech and stammering. Furthermore, the anxiety can lead up to panic attacks under intense fear and discomfort (American Psychiatric Association, 2013).

The disorder causes substantial personal distress and impairs normal functioning in at least some parts of everyday life. People who suffer with SAD often report distinct social isolation and role functioning (Dodge et al., 1987; Turner et al., 1986) substance abuse (Buckner, Eggleston, and Schmidt, 2006; Grant et al., 2005; Kushner, Sher, and Beitman, 1990; Schneier, 1992), high rates of depression (Schneier, 1992; Stein et al., 1990), and impaired career progression (Davidson et al., 1993; Phillips and Bruch, 1988; Turner et al., 1986). Furthermore, SAD has been associated with mood disorders (Grant et al., 2005; Kessler et al., 1997; Kessler et al., 1999), insomnia (Buckner et al., 2008) and suicidal tendencies (Davidson et al., 1993).

Next to the personal suffering, there are also the immense public health costs to consider (Greenberg et al., 1999), as SAD is the most common anxiety disorder (Magee, 1996) and thereby one of the most common psychiatric disorders in general. In western countries, SAD has a lifetime prevalence ranging between 7% and 13%

(Fehm et al., 2005; Furmark, 2002; Kessler et al., 2005; Ruscio et al., 2008).

There are some findings that women are more prone to develop anxiety disorders in general (Cohen et al., 1993; McLean et al., 2011) and SAD in particular (Kessler et al., 1994; Magee, 1996). However, other studies found no gender differences for SAD prevalence (Furmark et al., 1999; McLean et al., 2011; Moutier and Stein, 1999; Turk et al., 1998).

The onset for the disorder is mostly at an early age, as most SAD sufferers have already developed the disorder between 12 and 16.6 years (Fehm et al., 2005).

The most effective therapeutic method for SAD is Cognitive Behavior Therapy (CBT) (Mayo-Wilson et al., 2014). CBT usually involves in vivo behavioral exercises. However, approaches using Virtual Reality (VR) have been shown to be equally effective, but the more practical and cheaper alternative (Bouchard et al., 2017; Carl et al., 2019).

Cognitive models of social anxiety claim that cognitive processes are highly relevant for the etiology and maintenance of the anxiety disorders (Beck, Emery, and Greenberg, 1985; Clark and Wells, 1995; Eysenck et al., 2007; Mathews and Mackintosh, 1998; Rapee and Heimberg, 1997). Several anxiety researchers have put forward that distorted information processes directly lead to fear, but also modulate behavior, for example, avoidance behavior in threatening situations (Beck, Emery, and Greenberg, 1985; Clark and Wells, 1995; Mellings and Alden, 2000). In the case of social anxiety, basic distorted information processes are thought of as dysfunctional beliefs, which specifically refer to negative self-evaluation (Beck, Emery, and Greenberg, 1985; Stopa and Clark, 1993).

The most recent cognitive model of maintenance of SAD comes from Rapee and Heimberg (1997). It is based on the model from Clark and Wells (1995), which in turn refers to Beck, Emery, and Greenberg (1985) as an essential and substantial influence on the development of their model.

Clark and Wells (1995) put forward a model in which they postulate that anxious individuals have problematic assumptions about themselves and their surroundings, due to earlier negative experiences. These assumptions let them generally perceive social situations as threatening. The negative evaluation and the resulting anxiety are maintained due to various vicious cycles. 1) Attention is primarily allocated away from the social situation towards themselves. This increased self-focus leads to false assumptions. The awareness for feared anxiety symptoms is heightened, assessment of the situation and others' behavior is obscured, and internal information is only taken to enhance negative self-evaluation. 2) Anxious individuals use cognitive and behavioral safety-strategies, to avoid catastrophes, which in turn keeps up their negative assumptions. 3) They are further prone to perceive only the adverse and humiliating reactions of others, thereby overestimating how negatively their behavior is evaluated. 4) In the same way, people who suffer from SAD evaluate their behavior and performance in a social situation as exaggeratedly negative, only focusing on failures, and furthermore predict to perform equally bad in future situations (see Figure 2.1 for an schematic example).

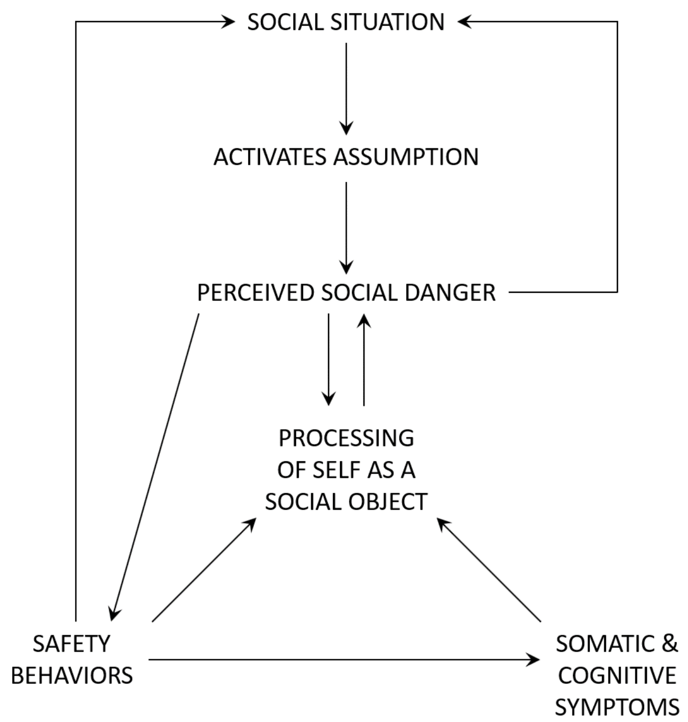

FIGURE 2.1: Schematic representation of the model from Clark and Wells (1995) on the example of a feared social situation (adapted from Clark (2005))

Another model with quite similar reasoning is the cognitive-behavioral model of the maintenance of social anxiety by Rapee and Heimberg (1997) (see Figure 2.2 for a schematic representation of the model). They also propose that exposure to social situations elicits several cognitive processes, which result in social anxiety and its maintenance. Central to their model is the mental self-representation as perceived by others and the discrepancy between what individuals with SAD perceive about themselves and how they expect to be evaluated from others. Notably, their perception of themselves are unrealistically perfectionistic, and they overestimate what others expect of them. This misperception leads to them getting the impression of being negatively evaluated, which in turn results in the activation of anxiety symptoms typically composed several components: a behavioral component, avoidance, a cognitive component, negative thinking, and a physical component, somatic arousal. Anxiety components than in turn influence the mental representation of the self. For example, the somatic arousal typically refers to visible symptoms such as, excessive sweating or blushing, twitching and speech related symptoms, such as stammering and rapid speech (American Psychiatric Association, 2013), which can, therefore, be perceived by others and used as factors for negative evaluations. The negative influence on the mental self-representation, via anxiety symptoms, finally closes the vicious circle.

In the model by Rapee and Heimberg (1997) avoidance is integrated as anxiety maintaining factor. The model predicts that a social situation, with the threat of possible negative evaluations by others, leads to the activation of anxiety symptoms typically composed of behavioral, cognitive and physical components. In order to reduce those symptoms, they start to avoid impending evaluations. In cases where a complete avoidance of the situation is impossible, these avoidance behaviors are subtle (Clark and Wells, 1995). For example, they stay out of conversations, try to prevent eye contact. Avoidance behavior is, therefore, an essential maintaining factor for SAD because it averts elaborate apprehension of the situation and inhibits the rejection of negative beliefs (Turk et al., 2001). It also affirms the notion, that individuals with SAD cannot engage in social situations, restarting the vicious circle.

Avoidance of the threatening stimuli contradicts the assumption coming from anxiety disorders in general that anxious individuals show hypervigilance towards their fears (Beck, Emery, and Greenberg, 1985; Eysenck et al., 2007; Mogg et al., 1997; Williams et al., 1988; Williams et al., 1997). However, the vigilance-avoidance hypothesis (Bögels and Mansell, 2004; Mogg et al., 1997) suggests that hypervigilance in social anxious is followed by avoidance, as a defensive mechanism to avoid

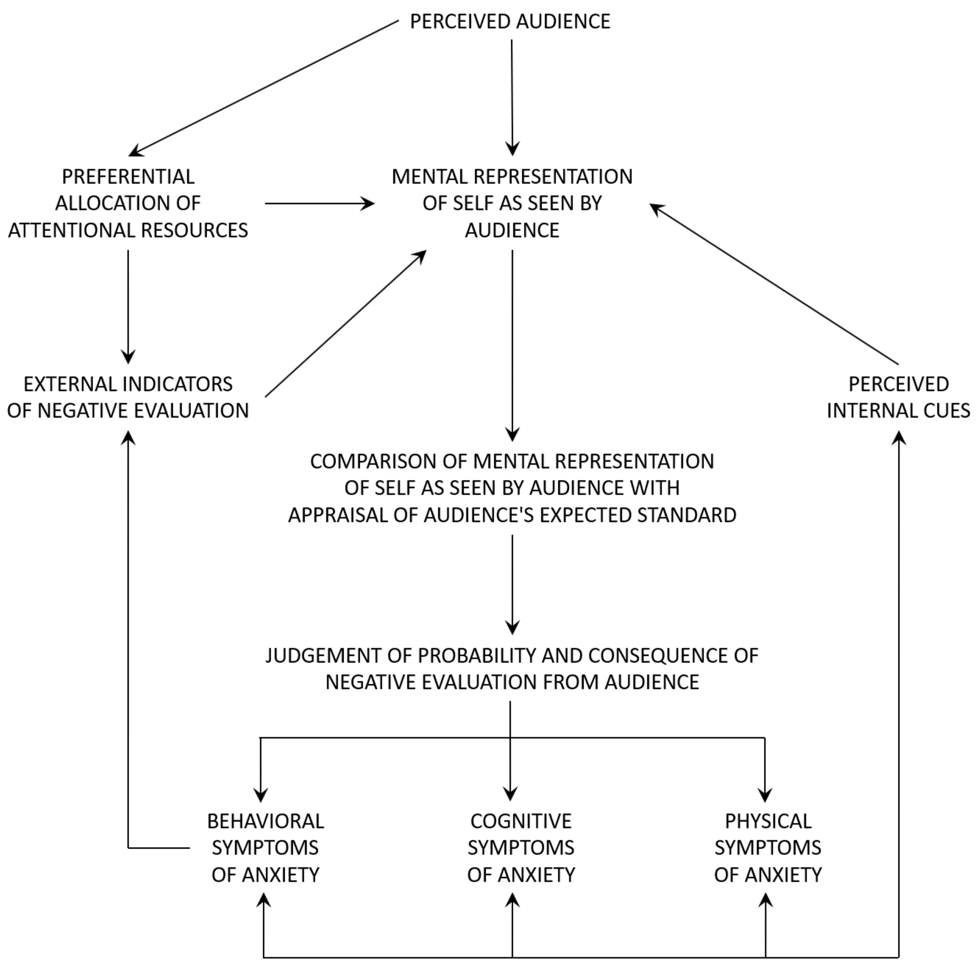

FIGURE 2.2: Schematic representation of the model from Rapee and Heimberg (1997) on the generation and maintenance of anxiety in social situations (adapted from (Rapee and Heimberg, 1997)).

or minimize threat (Bögels and Mansell, 2004; Mogg et al., 1997).

Furthermore, the models of social anxiety mentioned above partially match the vigilance-avoidance hypothesis (Beck, Emery, and Greenberg, 1985; Clark and Wells, 1995; Rapee and Heimberg, 1997), as they include increased attention towards the threatening elements of social situations, as well as the avoidance thereof.

Finally, as the impression from others is the defining characteristic of SAD, it is essential to discuss the perception of facial expressions. First, facial expressions are an important source of information of how other people react to oneself, by showing their emotions and their intentions (Erickson and Schulkin, 2003; Mansell et al., 1999; Blair, 2003; Darwin, 1965). Second, because emotions are biologically relevant for reacting towards cues in the environment, as stated in the already mentioned motivational priming hypothesis (Lang and Bradley, 2010). Emotions are separated into a specific set of, so-called basic emotions (Ekman, 1992). These basic emotions are accompanied by distinct facial expressions (Ekman, Friesen, and Ellsworth, 1972). Therefore, the perception of emotional facial expressions is essential for interacting with the social environment.

Moreover, emotional facial expressions are of distinct significance in SAD. For example, it has been shown, that individuals with SAD judge all facial expressions as more negative (Coles, Heimberg, and Schofield, 2008). Furthermore, socially anxious individuals show attentional biases towards emotional faces (Garner, Mogg, and Bradley, 2006; Wieser et al., 2009), which is for example reflected in increased attention allocation towards angry faces (Kolassa and Miltner, 2006; Kolassa et al., 2007; Mühlberger et al., 2009). Finally, there is some evidence, that people suffering SAD display a general hypervigilance for facial expressions (Kolassa et al., 2007), with a particular focus on threatening faces (Bradley et al., 1998; Mogg and Bradley, 1999; Mogg and Bradley, 2002; Mogg, Philippot, and Bradley, 2004; Pishyar, Harris, and Menzies, 2004).

To sum up, the described cognitive models and theories state that SAD stems from and is maintained by distorted information processing. Dysfunctional beliefs lead to the allocation of attention only to threatening external and internal perceptions, which in turn lead to avoidance behavior. As this thesis is mainly focusing on these avoidance behaviors and because the allocation of attention plays a prominent role, a more in-depth discussion on those topics will follow, with a focus on how they have been researched.

2.2 Social anxiety disorder and social approach-avoidance

The motivational priming hypothesis by Lang and Bradley (2010) states that motivational circuits in the brain lead the body in reacting towards emotional stimuli in the environment and that all emotions are based on this process. More specifically the organism is primed by appetitive and aversive cues, thereby pre-activating the appetitive or the defensive motivational system, respectively. The body is enacted to approach positive stimuli and to avoid negative stimuli.

In the laboratory, Approach-Avoidance Tasks (AATs) have been used to investigate approach-avoidance behaviors to affective stimuli, which mainly assess hand and arm movements (Phaf et al., 2014). For example, participants in a study by Chen and Bargh (1999), were confronted with words on a computer screen, which were either positive (i.e., "puppy") or negative (i.e., "cockroach"). They then had to react by either pushing or pulling a lever. This task, and in the ATT in general, arm flexion represents approach, and arm extension represents avoidance behavior. Typically, stimuli with a positive valence facilitated approach behavior, while negative stimuli facilitated avoidance behavior. The AAT in this form has seen multiple replications with varying set-ups, for example using controllers instead of levers and affective pictures instead of words (Chen and Bargh, 1999; Eder and Rothermund, 2008; Houwer et al., 2001; Markman and Brendl, 2005; Rinck and Becker, 2007; Saraiva, Schuur, and Bestmann, 2013). One general limitation of these tasks is that they mainly involve arm movements restricted to one axis, in other words, movements can only be forward or backward. These restrictions to one axis arm movements limit the extent of implications for approach or avoidance behavior of the person, for example regarding whole-body movement.

In social interactions, the whole human body can be the social stimuli. However, as stated before, the face is the most crucial factor for non-verbal communication (Adolphs, 1999; Erickson and Schulkin, 2003; Gelder, 2009), with emotional facial expressions projecting information about mental state and intended actions. It is of utter importance for social interaction. In other words, faces are salient social and emotional cues, which are further presumed to provoke approach and avoidance behaviors (Seidel et al., 2010). Several studies using emotional facial expressions could replicate the common AAT findings (Marsh, Ambady, and Kleck, 2005; Roelofs, Elzinga, and Rotteveel, 2005; Stins et al., 2011). One example comes from Marsh and colleagues (2005), who found that angry expressions elicited avoidance-related behaviors. In the study participants were confronted with a series of eight anger and eight fear expressions, which were presented in the center of a computer screen. They were instructed to do a simple expression detection task, where they had to push or pull a lever, depending on the facial expression. The instruction, of when to pull and when to push, changed between two conditions. In one condition participants had to pull when seeing a fearful expression and to push in response to an angry face. In the second condition, it was the other way around, push for a fearful face and pull in response to an angry facial expression. Results showed that participants were faster in pulling away from the angry expression. These findings support the notion of angry expressions being a threatening stimulus, which must be avoided. Responses regarding fearful faces elicited faster pushing behavior, thereby showing facilitation of approach-related behavior.

Moreover, a meta-analysis done by Laham and colleagues (Laham et al., 2015) on the relative facilitation of arm flexion and extension movements, in response to affective stimuli, found that approach-avoidance effects for faces were significantly higher compared to findings with words or pictures as positive and negative stimuli (Laham et al., 2015).

Accordingly, the AAT has been used to study approach-avoidance behavior in social anxiety, using emotional faces as affective stimuli (Heuer, Rinck, and Becker, 2007; Roelofs et al., 2009; Roelofs et al., 2010). In an AAT study by Heuer and colleagues (2007), the performance of participants high in social anxiety was compared with non-anxious controls. The study found that higher levels in social anxiety lead to increased avoidance tendencies (pushing a joystick away from self) toward emotional facial expressions compared to neutral faces.

However, in everyday life and more natural situations, approach-avoidance behaviors are not restricted to pure flexion or extension movements of the arm. Approach and avoidance are the actions of decreasing or increasing the distance between oneself from an environmental cue. Therefore, whole-body movements are the most direct and ecologically valid form of approach and avoidance behavior (Koch et al., 2009). Supportively, in a study, where participants had to step towards or away from a monitor showing emotional facial expressions, the approach towards angry faces compared to happy faces was slower (Stins et al., 2011).

More complex social-related behaviors can also be studied by looking at interpersonal distance, which is the reliable distance people automatically keep between themselves and others. Influences on personal distance were usually examined by letting participants approach confederates and instruct them to stop when they felt uncomfortable, or they were themselves approached by confederates and had to say when they should stop (Adler and Iverson, 1974; Aiello, 1977; Uzzell and Horne, 2006). The results of studies using confederates are quite mixed and inconsistent (Hayduk, 1983). In line with this, a more recent article states that confederates act differently depending on their interaction partners (Bombari et al., 2015), which in turn influences how participants behave (Kuhlen and Brennan, 2013). It has therefore been argued that measures obtained using confederates are lacking ecological validity and are unreliable or inaccurate measurements (Uzzell and Horne, 2006). These drawbacks are likely a reason why research on personal distance has been scarce.

The research on personal distance, together with the study by Stins *et al.* (2011), demonstrates progress in the right direction to increase ecological validity, by investigating more natural behavior. Further improvements may be possible due to new advances in the field of VR, stepping up as a promising alternative research tool (McCall and Blascovich, 2009). In the field of social approach-avoidance, virtual persons, agents (controlled by computers) or avatars (controlled by humans), may substitute pictures on computer screens or confederates to reenact social encounters. Applying VR as a tool for social psychological research has already been put forward (Blascovich et al., 2002; McCall and Blascovich, 2009; Parsons, Gaggioli, and Riva, 2017), as it provides full experimental control leading to high internal validity, combined with high ecological validity. For example, a recent study by Rubo and Gamer (2018) could show that VR scenarios can elicit behavior comparable to real-world situations. The employment of VR as research method further adds the benefit, that essential factors of the interaction partner, such as gender, gaze direction, movement, and facial expressions can be manipulated systematically (McCall and Blascovich, 2009; Parsons, Gaggioli, and Riva, 2017). Another big advantage of using VR is the possibility of implicit data recording. Including objective measures, like tracking head, body and eye movement. In the past numerous studies were successful in applying VR as research tool (Blascovich et al., 2002; Garau et al., 2005; Hoyt, Blascovich, and Swinth, 2003; James et al., 2003; Kane et al., 2012; McCall et al., 2016; Parsons and Rizzo, 2008; Rinck et al., 2010; Wieser et al., 2010; Geraets et al., 2018).

VR research on approach-avoidance behavior grossly replicated the above-described results. Thus, agents displaying angry facial expressions were physically more avoided than agents with sad or neutral facial expressions (McCall et al., 2016). Interestingly, socially anxious individuals were slower in approaching virtual people and kept larger distances from them (Rinck et al., 2010). In line, were results by Wieser *et al.* (2010) who found that, when approached by agents displaying a direct gaze, women high in social anxiety avoided gaze contact at further distances and showed avoidance behavior (i.e., backward head movements), when closer to the agent. As VR research is just beginning to get more widely used, there is a need for more studies supporting the described results.

In sum, the above-described findings show that socially threatening stimuli, mainly in the form of angry faces, lead to avoidance behavior. Moreover, highly social anxious individuals show increased avoidance tendencies.

2.3 Social anxiety disorder and social attention

As has been described above the dysfunctional beliefs of individuals suffering SAD lead to the allocation of attention only to threatening external and internal perceptions, which in turn lead to avoidance behavior. Therefore, it is essential to discuss the theoretical background and research that was conducted regarding attention allocation of socially anxious individuals.

From an evolutionary viewpoint, it is important to quickly react to threatening cues in the environment (Öhman, Flykt, and Esteves, 2001). Therefore, it is a big advantage when the detection process of threats is rapid and automatic. In line with this train of thought, autonomic responses towards threatening cues, snakes and angry faces, could be eliparencited without awareness (Öhman and Soares, 1993). Further empirical evidence for automatic processing of angry faces in humans comes from psychophysical studies. Most of these studies are conditioning experiments, where participants learn to associate emotional facial expressions (e.g., angry or happy) with a negative stimulus (e.g., electric stimulus). Angry faces are easier to condition with the negative stimulus and result in slower extinction learning, even when the faces were presented subliminally due to backward masking (Dimberg and Öhman, 1996; Esteves, Dimberg, and Öhman, 1994; Esteves et al., 1994; Parra et al., 1997).

This distinct reaction towards angry facial expressions has been further confirmed by empirical evidence, using visual search tasks (Fox et al., 2000; Hansen and Hansen, 1988; Lundqvist, Esteves, and Öhman, 2004; Öhman, Lundqvist, and Esteves, 2001; Tipples et al., 2002). These studies all show the so-called anger superiority effect. This effect describes the phenomenon that angry faces are detected faster in a crowd of neutral or happy faces, then happy faces in crowds of angry or neutral faces.

Regarding people with social anxiety, it has been argued that this facilitated reaction towards negative faces is eliparencited easier and more strongly, as negative faces represent a negative evaluation of others.

Several experimental paradigms have been used to test the hypothesis that SAD is associated with hypervigilance and avoidance concerning social threat stimuli. In order to get a better understanding on the matter of hypervigilance and avoidance in SAD, the following chapter gives an overview on this topic (for a more in-depth review, see Bögels and Mansell (2004)). From the various ways to study the processing of facial expressions, three paradigms have been used extensively, the already named visual search paradigm, the dot-probe paradigm and the emotional version of the Stroop test. In addition, many studies made use of eye movement measurements.

2.3.1 Detection paradigms

The visual search task is a detection paradigm in which a target stimulus is presented among several distractors. When the target stimulus has higher threatening value, its detection takes less time. The detection time is also dependent on the number of distractors, more distractors leading to longer reaction times. However, in some cases, the detection time is not influenced by the number of distractors. This so-called pop-out effect, or pop-out phenomenon, is based on automatic search processes (Treisman and Souther, 1985). It occurs when a visual stimulus consists of numerous similar-looking elements, with one differing element noticeably standing out. Such a unique stimulus can be located much faster. An example would be a blue square among several yellow squares, which would be automatically seen without the need of searching for it.

Selective attention to threat is indexed by a shorter time to detect the target stimulus when it is threatening relative to when it is neutral. The paradigm can also be used the other way around, by using threatening stimuli as distractors — this way the distraction factor of the stimulus can be assessed.

Detection paradigms with faces as stimuli have been used by some research groups to study attention processes in SAD. Their results are mixed, with groups finding evidence for blurred attention in SAD (Gilboa-Schechtman, Foa, and Amir, 1999; Perowne and Mansell, 2002; Veljaca and Rapee, 1998) and some find no differences (Esteves, 1999; Pozo et al., 1991; Winton, Clark, and Edelmann, 1995).

One study from Gilboa-Schechtman and colleagues (1999) used the so-called ‚face-in-the-crowd' paradigm, comparing SAD patients with non-anxious controls. They presented participants a three by four matrix with black-and-white photographs of faces with different facial expressions. In some trials, all facial expressions were the same, but in some trials, one facial expression was different (e.g., angry face in a neutral crowd, or happy face in an angry crowd). The task was to indicate whether one of the presented faces differed in its facial expression. Interestingly, SAD patients were faster in detecting angry faces in a neutral crowd, than happy faces. However, SAD patients showed a higher distraction factor towards emotional faces. In other words, they needed more time to react, when an angry or happy face was presented in a crowd of neutral faces. This reaction deficit indicates that individuals suffering SAD might show a general sensitivity towards emotional facial expressions.

A similar study was conducted where schematic facial expressions were presented to sub clinic socially anxious individuals (Esteves, 1999). Here all participants showed faster detection rates towards angry faces, with no differences between high and low socially anxious individuals.

A different detection paradigm has been used by Veljaca and Rapee (1998). Here participants high and low in social anxiety had to give a speech to a three-person jury. During the speech, the jury eliparencited positive and negative nonverbal signs of evaluation. Participants had to detect those behaviors and press one of two buttons depending on the valence of the detected behavior. Results show that High Socially Anxious (HSA) individuals are faster and more reliable in detecting negative jury behavior, whereas Low Socially Anxious (LSA) were faster and more reliable in detecting positive behaviors. This approach is high in ecological validity but can be criticized for low internal validity, as jury members were instructed to spontaneously engage in the evaluation behavior when they felt it being most appropriate. This felt appropriateness could, however, be different between participants and more importantly between groups. For example, did HSA show more cues for negative evaluation behavior.

Another research group conducted a study with a similar design (Perowne and Mansell, 2002). They, however, avoided the problem of internal validity by using a video-presentation paradigm developed by Pozo and colleagues (1991). Here instead of a live audience, the speech had to be given in front of a jury displayed on a screen. Participants were told, that it was a live stream. The only finding, which pointed in the same direction as the study by Veljaca and Rapee (1998), was, that HSA assessed audience behavior as more negative. No differences on detection accuracy were found.

Overall, studies using detection paradigms, on the one hand, found indicators for the hypervigilance towards the social threat. On the other hand, these biases are not sustained over time, pointing towards avoidance behavior as well. Detection paradigms are criticized for the fact that expression of avoidance behavior gets restricted by the instructions of having to detect the usually avoided stimulus (Bögels and Mansell, 2004). Moreover, it has been argued that attention effects cannot be solely appointed to target stimuli, as distractors might have an influence as well (Koster et al., 2004).

In summary, studies using detection paradigms indicate that social anxiety may be associated with hypervigilance for social threat under conditions that more closely mimic real-life situations, such as photographs of faces or real behaviors from audience members. However, there are some indications that the attentional bias may not be sustained over time, possibly owing to avoidance. In most detection paradigms, the tendency to avoid a social threat cue would be blocked by the instructions of the task (to detect the social cue). Therefore, only detection tasks that do not explicitly instruct participants to detect the social cue would be expected to find attentional avoidance.

2.3.2 The emotional Stroop test

Research on selective attention processes regarding emotional cues has been conducted using the emotional version, of the in psychological circles well known, Stroop test (Mathews and MacLeod, 1985; Williams, Mathews, and MacLeod, 1996). In the original Stroop test (Stroop, 1935), words of color names are presented. The color words themselves are written in different colors. Participants have the task to name the color of the word. The Stroop effect is that naming the color of the word takes longer when it is printed in color not denoted by the name. Like in the original test, in the emotional version, participants must name the color of a word. However, here the latency of naming the color is compared between neutral words and words high in valence. In another emotional version, affective pictures were presented, here participants usually have to name the background color. Longer latency times to threatening stimuli have been associated with selective attention processes. However, as Bögels and Mansell (2004) described in their paper, there are numerous other cognitive processes, which could explain the difference between neutral and emotional words or pictures. First, longer latencies in color naming could be due to heightened emotional arousal (Cloitre et al., 1992). Second, it could be due to the suppression mechanisms of the threatening value of the stimuli (Ruiter and Brosschot, 1994). Finally, it could be a result of mental preoccupation (Wells and Matthews, 1994). Results of the emotional Stroop test should, therefore, be interpreted with caution (Bögels and Mansell, 2004).

Regarding social anxiety, studies employing the emotional Stroop test discovered that people higher in social anxiety have shorter latencies regarding socially threatening words, compared with neutral words (Amir et al., 1996; Becker et al., 2001; Hope et al., 1990; Lundh and Öst, 1996; Maidenberg et al., 1996; Mattia, Heimberg, and Hope, 1993; McNeil et al., 1995). However, there are also some studies which failed to replicate this finding of delayed color naming in socially anxious in general and exclusively to socially threatening words (Amir et al., 1996; Kindt, Bögels, and Morren, 2003; Mansell et al., 2002; van Niekerk, Möller, and Nortje, 1999).

In addition to the above-mentioned general concerns, the mixed results for social anxiety could be due to the low ecological validity, which is mainly due to the focus on words as stimuli. Here faces would be a much better choice. Unfortunately, to date, no studies are using the emotional faces version of the Stroop test, for the investigation of social anxiety.

To sum up, results of the emotional Stroop test indicate that the performance of socially anxious individuals is disrupted by socially threatening cues, it is indeed difficult to interpret this interference as solely based on attentional processes.

2.3.3 The modified dot-probe task

Another paradigm used to study selective attention processes is the visual dot-probe task. Here participants are instructed to fixate a central point on a computer screen. Then two stimuli are presented, one above the other. One of the two stimuli, which can be words or pictures, is threatening, while the other is neutral. After some time (usually less than 500 ms) a probe, a dot or a letter, is presented at the position of one of the two stimuli. Participants are told to react with a button press as soon as they perceive the probe. The attention towards one of the two stimuli is labeled as biased, when participants react faster towards the probes at the location of the threatening stimulus, compared to probes presented at the place of the neutral stimulus. This effect is thought to arise from an increased attention allocation towards the threatening stimulus, whereby the probe at this location is detected faster.

There are several advantages of the dot-probe task. The first advantage is that threatening and neutral stimuli are presented at the same time. Therefore it cannot be argued to measure selective attention towards one over the other. Furthermore, as participants react towards the probe and not the stimuli itself, factors of other cognitive processes can be ruled out as slowing the reaction time. Finally, it can be used to measure selective attention towards and away from the threatening stimulus.

As mentioned before, the stimuli used for the dot-probe task can be words or pictures. Studies using words as stimuli have failed to find social anxiety specific effects, towards socially threatening stimuli (Amir et al., 2003; Asmundson and Stein, 1994; Horenstein and Segui, 1997). Even when the task has been assessed in a socially relevant context (Mansell et al., 2002), there was no difference between individual slow or high in social anxiety.

Moreover, by comparing dot-probe studies using words or pictures of facial expressions as stimuli, only studies with facial pictures were found in support for an attentional bias towards threatening stimuli in social anxiety (Pishyar, Harris, and Menzies, 2004). This difference in results makes sense considering ecological validity, which words lack. Also, it shows that faces are important stimuli for socially anxious individuals (Bradley et al., 1997; Gilboa-Schechtman, Foa, and Amir, 1999).

Many studies have been conducted with faces as threatening stimuli in the dot-probe task, comparing socially anxious and non-anxious individuals. Some found early selective attention, hypervigilance, towards threatening faces (Bradley et al., 1998; Mogg and Bradley, 1999; Mogg and Bradley, 2002; Mogg, Philippot, and Bradley, 2004; Pishyar, Harris, and Menzies, 2004).

Other studies have found that socially anxious avoided the threatening stimuli (faces or negative facial expressions). Mansell and colleagues (1999) developed a modified version of the dot-probe task and used this to investigate selective attention in social anxiety. Stimuli were, on the one hand, faces with negative, neutral or positive facial expressions and on the other hand everyday objects. They further compared behavior under two conditions, a social-evaluative threat condition, where participants were told they had to give a speech, and a non-social-evaluative threat condition. Only in the threat induced condition showed HSA participants showed biased attention away from emotional faces (negative and positive).

The same modified dot-probe task has been used by another study, with patients suffering SAD (Chen et al., 2002). Here the same avoidance of emotional facial expressions was found, without the addition of social-evaluative threat. Other research groups conducted modified dot-probe task studies with SAD patients (Garner, Mogg, and Bradley, 2006; Sposari and Rapee, 2007). They presented emotional faces and everyday objects, with the social-evaluative component. In both studies, results showed hypervigilance towards faces in general, however independent of its facial expression.

Assessing selective attention with the dot-probe task has also been done with children (Stirling, Eley, and Clark, 2006). Here the researchers found preliminary evidence, that social anxiety is associated with avoidance of negative faces.

The at first glance contradictory results of hypervigilance and avoidance of socially threatening stimuli could be explained by differences in presentation time of the stimuli and the presentation context of faces. Studies with brief presentation times and presentation of two faces at the same time found hypervigilance. Avoidance was found with longer presentation times and when the faces were presented along with other objects. Further support for this comes from a study investigating individuals with high trait-anxiety (Bradley et al., 1998). Here vigilance towards threatening faces was only found with shorter presentation times.

Overall, the results of the modified dot-probe paradigm point towards the vigilance-avoidance hypothesis (Bögels and Mansell, 2004). However, they also show that the dot-probe task is only able to show a snapshot of the attentional focus, which is also argued by Fox and colleagues (2001). They state that the task cannot discern between initial visual attention allocation and later reallocation. Further, a study by Schmukle *et al.* (2005) tested the reliability of the dot probe task and stated that it does not reliably measure the allocation of attention.

2.3.4 Eye movements

Another approach to studying visual attention lies not in a new paradigm, but an altogether new method. The tracking of eye movement with an eye tracking apparatus. In this way, the focus of eye gaze over time can be assessed without the explicit effort of the participant.

Typically eye tracking delivers two objective measurements which can be taken as indicators for selective attention, fixations (time window in which eye gaze is focused on one point or stimulus) and saccades (quick eye movement between phases of fixation). The eye tracking data is known to partially correlate with selective attention (Corbetta, 1998; Rizzolatti et al., 1987). One factor, why the correlation between eye movements and selective attention is only partial, is that attention can also be covert (Posner, 1980). For visual attention, this could mean that while the gaze is fixed on one thing, the attention could be somewhere outside of the focus. Another factor is that shifts in visual attention precede eye movements (Hoffman, 1998). Both factors show that eye movement and attention are dissociated (Hunt and Kingstone, 2003). Besides the mentioned limitations it seems to be the case that eye movements are a good indicator of overt attention (Henderson, 1992; Klein, Kingstone, and Pontefract, 1992; Kowler et al., 1995).

There are a few studies, which have looked at the influence of social anxiety on gazing behavior towards faces. One study simply presented pictures of faces to socially anxious individuals and controls (Horley et al., 2003). They found that people suffering SAD scanned critical facial features, such as the eyes, less frequently, but showed hypervigilance scanning behavior towards other facial features. In a later study, Horley *et al.* (2004) confirmed these results and further showed that explicitly threatening faces increased hypervigilance and avoidance of the eye region. Another study found an initial hypervigilance of HSA towards faces in a free viewing of a video, showing an emotionally-neutral social situation. However, the found no further differences in eye-movement behavior between HSA and LSA participants (Gregory, Bolderston, and Antolin, 2018).

Further support comes from eye tracking studies using free-viewing tasks, presenting face pairs (e.g., angry-happy, angry-neutral). Here studies found that HSA participants fixated longer on threatening faces when presented along with other faces (Lazarov, Abend, and Bar-Haim, 2016; Liang, Tsai, and Hsu, 2017).

In another study comparing eye movements of high and low socially anxious individuals (Garner, Mogg, and Bradley, 2006), once more two stimuli were presented in pairs next to each other. However, in addition to pairing faces (happy-neutral, angry-neutral), they also paired faces with objects. Results show that HSA participants initially directed their gaze more often at neutral faces, than at objects. To increase the threatening value of the experiment, the authors repeated the study and included the threat of giving a speech. Under these conditions, HSA showed reduced attention towards the neutral faces, compared to LSA. In contrast to the study without threat, in this study, HSA also showed faster initial orientation towards emotional faces, with shorter overall fixation times compared to participants low in social anxiety.

However, there are also studies with HSA participants, finding only the attentional hypervigilance towards threatening faces and no attentional avoidance thereof

(Gamble and Rapee, 2010; Seefeldt et al., 2014; Stevens, Rist, and Gerlach, 2011; Wermes, Lincoln, and Helbig-Lang, 2018).

An interesting general finding is that HSA show selective attention towards all emotional faces (happy and angry) and not just the ones associated with negative valence. Moreover, in general, there is an increase of evidence showing that socially anxious individuals fear evaluation independently of its valence (Byrow, Chen, and Peters, 2016; Chen et al., 2012; Weeks et al., 2008; Weeks, Jakatdar, and Heimberg, 2010; Weeks and Howell, 2012; Weeks, 2015; Fernandes et al., 2018). In the same vein, Wieser *et al.* (2009) had HSA and LSA participants execute an emotional saccade task with facial expressions (happy, angry, fearful, sad, neutral) while measuring their gazing behavior. In the task participants performed either pro- or antisaccades regarding facial expressions, presented peripherally. The results of the study showed that HSA have difficulties in inhibiting themselves to reflexively attend to all facial expressions, independently to the valence of the facial expression.

Similarly to the findings of the other research paradigms, results from eye tracking studies are mixed. While many studies find deviant attention behavior for HSA participants, they are not in complete agreement. However, there is strong evidence for the hypervigilance-avoidance hypothesis coming from studies inducing extra social threat. More research in this relatively new attention research field is needed to come to a definite conclusion.

2.3.5 Summary

Altogether the above-described findings show that hypervigilance towards threat-related cues is common for individuals who are highly socially anxious. Furthermore, they show that sustained avoidance of socially threatening stimuli is another critical factor. Moreover, there are even a few studies showing evidence for both in one paradigm. However, overall the results are still mixed and are restricted by the above-described limitations of the used paradigms.

3. Study 1 - The way we move

3.1 Introduction

As stated in the theoretical background, investigating approach-avoidance behavior regarding affective stimuli is vital in broadening the understanding of Social Anxiety Disorder (SAD). Many studies in the field rely on Approach-Avoidance Tasks (AATs) based on simple hand and arm movements, or interpersonal distance measures, which return inconsistent results and lack ecological validity. Therefore, the first study introduces a newly developed Virtual Reality (VR) task, looking at whole-body movements.

Furthermore, investigated other studies mainly behavior, with direct interaction with a social stimulus. A still open research question, therefore, remains, namely how behavior not explicitly related to others is affected socially.

Also, in previous VR studies, participants had to wear a Head Mounted Display (HMD), which restricts natural body movement and the view onto the own body. Further, it only allows for movement with additional equipment (i.e., joysticks), where participants do not move physically but receive only simulated visual feedback from body movement.

The first study of the dissertation addresses the described issues and thus differs from previous research in two central aspects. First, it inspects the implicitly and subtlety effects of social factors on behavior with no explicit relation to other people. To examine this scientifically, the present study introduces a VR task during which participants must move past a virtual agent, varying in his facial expression, on their way to a specific target location. Any attention directed at, and any action taken towards the agent are entirely voluntary, as the agent is irrelevant for the task. This approach, in turn, allows studying implicit social approach-avoidance behavior.

Second, the study differs from VR studies with HMD setup, by using projection methods within a 5-sided Cave Automatic Virtual Environment (CAVE) to immerse participants. They could thereby move around being less restricted due to the VR equipment, which made movements, in general, more natural. Inside the CAVE system, it is possible to physically walk around in VR and still see one's own body. Two advantages, which are considered of high importance for measuring behavior in social situations.

Overall, the study was conducted to test three hypotheses. The first hypothesis predicts that all participants will show enhanced avoidance behavior (e.g., greater distance and less eye contact) when bypassing an agent with a negative compared to an agent with a neutral facial expression.

Secondly, it is expected that these avoidance behaviors are modulated by social anxiousness and therefore highly anxious participants will generally exhibit more avoidance behavior regarding all agents. The final hypothesis predicts that the avoidance behavior of participants with high social anxiety is further exaggerated towards agents with angry facial expressions.

3.2 Material and methods

3.2.1 Participants

Participants were screened and selected based on an online Social Anxiety Screening (SAS) questionnaire which was previously used successfully for recruiting socially anxious participants (Ahrens et al., 2015; Reutter et al., 2017; Wieser and Moscovitch, 2015). All five items of the questionnaire were 5-point Likert scale items, created from the criteria for social phobia from the Statistical Manual of Mental Disorders (American Psychiatric Association, 2000). Participants were selected as High Socially Anxious (HSA) participants when they had an average score of 3.2 or higher. The cut-off value was taken from the study from Reutter *et al.* (2017), where participants in this range made up the upper 19.26 % of all individuals screened. For the control group, participants with scores between 1.6 and 2.2 were selected and matched to the HSA participants regarding gender, age and education.

In addition to the SAS questionnaire, all participants gave demographic information and completed two more questionnaires, regarding fear of heights and personality. The last two were added to make it less apparent that the screening was solely conducted to select HSA people.

In total, 52 individuals participated in the study. Due to technical problems with the tracking system, one HSA participant had to be excluded, and therefore its matched control was excluded as well, which left data of 50 participants (25 HSA, 25 matched controls) for the statistical analysis. All participants signed the informed consent, reported normal or corrected-to-normal vision and received 10 € for their participation. The study was approved by the ethics committee of the University of Würzburg and was in accordance with the Helsinki declaration. The real purpose of the study was not revealed to prevent influences on the participants' behavior. They were instead told, that the study investigates movement in VR.

For the study, participants had to answer questionnaires, at the beginning of the experiment and the end. The state part of the State-Trait Anxiety Inventory (STAI) (Laux et al., 1981) and the Self-Assessment Manikin questionnaire (SAM) (Bradley and Lang, 1994) were used to assess the current state of the participant before and after the experiment. All other questionnaires were answered at the end of the study, including a sociodemographic questionnaire, the trait part of the STAI, the Igroup Presence Questionnaire (IPQ) (Schubert, Friedmann, and Regenbrecht, 1999), and the Simulator Sickness Questionnaire (SSQ) (Kennedy et al., 1993). Finally, the Social Phobia and Anxiety Inventory (SPAI) (Fydrich, 2002; Turner et al., 1989) and again the above described SAS questionnaire were filled in. Test-retest reliability of the screening questionnaire resulted in a correlation of 0.93.

There were no significant differences between groups' questionnaire scores (see Table 3.1). However, as expected, HSA participants had higher scores on social anxiety questionnaires (SPAI, pre-screen questionnaire), as well as higher trait anxiety (trait part of the STAI). Also, groups differed in levels of nausea after completing the experiment (SSQ-nausea).

For assessing differences in the emotional state before and after the experiment, repeated measures Analyses of Variances (ANOVAs) with the factors time (pre/post-experiment) and group (HSA/control) were conducted. The analysis revealed no

TABLE 3.1: **Group Characteristics**

	HSA		control				
Variable	*M*	*SD*	*M*	*SD*	t(48)	p value	cohens d
Age	23.9	3.5	24.1	3.3	- 0.20	.840	-0.06
SAS (online)	3.7	0.4	2.0	0.3	16.22	.001	4.50
SAS (laboratory)	3.7	0.5	1.9	0.5	12.49	.001	3.46
SPAI	3.0	0.9	1.7	0.7	5.52	.001	1.53
STAI-T	46.7	9.8	35.7	7	5.93	.001	1.68
SSQ (nausea)	24.2	21.6	12.5	13.4	2.35	.023	0.65
SSQ (oculomotor)	26.8	17.2	23.6	20.5	0.61	.544	0.17
SSQ (disorientation)	25.7	31.7	19.3	29.0	0.76	.449	0.21
IPQ (spatial presence)	4.1	1.0	3.9	1.1	0.56	.577	0.16
IPQ (involvement)	3.7	1.2	3.2	1.3	1.37	.178	0.38
IPQ (experienced realism)	2.8	1.1	2.8	1.0	0.00	.999	0.01

HSA, High Socially Anxious; SAS, Social Anxiety Screening; SPAI, Social Phobia and Anxiety Inventory; STAI-T, trait part of the State-Trait Anxiety Inventory; SSQ, Simulator Sickness Questionnaire; IPQ, Igroup Presence Questionnaire.

effects involving the factor group and only marginally significant effects of time for state anxiety and valence ratings. This suggests a reduction in state anxiety and a deterioration of reported valence (see Table 3.2).

TABLE 3.2: **Emotional state change over time**

	Pre		Post				
Variable	*M*	*SD*	*M*	*SD*	$F(1,48)$	p value	η_p^2
STAI-S	37.1	7.4	35.1	7.1	3.59	.064	0.07
SAM (arousal)	6.08	1.6	6.26	1.8	0.63	.432	0.01
SAM (valence)	2.92	1.4	2.58	1.4	2.90	.095	0.06
SAM (control)	6.36	1.6	6.70	1.6	2.78	.102	0.05

Pre, scores assessed at the beginning of the experiment; Post, scores assessed at the end of the experiment; STAI-S, state part of the State-Trait Anxiety Inventory; SAM, Self-Assessment Manikin questionnaire.

3.2.2 Virtual reality apparatus

For VR immersion of participants, a 3D-multisensory laboratory was used consisting of a 5-sided CAVE (by BARCO, Kuurne, Belgium). The VR scene was projected on the four walls and the floor (4 x 3 x 3 m3), with altogether six projectors. While four projection surfaces had a resolution of 1920 x 1200 pixel and one had a higher resolution of 2016 x 1486, due to an additional projector. Stereoscopic images, for three-dimensional depth, were created using two computers for each projection surface and passive interference-filtering-glasses (Infitec Premium, Infitec, Ulm, Germany). An active infrared LED tracking system with four cameras (PhaseSpace Impulse, PhaseSpace Inc., San Leandro, CA, USA) was employed to capture movement and orientation data. Data were recorded with a sampling rate of 60 Hz. Audio stimuli were presented with a 7.1 surround system. The virtual environment was created with a Source SDK (Valve Corporation, Bellevue, Washington, USA) based modification (VrSessionMod 0.6). Experimental control and data recording were established using the VR-software CyberSession (CS-Research 5.6, VTplus GmbH, Würzburg, Germany; see www.cybersession.info for details). The VR-software was executed on an additional computer, which was also running the rendering control unit.

3.2.3 Virtual reality environment

The virtual scene consisted of a small room the size of the CAVEs physical dimension (4 x 3 x 3 m3). Participants could move around freely, without the necessity of additional equipment (e.g., a gamepad). For immersion, they were equipped with 3D glasses and a tracking system. Finally, participants got a handheld controller with buttons for giving responses. The 3D images were adapted according to the position and orientation of the head. The walls texture consisted of a reddish brick stone pattern, which was chosen for two reasons. First, the background gave the feeling of being in a backyard ally and thereby enhanced the ecological validity. Second, it enhanced the visibility of the agents. The floor projection had a white marble pattern. Position markings, for the start position (red footsteps) and the target position (green circle), were only temporarily visible.

Moreover, in some trials a virtual agent was visible. The virtual agent stood in one position showing random idle behavior and depending on the experimental condition displayed different facial expressions. Furthermore, the agent followed the participant with gaze and body orientation. In total three different male agents were used. The facial expressions were designed using the SDK tool faceposer, which is based on the Facial Action Coding System (Ekman and Friesen, 1978; Ekman, Friesen, and Hager, 2002).

3.2.4 Procedure

At first, participants had to answer the above described and sign the informed consent. After that, participants were equipped with the necessary tools for VR immersion and positioned in the CAVE. During the VR immersion, participants could communicate with the experimenter via microphone. Furthermore, participants were monitored by the experimenter using a video screen. Participants were explicitly made aware, that they could always stop the experiment, without giving any reason.

Pre-recorded instructions were played via loudspeakers, installed in the CAVE system. During the experiment, participants could navigate through the instructions with giving responses using the buttons on the controller. When participants finished the instruction part of the experiment, which included four consecutive test trials, they had the opportunity to ask questions.

At the beginning of each trial, participants positioned themselves on the start location, which was marked with red footprints (see Figure 3.1). They then pressed a button on the controller to start the next trial. The button press let an agent appear at one of two locations in front of the participant (see Figure 3.1). The agent had either a neutral or an angry facial expression and had his gaze fixated on the head of the participants throughout the trial and faced them with his whole-body posture.

First, participants had to name the agent's hair color. This task was added so that participants had to look at the agents' head and be confronted with his face. Secondly, after naming the hair color, the target location was marked with a filled green circle (27.43 cm (10.8 in) diameter), which blinked up on the virtual floor for 100 ms. Participants were instructed to move to the target location as fast and accurately as possible. Finally, after reaching the position, they pressed a button to end the trial. Then, after 500 ms, the start marking was visible again, prompting participants to start the next trial.

Throughout the experiment, the target was presented at ten different locations (see Figure 3.1, for all possible locations). Out of those ten locations, only four were of interest (close and far labeled target positions in Figure 3.1). The remaining six target locations were used for dispersion and scattered throughout the room. From

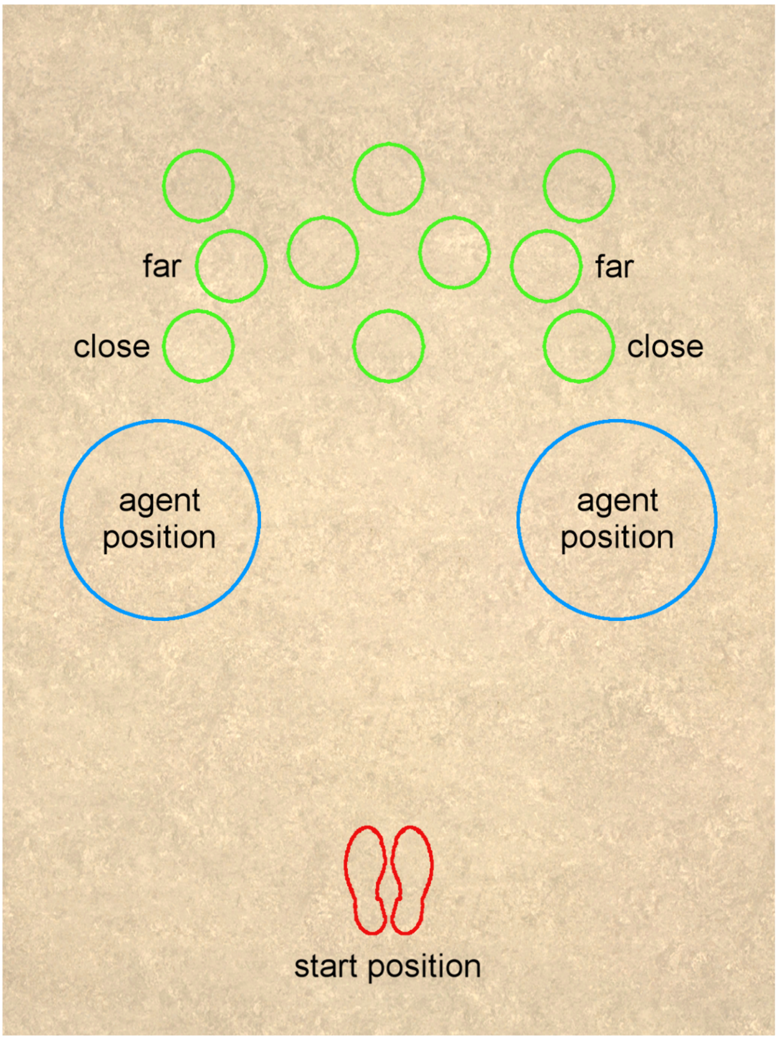

FIGURE 3.1: **Projection on CAVE floor.** Floor of the CAVE from above showing outlines for the start position (red) and all possible target positions (green), as well as the possible agent positions (blue) and the four "targets of interest" positions, labeled as close and far.

the total number of 108 trials, 36 were dispersion trials. For dispersion trials, only one of the six irrelevant target locations were used. Moreover, for dispersion trials, the presented agents differed in appearance, with different hair colors and clothing. Furthermore, agents in dispersion trials always had neutral facial expressions and did not follow the participants with gaze and body-posture. The dispersion trials were included in the experiment to hinder learning effects and to cover the purpose of the study. In another set of 36 trials, there was no agent present. Of those 24 contained the "targets of interest" and 12 trials had one of the dispersion targets. In case no agent was presented, participants were instructed to look directly for the target location. A comparatively large number of trials without an agent were included in the experiment to increase salience. For the analysis, the remaining 48 trials were used, which contained one of the four “targets of interest”.

Two of the four “targets of interest” were presented on the left side of the room and two on the right side. Moreover, these targets were always presented on the same side as the agent. So, for example, in trials were the agent appeared on the right side, “targets of interests” also blinked up on the right side. Regarding the agent’s position, the target could either be close or far (see Figure 3.1). Close targets were positioned about 33 cm behind the agent’s position and slightly to the middle. The far targets, on the other hand, were 66 cm away from the agent’s position and even more in the direction of the center.

3.2.5 Manipulation check

After all trials had been executed, participants were asked to rate all used agents regarding valence (“How pleasant is this person?”), angriness (“How angry is this person?”) and realness (“How real is this person?”) with Likert scale items ranging from 1 (“not at all”) to 9 (“very much”). The agents appeared in a randomized order one after the other, once with a neutral and once with an angry facial expression. The prerecorded rating questions were asked via loudspeakers.

3.2.6 Data reduction and statistical analyses

The primary data set was extracted from each trial for the time from the target presentation to the point where the participant reached the target position and pressed the button. However, a second data set was obtained for secondary explorative analysis. Here the data from the beginning of the trial to the target presentation was extracted. Several dependent variables were analyzed, from three different domains - movement, distance and pseudo-gaze direction (for reason of simplicity hereafter just called gaze direction).

In the movement domain, the **movement time** and the **movement speed** were analyzed. Movement time is the time participants needed for moving from the start position (starting with the target presentation) to standing on the target location. Movement speed is the average speed participants developed in that same time window.

The distance domain includes two dependent variables: First, the kept minimum distance (**distance minimum**) to the center of the agents' position. Second, the average distance (**distance average**) to the same position over all samples of the whole movement time.

Finally, the gaze domain consists of three dependent variables. In this domain, the vector for the direction participants where facing was calculated, using the head tracking data. Then a percentage score was calculated on how many times during a trial this vector hit the body of the agent (excluding the head) or the head of the agent, resulting in the first two dependent variables **gaze hits body** and **gaze hits head**. For the third variable, **gaze angle**, the angular distance from the direct gaze at the agents' head was calculated as well and again averaged over the number of sample points (McCall et al., 2016).

For the secondary analysis, gaze hits body, gaze hits head, and the gaze angle were additionally calculated in the time window between the start of the trial and target presentation.

The parameters described above were averaged for each participant and each condition and then analyzed with mixed repeated measures ANOVAs.

These ANOVAs consisted of the between-subjects factor **group** (HSA vs. control) and the within-subject factors **target position** (close vs. far) and agent's **expression** (neutral vs. angry), which resulted in a 2 X 2 X 2 mixed repeated measures design.

For parameters registered before the target presentation, as analyzed in the secondary analysis, only the factors group and expression were added to the statistical analysis, resulting in a 2 X 2 mixed repeated measures design. T-tests were used to follow-up significant interactions. All statistical analyses used the two-tailed 5 % level of statistical significance, and all t-test p values were corrected using the false discovery rate (FDR) correction (Benjamini and Hochberg, 1995).

3.3 Results

Movement domain

Analysis of the movement time returned a significant expression x target interaction effect ($F(1, 48) = 5.87$, $p < .05$, $\eta_p^2 = .11$) indicating that for trials with close targets participants completed the task faster when agents had an angry facial expression, compared to when they had a neutral expression ($M_{diff} = 97.36$ ms, $p < .05$). In addition, the main effect for group was marginally significant ($F(1, 48) = 3.68$, $p = .061$, $\eta_p^2 = .07$) indicating that HSA individuals were completing the task faster than controls ($M_{diff} = 329.23$ ms).

Similar results were returned by the ANOVA on movement speed, again results contained a significant interaction effect of expression x target ($F(1, 48) = 4.71$, $p < .05$, $\eta_p^2 = .09$) indicating that for trials with close targets participants developed a higher average speed when agents had an angry facial expression ($M_{diff} = 0.67$ cm/s, $p = .05$). In other words, participants avoided being in close interaction with the angry agent, by speeding up. Moreover, as with movement time, groups differed significantly ($F(1, 48) = 5.39$, $p < .05$, $\eta_p^2 = .10$), with HSA developing a higher average speed ($M_{diff} = 3.53$ cm/s).

Distance domain

Analysis of the average distance to the agent, showed a significant interaction effect of expression x target ($F(1, 48) = 8.53$, $p < .01$, $\eta_p^2 = .15$). Follow up analysis showed that this was due to participants keeping more distance towards agents with angry facial expressions at close targets ($M_{diff} = 0.61$ cm, $p < .01$). This expression effect was not statistically significant for far targets ($M_{diff} = 0.38$ cm, $p = .097$). The ANOVA further returned a group x target interaction of marginal significance ($F(1, 48) = 3.76$, $p = .058$, $\eta_p^2 = .07$) suggesting that HSA participants kept more distance to the virtual agents then controls in the close target condition ($M_{diff} = 2.99$ cm, $p < .05$).

The distance minimum analysis revealed a main effect of target ($F(1, 48) = 595.88$, $p < .001$, $\eta_p^2 = .93$); due to the target manipulation close targets resulted in a smaller minimum distance ($M_{diff} = 10.44$ cm).

Gaze domain

The ANOVA on the gaze hits body variable returned a significant three-way interaction of group x expression x target ($F(1,48) = 8.08$, $p < .01$, $\eta_p^2 = .14$). Post hoc analysis showed that, HSA participants showed no significant differences, between the different conditions. Control participants, however, directed their gaze more often at the body of the angry agent, than at the neutral agent, but only when the target was close ($M_{diff} = 0.82$ %, $p < .05$; see Figure 3.2).

The analysis of gaze hits head returned a main effect for target ($F(1,48) = 23.42$, $p < .001$, $\eta_p^2 = .33$), as participants directed their gaze at the agents' head more often when targets were close ($M_{diff} = 2.33$ %). In addition, this ANOVA showed a marginal significant main effect for expression ($F(1,48) = 3.42$, $p = .070$, $\eta_p^2 = .07$) suggesting that participants directed their gaze more towards the agents' head when they had an angry expression ($M_{diff} = 0.40$ %).

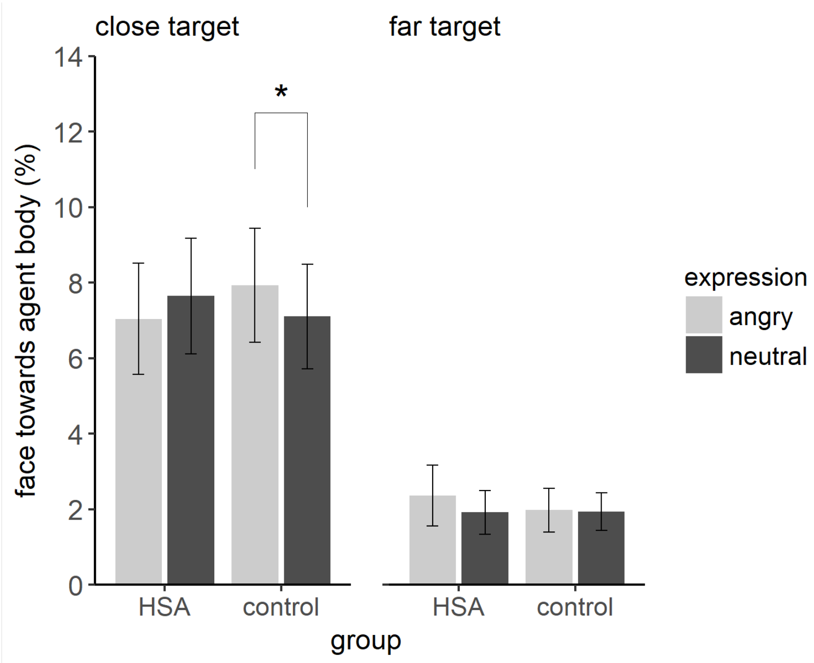

FIGURE 3.2: **Percentage of face directed at agent body per trial.** Mean and standard deviations for group (HSA and control), regarding different facial expressions (angry and neutral) for trials with close and far targets separately. (# $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$)

In addition to the results of the gaze target hits variables, the ANOVA on gaze angle returned a significant main effect for target ($F(1,48) = 305.36$, $p < .001$, $\eta_p^2 = .86$) with a smaller angular distance for close targets ($M_{diff} = 8.25°$), indicating that the participants' gaze was drawn more to the agents' head when participants were closer to the agent.

Gaze before target presentation

The analysis of gaze hits body before target presentation revealed an interaction of group x expression ($F(1, 48) = 4.61$, $p = .037$, $\eta_p^2 = .09$). As can be seen in Figure 3.3, control participants gazed more towards the body of the agent when he had an angry facial expression ($M_{diff} = 1.35$ %, $p < .05$), while HSA participants did not.

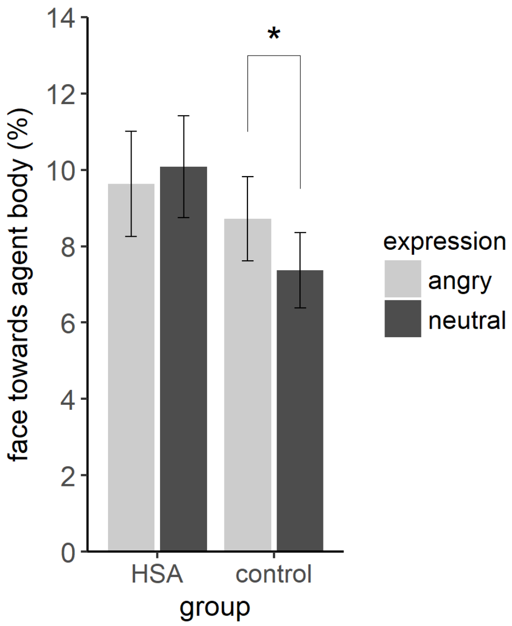

FIGURE 3.3: **Percentage of face directed at agent body per trial.** Mean and standard deviation, for group (HSA and control), regarding different facial expressions (angry and neutral). (# $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$)

The ANOVA returned two main effects for gaze hits head. First, it returned a significant main effect for group ($F(1, 48) = 4.49$, $p = .039$, $\eta_p^2 = .09$) and second for expression ($F(1, 48) = 6.98$, $p = .011$, $\eta_p^2 = .13$). With the first, HSA showed clear avoidance behavior by directing their gaze about 7.47 % less often at the head of the agent compared to controls. Interestingly, the second main effect showed that all participants focused their gaze more at the agent's head when the facial expression of the agent was angry compared to neutral ($M_{diff} = 1.29$ %).

The final analysis of data before the target presentation, the analysis on gaze angle, did not return any significant effects.

Results manipulation check

As a manipulation check for how participants perceived the agents, they had to rate them on three different levels: pleasantness, angriness, and realness. The rating means and standard deviations from HSA and controls are presented in Table 3.3. Independent of the group, agents with an angry compared to a neutral expression were perceived as less pleasant ($F(1, 48) = 116.76$, $p < .001$, $\eta_p^2 = .71$). Groups did not differ in the valuated angriness of the neutral agents but of the angry agents ($F(1, 48) = 5.00$, $p = .030$, $\eta_p^2 = .09$) with HSA perceiving the angry agents as more angry ($M_{diff} = 0.8$, $p < .05$).

TABLE 3.3: **Agent rating**

	HSA				control			
	neutral		angry		neutral		angry	
Question	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
How pleasant?	6.5	1.3	4.0	1.2	6.2	1.2	4.2	1.2
How angry?	1.6	0.6	6.2	1.6	1.8	0.6	5.4	1.5
How real?	6.1	1.4	5.9	1.5	6.3	1.7	6.2	1.6

Rating scores for agents with neutral and angry facial expressions. As rated by high socially anxious (HSA) and control participants.

3.4 Discussion

The described study investigated whether HSA differed in whole-body behavior when they were bypassing another (virtual) person displaying angry or neutral facial expressions.

As expected and described in the first hypothesis, all participants exhibited increased avoidance behavior when moving past the angry virtual bystanders. More specifically, they moved faster along the angry agent, indicated by the shorter trial times and higher average speed, and kept a higher interpersonal distance, when they had to get close to the agent.

That the participants keep greater interpersonal distance only in the close target condition, can be attributed to the targets being in two distinct zones related to different forms of personal space, as described by Hall (1966). Here the far target condition corresponds to the personal distance zone (46 to 76 cm) which is described as the distance for interactions between friends or family members. The close target condition falls already into the intimate distance zone, which is meant for close body contact, such as embracing and touching. As both examined zones are reserved for friends and family members, one would expect, that an angry stranger would elicit more considerable interpersonal distance in both zones. However, it seems that due to the task requesting participants to overcome those urges several times an extreme closeness like the intimate zone must be reached to elicit clear differences. Alternatively, it may be speculated that behaviors towards virtual persons differ in this respect from real people. Further studies are needed, which systematically look at interpersonal distance zones and task compliance, to make a clear statement.

In contrast to the above-described avoidance behaviors, but in line with findings from the study by McCall and colleagues (2016), participants gaze was directed generally more to angry compared to neutral faces. These findings replicate results found by non-VR studies, indicating that emotional expressions attract and hold attention (Batty and Taylor, 2003; Green and Phillips, 2004; Lundqvist, Juth, and Öhman, 2014; Palermo and Rhodes, 2007).

The presented results also confirm the second hypothesis, that HSA displayed generally enhanced avoidance behavior towards agents. As participants of the HSA group spend less time in the social situation, indicated by their higher movement speed. Similar to results by Wieser *et al.* (2010), HSA kept more interpersonal distance, when they had to get close to the agent (close targets).

There were no significant group differences regarding the attention participants directed towards agents, during task executing. In other words, all participants spend the same amount of time gazing at virtual bystanders. This is most likely because the task directed attention towards the target location and away from the agents. However, attention allocation was less restricted by the task in the time before the target was presented. To investigate this an explorative analysis of the time before the target presentation was added, which was initially no objective of the study. This analysis revealed that HSA gazed less at the head of the agent, thereby confirming the expected avoidance of gaze contact related to HSA.

The study failed to find any evidence for the last hypothesis. The socially anxious participants did not show any specifically exaggerated avoidance behavior toward agents with negative facial expressions. Only gazing behavior towards the body of the angry agent showed group differences. Here control participants allocated more attention towards the angry agent than towards the neutral agent while HSA displayed no statistically significant differences. As before, the already mentioned restrictions of the task are a likely reason for the levels of variation between groups. Moreover, all participants executed the task with ease and were highly accurate in positioning themselves on the target position. In a future study, the task difficulty should be increased, to increase the level of variation and thereby the possible influence of social factors. One way to raise the task difficulty would be to lengthen the time between target presentation and the start of the movement, by for example letting participants name the hair color in between. Another cause for the lack of exaggerated avoidance behavior of HSA towards angry agents could be that, despite agents being rated as angry, facial expressions were not aversive enough. To get an objective measure of stimulus aversiveness and as a general measure of arousal, it would be advisable to add physiological recordings to the study design. Here skin conductance would be the best choice, as skin conductance has been shown to be sensitive for approach-avoidance in VR experiments (Dotsch and Wigboldus, 2008; Wilcox et al., 2006).

To the author's knowledge, this is the first study which used immersive VR with a CAVE setup to study social whole-body approach-avoidance behavior in HSA. As mentioned before, the study successfully replicated prior findings, and the newly developed VR task proved to be a valid tool for research on approach-avoidance behavior. In line with other studies (Dotsch and Wigboldus, 2008; McCall et al., 2016; Wieser et al., 2010) it showed that VR allows research with high ecologically and internal validity. Furthermore, to the author's knowledge, this is the first study on social approach-avoidance behavior in VR in which the agent was irrelevant for the task and where action or attention towards the agent was entirely voluntary.

Finally, some limitations and methodological difficulties of the described study need be further addressed in future research. The agents used were all male. Future research should investigate, whether the gender of the agent affects the social approach-avoidance behavior. Another possible limitation of the study is the usage of head orientation as a factor for were participants directed attention. Here the measurement of eye movement would be the more valuable method. However, head orientation alone has an accuracy of 88.7 % to detect the focus of attention (Stiefelhagen and Zhu, 2002).

4. Study 2 - The way we shift attention

4.1 Introduction

In everyday life, eye gaze is an important stimulus, as eye gaze gives a valuable indication of other people's focus of attention and gives information about their mental state and behavioral intention. Furthermore, peoples' emotional expression conveys how they feel about what they see. Also, if another person changes their gaze direction, thereby indicating a shift in attention, once own attention is automatically shifted as well. In other words, perceived gaze direction introduces shifts in visuospatial attention in the corresponding direction (Driver et al., 1999; Friesen and Kingstone, 1998; Hietanen, 1999). It is conceivable, that when an emotional expression accompanies other persons' change in gaze direction, that this should change the manner of the introduced automatically shift as well. As the change in expression can give information about stimuli that are outside of our current focus of attention, which might potentially be threatening, rewarding or otherwise relevant (Frischen, Bayliss, and Tipper, 2007; Itier and Batty, 2009; Nummenmaa and Calder, 2009). For example, when someone looks to the left, with a fearful facial expression, one would expect that the observer's attention shifts that way as fast as possible. As in that direction might lay danger.

To study the question if the emotional expressions of others change the way we reallocate attention, one method used is the gaze cueing paradigm. The gaze cueing paradigm is adapted from the Posner cueing paradigm (Posner, 1980). In a typical gaze cueing paradigm, a facial cue, looking left or right is presented before a peripheral target is presented. Participants task is to detect the target and indicate its position. As in the original Posner paradigm, reaction times are faster, when the gaze direction and the target location are congruent, compared to incongruent trials, when the gaze is directed in the direction opposite to the target location.

Results of gaze cueing experiments with emotional expressions so far have been somewhat mixed. While some studies showed that emotional facial expression seems to have little effect (Hietanen and Leppänen, 2003; Pecchinenda et al., 2008). Other studies found that emotional expressions, especially fearful expressions, enhance the gaze cueing effect (Fox et al., 2007; Holmes, Richards, and Green, 2006; Mathews et al., 2003; Putman, Hermans, and van Honk, 2006; Tipples, 2006; McCrackin and Itier, 2018). Importantly, the gaze cueing effect was only found with participants showing higher than average levels of anxiety. So, it might be, that for the effect to be significant, a certain level of anxiety is necessary. As those studies take place in the relatively safe environment of a laboratory, facial expressions might fail in introducing any sense of danger. One might say it, that the effect could become relevant depending on the context (Pecchinenda et al., 2008).

The following study tried to investigate this and to answer the question: Does facial expression modify the shifts in visuospatial attention when presented in a threatening context? Furthermore, it is important to investigate, if also high levels of social anxiety lead to the enhancing effect of negative emotional expressions. As social anxious individuals tend to be sensitive to social stimuli, this is somewhat likely.

The following study applied the gaze cueing paradigm in two different contexts, one Conditioned safety context (CTX-) and one Conditioned anxiety context (CTX+). The contexts were induced using context conditioning. Furthermore, we compared the performance of High Socially Anxious (HSA) participants with Low Socially Anxious (LSA) participants. In addition to the behavioral data, we also measured neural activity using Electroencephalography (EEG), as the study of Galfano and colleagues (2011) found that the N2pc component is modulated by gaze cueing effects and therefore an ideal marker for the reorienting of attention in the gaze cueing paradigm.

Moreover, two recent studies found that the N2pc component is sensitive to social anxiety levels, with higher N2pc amplitudes for emotional faces (Reutter et al., 2017; Wieser, Hambach, and Weymar, 2018) and earlier peak latencies for threatening faces (Reutter et al., 2017).

The N2pc consists of a more pronounced negative activity in the posterior sites contralateral to the side of the target stimulus and typically arises at post target latencies of 180 – 300 ms (Luck, 2006; Mazza et al., 2007). The N2pc component is calculated by subtracting the EEG signal at the electrode sites ipsilateral to the target from the corresponding activity at the electrode sites contralateral to the target (Galfano et al., 2011).

We predict that the facial expression of the cue stimulus enhances the gaze cueing effect, but only in the CTX+. Furthermore, we expect that HSA show this enhancement also in the CTX-. The enhancement will be reflected in the behavioral data, as well as in the N2pc modulations.

The presented data was collected in two separate studies. However, as the design did not change between studies and to increase statistical power, the two data sets were analyzed together. All conducted statistics included a study as a factor, with levels Study 2-A (S2-A) and Study 2-B (S2-B), to check for unwanted influences.

4.2 Method

4.2.1 Participants

In total, 88 individuals were invited to participate in the two studies, 35 participants for the first study (S2-A) and 53 for the second study (S2-B). Overall, 13 participants had to be excluded from the analysis. Eight exclusions were due to EEG artifacts and the remaining five due to problems with data logging. That left 75 participants (S2-A: 30, S2-B: 45) for the statistical analysis.

All participants signed the informed consent, reported normal or corrected-to-normal vision and received 12 € for their participation. The study was approved by the ethics committee of the University of Würzburg and performed in compliance with the Declaration of Helsinki guidelines.

During the study participants answered several questionnaires. Before the experiment started, they answered a sociodemographic questionnaire and the state part of the State-Trait Anxiety Inventory (STAI) (Laux et al., 1981), before and after to assess the current state of the participant. All other questionnaires were answered after the experiment: The trait part of the State-Trait Anxiety Inventory (Laux et al., 1981), to assess the trait anxiety of participants, and as mentioned before the Social

Phobia and Anxiety Inventory (SPAI) (Fydrich, 2002; Turner et al., 1989) to assess levels of social anxiety.

Participants of each study were sorted in either of two groups (HSA or LSA) based on a median split of the SPAI scores.

TABLE 4.1: **Group Characteristics Study S2-A**

	HSA		LSA	
Variable	*M*	*SD*	*M*	*SD*
Age	26.3	9.8	30.7	7.6
SPAI	3.1	0.7	1.5	0.5
STAI-T	45.7	9.0	36.1	5.2
STAI-S (pre)	39.2	5.9	35.1	8.3
STAI-S (post)	39.3	6.9	35.5	10.3
	female	*male*	*female*	*male*
Gender	7	8	8	7

TABLE 4.2: **Group Characteristics Study S2-B**

	HSA		LSA	
Variable	*M*	*SD*	*M*	*SD*
Age	25.1	7.1	25.8	6.0
SPAI	3.7	0.7	1.7	0.5
STAI-T	47.8	9.3	39.0	7.6
STAI-S (pre)	41.1	8.4	36.2	8.1
STAI-S (post)	43.7	11.3	42.2	13.2
	female	*male*	*female*	*male*
Gender	18	4	17	6

HSA, High Socially Anxious; LSA, Low Socially Anxious; SPAI, Social Phobia and Anxiety Inventory; STAI-T, trait part of the State-Trait Anxiety Inventory; STAI-S, state part of the STAI.

Age, SPAI and STAIT scores were analyzed with a 2 x 2 between-subject design, comparing study (S2-A and S2-B) and group (HSA and LSA). Means and standard deviations can be seen in Table 4.1 and Table 4.2, separate for each study.

For age there was a main effect of study ($F(1, 71) = 3.04$, $p = .085$, $\eta_p^2 = .04$), with an higher mean age in study S2-A ($M_{diff} = 3.1$ years).

The analysis of SPAI score returned a significant main effect for study ($F(1, 71) = 6.23$, $p = .015$, $\eta_p^2 = .08$) and for group ($F(1, 71) = 159.46$, $p < .001$, $\eta_p^2 = .69$). Participants of study S2-A were one average less socially anxious than those of study S2-B (M_{diff} =

0.4). Independently of study, HSA were on average more socially anxious then LSA (M_{diff} = 1.8).

Regarding the STAI trait scores, a significant main effect of group was found ($F(1, 71) = 23.65$, $p < .001$, $\eta_p^2 = .25$), with HSA scoring on average 9.2 scores higher, then LSA.

Adding the within-subject factor time (before and after the experiment) to the Analyses of Variance (ANOVA), the analysis on STAI state returned no significant results.

Gender distributions were analyzed with the χ^2 test, comparing group and study separately. While social anxiety groups did not differ in gender distribution, the distributions between studies were significantly different ($\chi^2(1,N=75) = 5.06$, $p < .05$). In S2-A the number of female and male participants were equal, but in S2-B there were more significantly more female participants.

4.2.2 Behavioral procedure

The study consisted of two experimental phases: a context conditioning phase and a test phase. In the context conditioning phase, participants learned to associate one context (CTX+) with the possible occurrence of an unpleasant burst of white noise (Unconditioned stimulus (US)), presented at 95 dB for 500 ms. In the second context (CTX-) the unpleasant stimulus was never presented. The two contexts could be differentiated by the ambient color (green or yellow) of the laboratory cabin, in which participants were seated. In the context phase, there were 16 trials in total, 8 for each context. Each trial lasted for 60 seconds. During the trial, participants were instructed to fixate on a white fixation cross, which was presented on a computer screen with a grey background, with an Intertrial interval (ITI) of 2 seconds. The order of trials was random. During each trial of the CTX+, the US was presented at least once and maximal three times, laterally to the left or the right ear. Presented US were randomly presented between 2 and 58 seconds after trial onset. Context-specific ambient color was counterbalanced across all participants.

Participants of the second study (S2-B), had to indicate, after each phase, in which context they heard the loud noise. As an explicit way to measure awareness. Furthermore, they had to rate the contextual stimuli on a 9-point rating scale regarding valence, arousal, and anxiety, before and after the conditioning phase, and after the test phase. The order of which context was rated first was counterbalanced across all participants.

In total, participants executed 360 trials, consisting of 15 repetitions of 24 different trials. Trials differed regarding four factors in a fully-crossed 3 x 2 x 2 x 2 design. The factors were a facial expression (fearful, angry, neutral), gaze direction (left, right), target position (left, right), and context (CTX+, CTX-). The experiment was divided into three blocks with five trial repetitions per block, leading to 120 trials per block. Each of the three blocks was further divided into eight context blocks (4 CTX+, 4 CTX-), with 15 trials in each. The order of context blocks was randomized. Furthermore, the trial order within each of the three blocks was randomized, separately for each context.

In the test phase, participants had to execute a simple target detection task. Two symbols, a square, and a diamond, were presented on the left and right side of the screen. One of the two was the target stimulus, which one was counterbalanced over all participants. Participants had to detect on which side the target symbol was and react as quickly and as accurately as possible with a corresponding button press ('arrow up' for left and 'arrow down' for right) on a standard computer keyboard. The two stacked keys were chosen, instead of keys on a horizontal line, to reduce the Simon effect. The Simon effect names the effect, that reaction times are faster and more accurate if the key and the target location are spatially congruent. If participants' reaction times were slower than 1995 ms, they got feedback to react faster next time.

Before the target presentation, a cue stimulus was presented. The presented cue stimuli consisted of five female and five male faces. For each of the ten identities, a fearful, angry, and neutral facial expression, gazing to the left and the right was available. Pictures were taken from the Radboud Faces Database (Langner et al., 2010), converted to grayscale, and an elliptical mask was applied to hide hair, ears, and shoulders so that only the face was visible.

Cues were presented for 1995 ms after a random fixation period of 789 – 805 ms. At 700 ms after the onset of the faces, the target stimulus appeared. The ITIs were 500 ms long, showing a grey blank screen. Faces were displayed centrally such that the eyes appeared at the position of the fixation cross. The fixation cross was presented throughout the whole trial to encourage central fixations. To maximize gaze cueing effects, a longer Stimulus Onset Asynchrony (SOA) of 700 ms, between cue and target stimulus, was chosen (Driver et al., 1999; Graham et al., 2010; Mathews et al., 2003). See Figure 4.1 for an example trial sequence. It is important to note, that target location and gaze direction were fully counterbalanced, creating an equal amount of cue-target congruent and incongruent trials. The gaze was therefore not predictive of the target location.

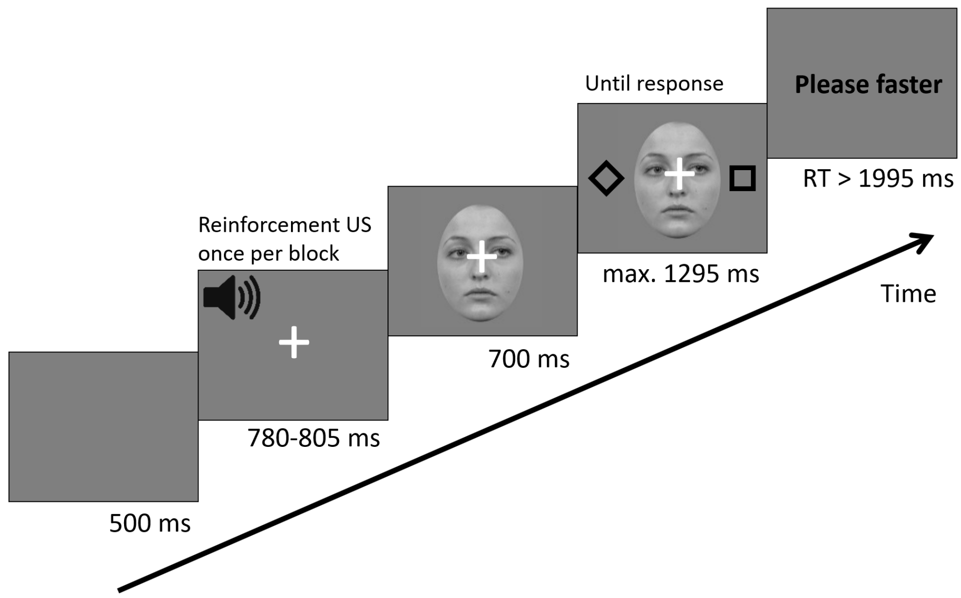

FIGURE 4.1: **Example trial sequence of events in the test phase.** Participants had to execute a simple target detection task. All trials started with a 500 ms blank page, followed by the presentation of a fixation cross, shown randomly between 780 and 805 ms. During the presentation of the fixation cross, a reinforcement US could occur once in every block. Next, the facial-cue was presented for 700 ms, followed by the target stimuli. The targets were presented until the participant responded, up to a maximum of 1295 ms. If there was no response in this time window, a reminder was presented to react faster. Stimuli are not drawn to scale.

4.2.3 EEG procedure

For the continuous EEG recording, a HydroCel Geodesic Sensor Net (Electrical Geodesics, Inc., Eugene, OR) with 128 channels was used, with the vertex sensor (Cz) as a reference. The impedance for each sensor was controlled to be below 50 kΩ as is recommended for the Electrical Geodesics high-impedance amplifiers. For EGG data collection the software NetStation ran on a Macintosh Computer with 250 Hz sampling rate and an online bandpass filter of 0.1 – 100 Hz.

Data preprocessing and the reduction was made using the emegs package (Peyk, Cesarei, and Junghöfer, 2011) with MATLAB (MATLAB and Statistics Toolbox Release 2012b, The MathWorks, Inc., Natick, Massachusetts, USA). Before preprocessing, a 40 Hz low-pass filter was applied offline on the continuous EEG data.

The resulting data set was segmented into 1200 ms cue-locked epochs from 100 ms before to 1000 ms after cue onset, and 1200 ms target-locked epochs from 200 ms before to 1000 ms after target onset.

The mean voltage of the 100 ms before cue and target onset were taken for baseline-correction of the resulting cue-locked and target-locked EEG epochs respectively. The preprocessed data set was subjected to artifact detection in two steps, as described by (Junghöfer et al., 2000).

In the first step, sensors were identified and rejected, which were contaminated or contained artifact activity. Sensors were rejected when they exceeded thresholds of specific statistical parameters, namely maximum absolute amplitude, standard deviation, and gradient. In the second step, data of the rejected sensors was replaced by interpolation of data from all remaining sensors. Next, the epochs were averaged separately for each condition, thereby creating Event-Related Potentialss (ERPs). For the cue-locked epochs, the N170 was analyzed at occipitotemporal sites, extracting and averaging the signal from electrodes 58, 65, 90 and 96 (see Figure 4.2) as the maximal negative amplitude, in the time window of 128 to 192 ms (Galfano et al., 2011). The N170 is a negative deflection, peaking around 170 ms after stimulus onset (Bentin et al., 1996). As the N170 is sensitive to facial expressions (Righart and Gelder, 2008) and has been found to be sensitive to apparent motion of the eyes

(Puce, Smith, and Allison, 2000), the analysis was a control for whether facial expression and gaze direction showed interaction effects prior target presentation.

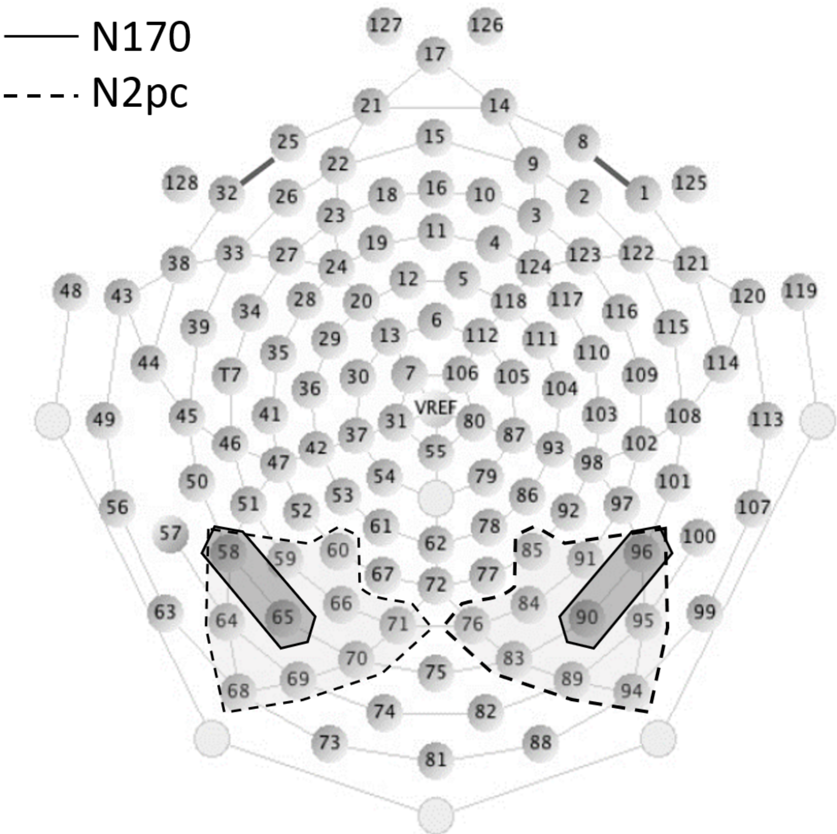

FIGURE 4.2: **Sensor layout of the HydroCel Geodesic Sensor Net.** Locations of the sensors included in the analysis, for components N170 and N2pc, are marked.

As described before, of the target-locked components the focus ley on the N2pc. Quantification of the EEG signal took place on the basis of amplitudes measured in the time window of 200 - 300 ms at occipitotemporal sensors 58, 59, 64, 65, 68, 69, 89, 90, 91, 94, 95 and 96 (see Figure 4.2), including sensors corresponding to P7/P8 and T5/T6, where N2pc usually has its maximum amplitude (Holmes et al., 2009; Jolicœur et al., 2006; Kappenman and Luck, 2012).

4.2.4 Statistical analyses

Behavioral data was averaged for each participant and each task and then analyzed with mixed repeated measures ANOVAs. The ANOVAs consisted of the between-subjects factors group (HSA / LSA) and study (S2-A / S2-B), and the within-subject factors context (CTX+ / CTX-), facial expression (neutral / angry / fearful) and congruency (congruent / incongruent), so a 2 x 2 x 2 x 3 x 2 mixed-factor design.

For the analysis of the EEG data of the target presentation, the above model was extended with EEG cluster (left / right), resulting in a 2 x 2 x 2 x 3 x 2 x 2 mixed-factor design. The ANOVA model for the EEG data corresponding to the cues was the same, but the within-subject factor congruency was exchanged with gaze direction (left / right).

Rating data was analyzed with statistics being performed for each rating dimension separately with a three-way repeated measures ANOVAs, with between-subject factor group (HSA / LSA) and within-subject factors time (before conditioning / after conditioning /after test phase) and context (CTX+ / CTX-).

T-tests were used to follow-up significant interactions. All statistical analyses used the two-tailed 5 % level of statistical significance, and all t-test p values were corrected using FDR correction (Benjamini and Hochberg, 1995). When the assumption of sphericity was violated, results were corrected using Greenhouse-Geiser.

4.2.5 Manipulation check

An additional rating was added, to check if the context conditioning was successful in creating differing contexts. Here participants of S2-B were asked after the whole experiment, what they thought in which context the US was most likely to appear.

4.3 Results

4.3.1 EEG results

Cue-locked ERPs

The ANOVA for the N170 minimum values returned a significant main effect of expression ($F(2, 134) = 16.54$, $p < .001$, $\eta_p^2 = .20$). N170 average minimum deflections of both emotional expressions (angry and fearful) were bigger than for the neutral faces (neutral-angry: $M_{diff} = 0.2$, $p < 0.01$; neutral-fearful: $M_{diff} = 0.5$, $p < 0.001$). In addition, the average minimum deflection for fearful faces were significantly more negative than for the angry faces ($M_{diff} = 0.3$, $p < 0.01$). See Figure 4.3 for the grand-averaged ERPs of the cue presentation.

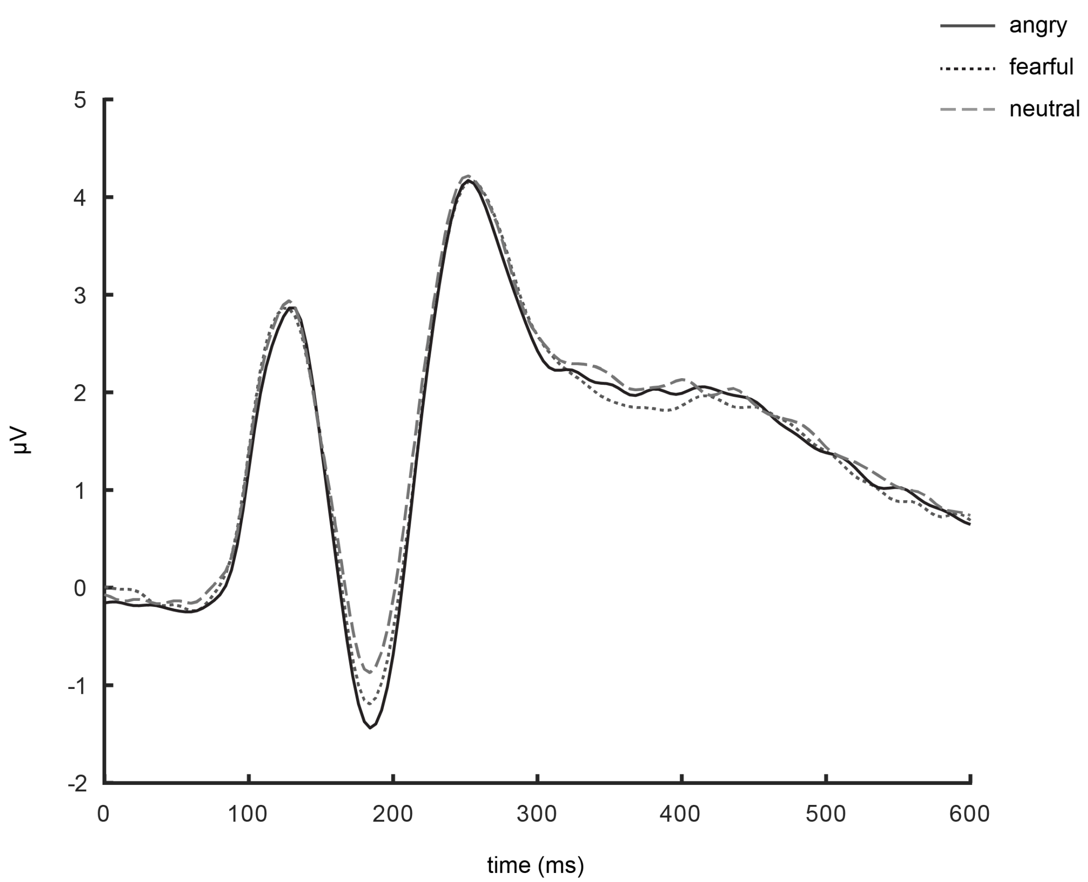

FIGURE 4.3: **Grand-averaged ERPs - Cue.** ERPs time-locked to cue stimuli at occipitotemporal sites for angry, fearful, and neutral facial expressions.

Target-locked ERPs

Analysis of the N2pc component did not return any conclusive results. See Figure 4.4 for the grand-averaged ERPs of the cue presentation.

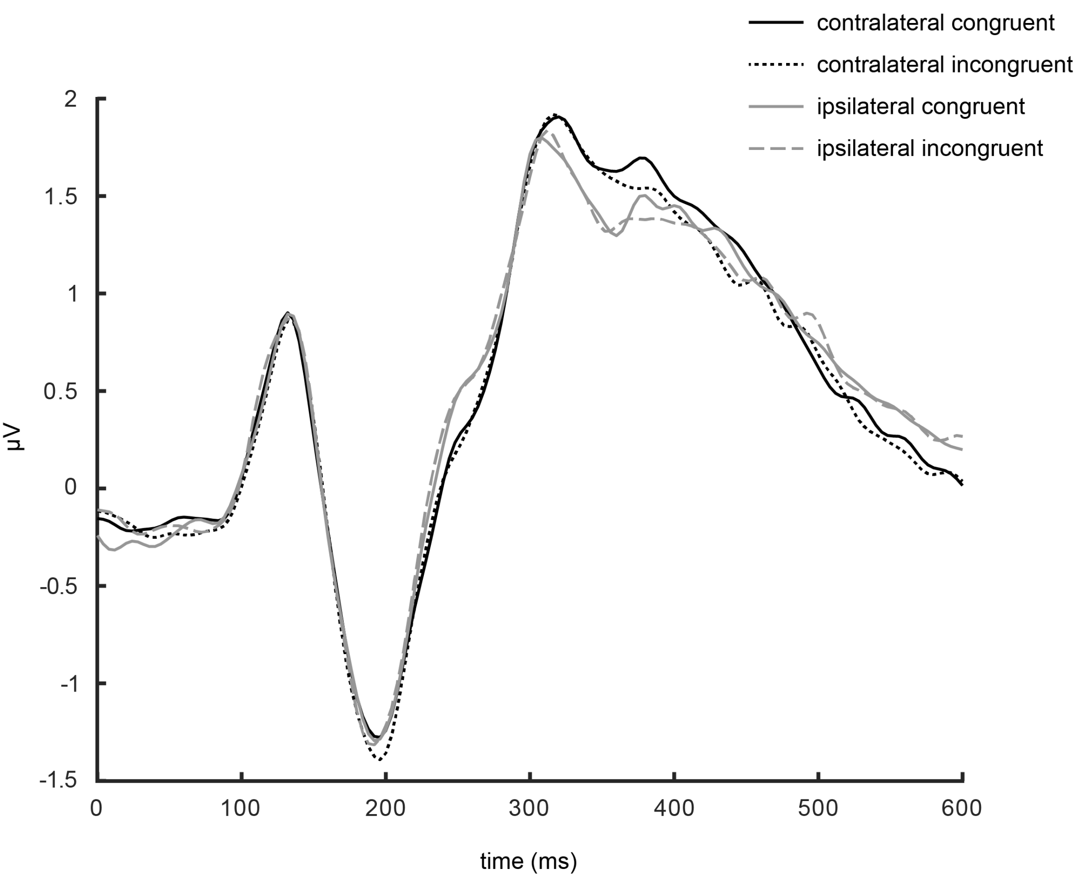

FIGURE 4.4: **Grand-averaged ERPs - Target.** ERPs time-locked to target stimuli at occipitotemporal sites for spatially congruent and incongruent target location. Ipsilateral and contralateral refer to the side of target presentation.

4.3.2 Behavioral results

Reaction times

The statistical analysis of reaction times revealed a significant interaction effect of context x facial expression x congruency ($F(2, 142) = 3.74$, $p < .05$, $\eta_p^2 = .05$). Post hoc t-tests showed that only the fearful cue faces in the threatening context (CTX+) lead to a significant congruency effect ($M_{diff} = 8.94$ ms, $p < .05$), with faster reaction times when the gaze was direct at the target position (congruent trials). See Table 4.3 for a more detailed view on the means and standard deviations split up for each condition.

TABLE 4.3: **Reaction times**

	HSA							
	CTX+				CTX-			
	congruent		incongruent		congruent		incongruent	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
angry	555.1	119.4	548.6	120.9	554.0	125.0	554.2	117.1
fearful	550.9	113.2	550.1	112.0	556.4	122.8	551.0	104.3
neutral	549.5	107.1	559.8	134.9	553.1	112.7	555.9	116.9
	LSA							
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
angry	559.8	127.9	556.0	138.6	558.9	139.7	575.3	151.5
fearful	548.2	116.7	566.6	140.7	567.8	139.8	566.1	145.9
neutral	556.6	121.1	564.1	142.4	563.7	134.4	567.3	143.0

Means and standard deviations of high and low socially anxious participants (HSA and LSA) reaction times to targets in milliseconds for correct trials, split up for context (CTX+ and CTX-), cue target congruency (congruent and incongruent), and facial expression (angry, fearful and neutral).

Accuracy

Analysis of accuracy did not yield any relevant results, which is most likely due to a ceiling effect, of the generally high accuracy (M = 95.8, SD = 8.3). See Table 4.4 for a more detailed view on the means and standard deviations split up for each condition.

TABLE 4.4: **Accuracy**

	HSA							
	CTX+				CTX-			
	congruent		incongruent		congruent		incongruent	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
angry	96.2	6.3	95.7	10.4	95.7	7.9	95.3	10.9
fearful	96.3	6.3	96.2	9.2	96.1	10.0	96.2	6.9
neutral	95.8	7.3	96.4	9.0	96.5	6.8	96.0	6.6
	LSA							
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
angry	96.7	6.7	95.9	8.1	95.5	7.9	96.1	7.0
fearful	94.7	8.7	95.5	9.2	95.3	10.1	95.5	8.0
neutral	94.7	9.5	94.5	9.4	96.2	6.6	95.5	8.3

Means and standard deviations of high and low socially anxious participants (HSA and LSA) for trial accuracy in percentage, split up for context (CTX+ and CTX-), cue target congruency (congruent and incongruent), and facial expression (angry, fearful and neutral).

4.3.3 Manipulation check

Self ratings

Valence

The ANOVA on valence ratings returned a significant interaction effect of time x conditioning context ($F(2, 86) = 30.27$, $p < .001$, $\eta_p^2 = .41$). As expected, the perceived valence of the CTX+ dropped significantly from the ratings before the conditioning procedure (before conditioning - after conditioning: $M_{diff} = 2.73$, $p < .001$; before conditioning - after test phase: $M_{diff} = 2.44$, $p < .001$). Ratings of the CTX- increased significantly from before to after conditioning (before conditioning - after conditioning: $M_{diff} = 0.98$, $p < .05$) and then dropped again (after conditioning - after test phase: $M_{diff} = 0.87$, $p < .05$).

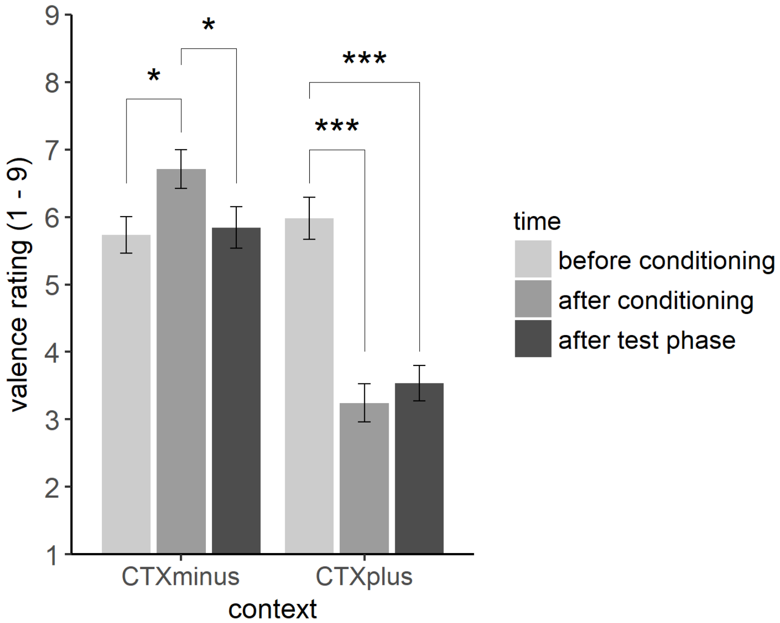

FIGURE 4.5: **Valence ratings.** Mean and standard deviations for CTX- and CTX+ before and after conditioning, and after task. (# $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$).

Arousal

Analysis of the arousal ratings showed a significant interaction effect of time x context ($F(1.54, 66.39) = 23.33$, $p < .001$, $\eta_p^2 = .35$). While arousal ratings of the CTX- stayed the same over the three time points, CTX+ rating increased significantly after the context conditioning procedure (before conditioning – after conditioning: M_{diff} = 2.38, $p < .001$; before conditioning - after test phase: M_{diff} = 2.04, $p < .001$).

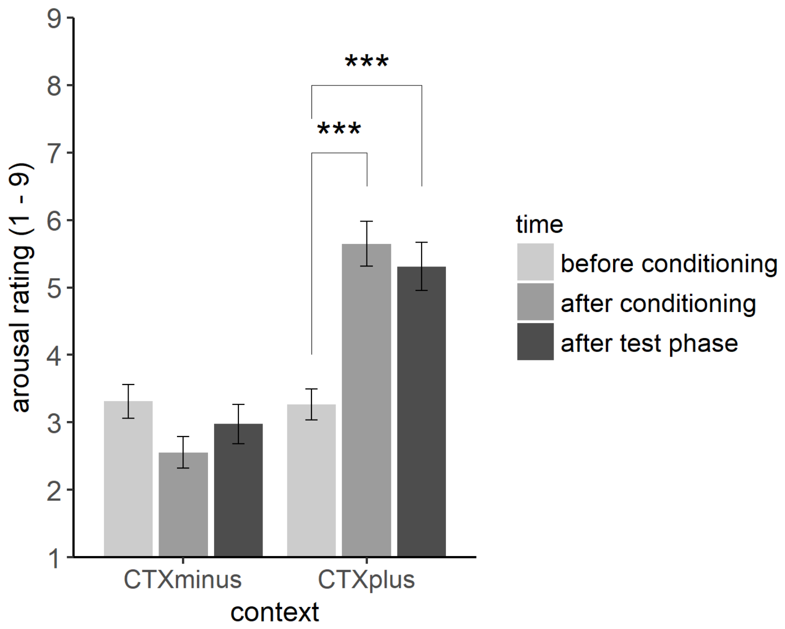

FIGURE 4.6: **Arousal ratings.** Mean and standard deviations for CTX- and CTX+ before and after conditioning, and after task. (# $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$).

Anxiety

The ANOVA on the anxiety ratings returned a significant interaction effect of time x context ($F(1.57, 67.59) = 28.96$, $p < .001$, $\eta_p^2 = .4$). There were no significant differences between timepoints in the

CTX-, but in the CTX+ anxiety ratings increase from before the context conditioning to after

(M_{diff} = 2.44, $p < .001$) and then decreased again albeit to a lesser decree (after conditioning – after test phase: M_{diff} = 0.6, $p < .05$), staying significantly higher than the first rating (before conditioning – after test phase: M_{diff} = 1.84, $p < .001$).

In addition, the ANOVA returned a marginal significant interaction effect of group x context ((1, 43) = 3.19, $p < .1$, $\eta_p^2 = .07$). HSA and LSA showed the same average rating of the CTX-, independent of timepoint, but HSA rated the CTX+ as more anxious then LSA (M_{diff} = 1.03, $p < .05$).

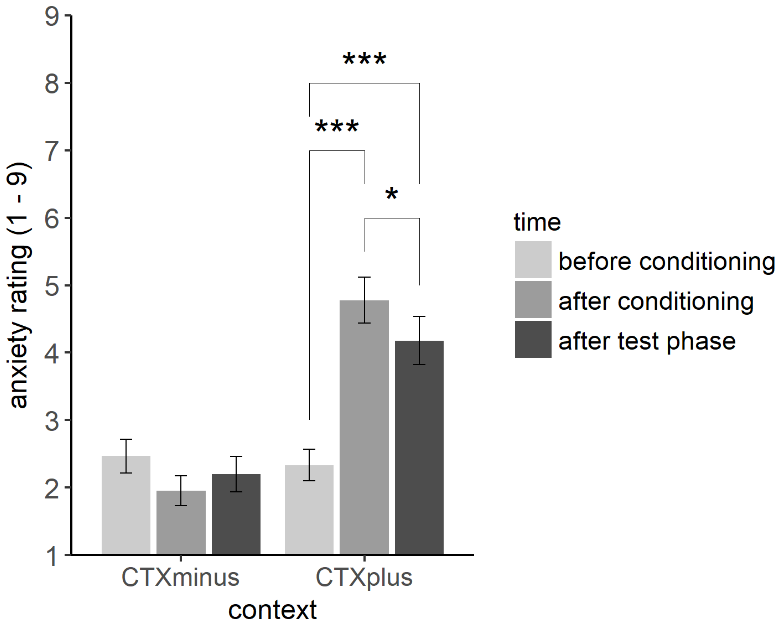

FIGURE 4.7: **Anxiety ratings.** Mean and standard deviations for CTX- and CTX+ before and after conditioning, and after task. (# $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$).

Awareness of CTX+

Awareness ratings showed that 32 out of the 45 valid participants of study S2-B were aware that the unpleasant sound only appeared in the CTX+. Analysis showed that there were no differences on awareness between group (χ^2 = 1.49, df = 1, p-value = 0.22).

TABLE 4.5: **Awareness of threat**

	aware	
	yes	no
HSA	18	4
LSA	14	9

Awareness of the two groups (HSA and LSA) about the threatening context.

4.4 Discussion

We predicted that the automatic allocation of visual attention would be enhanced in a threatening context. In the applied gaze-cueing paradigm, this should have been reflected in an increased congruency effect. Both investigated marker for attention allocation, reaction times and the N2pc component of the EEG, failed to provide evidence for this hypothesis. However, the reaction times analysis revealed another interesting effect. Despite the lack of a general enhancement, the study was successful in showing that a threatening context enhances the congruency effect of fearful faces. Similar enhancement effects have also been observed in other studies, were participants high in trait or state anxiety, showed similar enhancement of the congruency effect for faces with fearful facial expressions (Fox et al., 2007; Mathews et al., 2003; Putman, Hermans, and van Honk, 2006; Tipples, 2006). In other words, this study presents the first, experimental evidence, that the levels of fear, modulate gaze-cueing effects of facial expression. Moreover, the fact that the congruency effect for fearful faces was only present in the CTX+ condition shows, together with the results of the manipulation check, that the study successfully created a difference in contexts, which lasted till the end of the experiment.

Also, as the effect was only present for fearful facial expressions, it can be concluded, that the faces with different expressions were processed differently. The differential processing of emotional faces is also reflected in the analysis of the EEG signal during the cue stimulus presentation, which showed a clear differentiation between neutral, angry and fearful expressions.

In a second hypothesis, it was predicted that HSA show enhancement on the congruency effect, even in the non-threatening context (CTX-). The enhancement was expected to be reflected in the behavioral data, as well as in the N2pc modulations. However, again the study did not find any evidence for this hypothesis.

In general, the lack of any statistical evidence for our hypothesis may be due to the differences we implemented in our experiment design, compared to designs used by other researchers in the field.

Foremost, as this is the first study that combines the gaze-cueing paradigm with context conditioning, it is likely that the presence of an actual threat influences spatial attention location in unforeseen ways. The application of context conditioning to create a threatening context provided the best way to study the influence of threat in a within-study design. However, it might be that spilling over effects, or the threatening situation in general, restricted the detection of experimental differences. One alternative, to avoid these effects for future research, would be to use a between-subject design, with participants being either in a threatening context or a non-threatening context.

Regarding the cue stimuli set, it has to be noted that we used another set of facial pictures (Radboud Faces Database; Langner et al., 2010), compared to other studies. Most research teams (Fox et al., 2007; Hietanen and Leppänen, 2003; Holmes, Richards, and Green, 2006; Mathews et al., 2003; Pecchinenda et al., 2008), investigated emotional effects on gaze-cueing with the Pictures of Facial Affect set from Ekman and Friesen (1976). Only Galfano and colleagues (2011), also used another set, the NimStim Set of Facial Expressions (available at www.macbrain.org/faces, see Tottenham et al., 2009). However, as the Radboud Faces Database is well established (Langner et al., 2010), it is not likely that they are the reason for our lack of results, at least for their emotional value. However, it might be that the gaze of the pictures was not as directional as in other sets. The difference should not be of relevance, but it would be necessary to investigate differences of this kind in a future study.

For the neural data, we based many parts of the experimental design on the study done by Galfano *et al.* (2011), and because we found no statistically significant effects on the N2pc component, it is especially important to note the difference to their study design. Next to the already mentioned added context conditioning and the differences in the used set of facial stimuli, the SOA between cue and target differed. While Galfano and colleagues (2011) used an SOA of 200 ms, our study relied on a longer SOA of 700 ms. Of course, with a relatively long SOA of 700 ms between cue and target, it is possible that by the time the target appeared, any small effects of the emotional expressions, but also the gaze direction in general, might have already vanished.

Finally, also the presentation of cue faces differed, as other studies (Galfano et al., 2011; Mathews et al., 2003) first presented a face with direct gaze, then followed by the actual cue stimulus of the same face with an averted gaze. This more dynamic presentation of the shift in gaze direction could lead to a more pronounced shift in attention allocation thereby leading to more precise results. In general, most studies in the field differ in at least one factor of the trial procedure. As this has not been systematically researched, it remains to be proven if that could be a reason for the overall lack of results. Next to the experimental differences, another possibility for the lack of significant differences might be, that the task was to easy and participants were therefore consistently fast, leading to a ceiling effect for reaction times. The high task accuracy supports this notion.

To conclude, as the experiment was not able to replicate prior findings and failed to provide evidence for the hypotheses, it is necessary to improve the research design in future research projects. Notably, the influence of the threatening context on spatial attention allocation should be investigated more directly. One example would be to change the context condition to a between-subject factor.

For the understanding of social anxiety, it would be interesting to exchange the used threatening context with a social threat. To increase the detection of differences between factors, the task difficulty should be increased, by for example smaller target stimuli. The SOA between cue and stimulus should be tested for maximizing the manifestation from the N2pc component. Moreover, the gaze-cue should be presented more dynamically, by adapting the trial procedure of presenting a direct gaze, before the averted one.

5. Study 3 - The way we attend

5.1 Introduction

As described in the introduction of this thesis, the measurement of eye movements is an ideal method for investigating the allocation of attention. In the following study, an eye-tracking apparatus was employed to assess selective attention towards social and non-social stimuli in an elaborate scenery. As former research has shown, people look at heads and eyes first when looking at a picture, they look longer and more often on social stimuli and analyze gaze direction rapidly and automatically (Birmingham, Bischof, and Kingstone, 2009; Langton, Watt, and Bruce, 2000; Birmingham et al., 2007; Birmingham, Bischof, and Kingstone, 2018). Even if there are other interesting stimuli in a picture, people tend to fixate social stimuli like faces more often than other stimuli (Birmingham, Bischof, and Kingstone, 2009).

The following study investigates if this effect holds up when participants execute a task which directs attention towards or away from social stimuli. Furthermore, the study looks at if and how social anxiety influences attention towards social stimuli. The task in this study was either to direct attention towards non-social stimuli (arrows, non-social task) or social stimuli (people's heads, social task).

The first expected result is that participants' initial attention allocation will be on the task-relevant stimuli. Latencies of the first fixations on the task-relevant stimuli will, therefore, be shorter, than for the task-irrelevant stimuli. Second, it is predicted that little attention will be directed at the non-social stimuli in the social task, but that some attention is always allocated to the social stimuli. In other words, participants will look less at the arrows in the social task, as at the heads in the non-social task. The third hypothesis states that people high in social anxiety will allocate their attention faster to the social stimuli than non-anxious individuals. Finally, it is expected that High Socially Anxious (HSA) will avoid social stimuli after initial attention allocation. They will thereby show fewer fixations on social stimuli.

5.2 Method

5.2.1 Participants

In total, 58 individuals were selected with the same social anxiety online screening procedure used in the previous study and invited to participate. No participants had to be excluded, so data of all participants were eligible for the statistical analysis.

All participants signed the informed consent, reported normal or corrected-to-normal vision and received 12 € for their participation. The study was approved by the ethics committee of the University of Würzburg and performed in compliance with the Declaration of Helsinki guidelines.

The participants answered several questionnaires during the study. At the beginning of the experiment, participants filled in a sociodemographic questionnaire, the state part of the State-Trait Anxiety Inventory (STAI) (Laux et al., 1981), and the Self-Assessment Manikin questionnaire (SAM) (Bradley and Lang, 1994). The last two were used to assess the current state of the participant before and after the experiment. All other questionnaires were answered at the end of the study, starting with a follow-up questionnaire regarding perceived difficulty of the tasks ("How easy was the task from 1 - easy to 7 - difficult") and participants' perceived own rating accuracy ("Estimate how often you gave the right answer from 1 – "seldom" to 7 – "frequently").

Here the order in which questions regarding the tasks was counterbalanced across participants. Other questionnaires were the trait part of the STAI (Laux et al., 1981; Spielberger, 2010), to assess the trait anxiety of participants, and several questionnaires to assess levels of social anxiety (Social Phobia and Anxiety Inventory (SPAI) (Fydrich, 2002; Turner et al., 1989), Liebowitz Social Anxiety Scale (LSAS) (Liebowitz, 1987; Stangier and Heidenreich, 2003), and Social Interaction Anxiety Scale (SIAS) (Mattick and Clarke, 1998; Stangier et al., 1999)). For data analysis participants were sorted in two groups (HSA or Low Socially Anxious (LSA)). The group belonging was based on a median split of the SPAI scores.

The data in Table 5.1 shows that the two groups did not differ in age and gender distribution. However, as expected HSA participants had higher scores on all social anxiety questionnaires (SPAI, Social Anxiety Screening (SAS), SIAS, and LSAS), as well as higher trait anxiety (trait part of the STAI).

TABLE 5.1: **Group Characteristics**

	HSA		LSA				
Variable	*M*	*SD*	*M*	*SD*	t(48)	p value	cohens d
Age	25.5	8.4	25.3	4.3	0.10	.922	0.03
SAS	3.3	1.0	1.6	0.5	8.51	.001	2.24
SPAI	3.2	0.8	1.5	0.5	9.89	.001	2.60
SIAS	48.0	15.6	29.5	6.1	5.94	.001	1.56
LSAS	57.2	26.3	24.8	12.5	6.00	.001	1.57
STAI-T	44.3	10.8	35.1	5.6	4.10	.001	1.08
	female	*male*	*female*	*male*	χ^2(1,N=58)	p value	
Gender	24	5	19	10	1.44	.230	

HSA, High Socially Anxious; LSA, Low Socially Anxious; SPAI, Social Phobia and Anxiety Inventory; SIAS, Social Interaction Anxiety Scale; LSAS, Liebowitz Social Anxiety Scale; STAI-T, trait part of the State-Trait Anxiety Inventory.

Analysis of the state part of the STAI questionnaire with the factors time point (pre/post experiment) and group (HSA/LSA), revealed a main effect group ($F(1, 56)$ = 5.52, p = .022, η_p^2 = .09) and a main effect time point (F(1, 56) = 7.68, p = .008, η_p^2 = .12). While HSA were generally in a higher state of anxiety (M_{diff} = 4.33), all participants showed an increase of anxiety of the course of the experiment (M_{diff} = 2.47). The SAM questionnaires scores showed that HSA participants felt significantly more aroused (M_{diff} = 0.40, $p < .05$) and less comfortable (M_{diff} = 0.39, $p < .05$) compared with LSA participants, independent of time point. Furthermore, all participants felt less comfortable after the experiment (M_{diff} = 0.30, $p < .001$).

5.2.2 Stimuli

To get a total of 64 different stimuli, 32 pictures were created using the Valve Hammer Editor from the source SDK (Valve Corporation, Bellevue, Washington, USA) and then mirrored. All pictures had a resolution of 1920 x 1200 pixel. The stimuli pictured four different scenes, taking four different perspectives in each scene. Two scenes were outside a university campus and a street in a business district. Moreover, two scenes were inside a foyer in a university building and an office room. Each picture contained six people (three male and three female) and six white arrows.

5.2.3 Apparatus

Eye movements of the right eye were recorded using an Eye Link 1000plus by SR-Research (Ontario, Canada), with a sampling rate of 1000 Hz. Participants were sitting in a dimly lit cabin in front of a computer screen (24" LG 24MB 65PY-B screen; 516.9 x 323.1 mm; 1920 x 1200 pixels, $54.67°$ x $35.81°$ visual angle, 60 Hz). Participants' heads were resting in a shin-rest 50 cm away from the screen. Stimuli were presented in full screen using the Psychophysics Toolbox extension in Matlab (Brainard, 1997; Kleiner et al., 2007; Pelli, 1997).

5.2.4 Design and procedure

After arriving at the laboratory and answering the above-described questionnaires and signing the informed consent, participants were seated in the eye tracking cabin.

At the beginning of the experiment, participants did eight training trials to familiarize with the task.

As depicted in Figure 5.1, each trial started with a 400 ms blank screen, followed by a 1 s presentation of a white fixation cross. Then the stimulus picture was presented for 10 s followed by the rating stimulus. Trials were separated by a blank screen randomly presented between 1 and 3 seconds. Eye movements were recorded during the 10 s stimulus presentation.

In total the experiment consisted of 128 trials divided into four blocks of 36 stimuli. Between the blocks, participants had a short break. Each stimulus was presented twice. The order in which stimuli were presented was random.

Participants had two different tasks, which changed between blocks. The task order was counterbalanced across participants. After passively viewing the stimulus participants had to rate the main direction either arrows (non-social task) or people (social task) were facing. For this, the task stimulus was followed by the same stimulus excluding the arrows and people, but including a blue circle with grey dots pointing in 8 different directions. One of the eight dots was colored green and could be moved by pressing one of two keys on the keyboard ("A" for left and "L" for right). The chosen direction was then confirmed by pressing the "space" key.

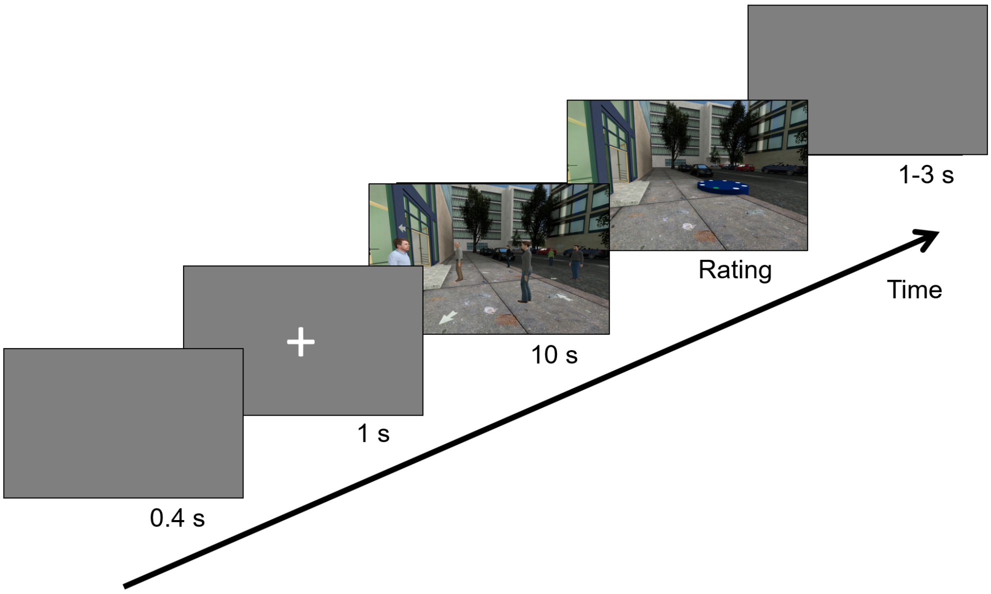

FIGURE 5.1: **Trial procedure.** After a 400 ms grey blank screen, a white fixation cross was presented for 1000 ms, where participants were instructed to fixate. Then the stimulus was presented for 10 s, followed by a rating phase, which participants ended with a button press. At the end, the grey blank screen was presented again, before the next trial started. The length of this Intertrial interval (ITI) was randomly selected between 1-3 s.

5.2.5 Data processing

For each trial, the fixations and saccades were extracted from the eye tracking data using the SR Research's EyeLink DataViewer software. While saccades were defined as eye movements surpassing a velocity threshold of 30°/s or an acceleration threshold of $8.000°/s^2$, fixations were defined as the period between saccades.

Based on a 300 ms baseline before stimulus presentation, in which participants fixated on the presented cross, the x and y coordinates of fixations for each stimulus were drift corrected. The drift correction was done separately for each participant. The baseline fixation was checked with an iterative procedure, testing it against the fixation position of all trials' baselines (see End and Gamer (2017) for a more detailed description of the procedure). In short, per iteration minimum and maximum values of the baseline position were excluded, when they deviated more than three standard deviations from the mean. The iteration process was finished, when no extreme value exceeded the three standard deviations threshold anymore.

From the trials with valid baseline data, we extracted two measures: 1) We determined the latency in ms until a predefined Region Of Interest (ROI) was first fixated. ROIs were manually traced on the original images using GIMP software (GNU Image Manipulation Program, http://www.gimp.org) separately for the heads and bodies of depicted individuals as well as the arrows. 2) We calculated the cumulative fixation density on the ROIs across the whole viewing period. To take into account differences in saccade and blink frequency, we divided the cumulative fixation time on each ROI by the total viewing time during image presentation excluding saccades and blinks. The resulting values thus reflect the percentage of the overall viewing time that was directed towards heads, bodies, and arrows, respectively.

In addition to the eye movement data, the rating time was extracted from the behavioral data from the rating phase. Rating time was merely the overall time in milliseconds needed to execute the rating.

5.2.6 Statistical analyses

Eye movement data and rating times were averaged for each participant and each task and then analyzed with mixed repeated measures Analyses of Variance (ANOVA). These ANOVAs consisted of the between-subjects factor **group** (HSA vs. LSA) and the within-subject factors **task** (social vs. non-social) and **ROI** (arrow vs. body vs. head), so a 2 x 2 x 3 mixed-factor design. T-tests were used to follow-up significant interactions. All statistical analyses used the two-tailed 5 % level of statistical significance, and all t-test p values were corrected using False Discovery Rate (FDR) correction (Benjamini and Hochberg, 1995).

5.3 Results

5.3.1 Eye movement data

Latency

Analysis of latency returned a significant three-way interaction between group, task, and ROI ($F(1.65, 92.34) = 3.61$, $p = .039$, $\eta_p^2 = .06$). Follow up analysis showed, that HSA shifted their gaze earlier to the head ROI compared to LSA ($M_{diff} = 394.26$ ms, $p < .10$), but only in the non-social task condition. In the non-social task latencies for arrow and body ROIs were the same in the non-social task latencies for arrow and body ROIs were the same and significantly shorter than latencies towards the head ROI (head/arrow $M_{diff} = 1271.52$ ms, $p < .001$; head/body $M_{diff} = 1242.54$ ms, $p < .001$). On average, in the social task participants' fastest fixation was on the head ROI and second fastest, with a mean difference of 1019.06 ms (p < .001), on the body ROI. Finally, participants fixated on the arrow ROI with the longest latency average (arrow/body $M_{diff} = 1722.84$ ms, $p < .001$). See Figure 5.2 for a depiction of the different latency averages.

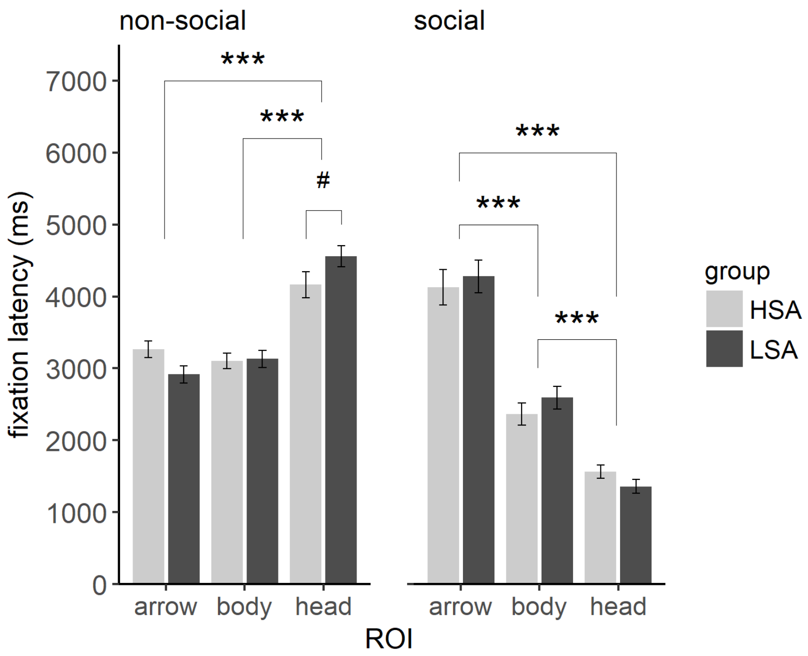

FIGURE 5.2: **Fixation latencies per trial.** Average latency of the first saccade to one of the three regions of interest (ROI; arrow, body, and head), regarding task (non-social and social) and group (High Socially Anxious (HSA) and Low Socially Anxious (LSA)). (# $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$).

Fixation duration

The ANOVA on fixation durations returned a significant three-way interaction of group, task, and ROI ($F(1.70, 95.16) = 5.18$, $p = .011$, $\eta_p^2 = .08$). Post hoc analysis showed, that for the social task there were significant differences between grthe oup. HSA participants fixated the head ROI significantly less than LSA ($M_{diff} = 5.3$ %, $p < .001$). Furthermore, albeit only with marginal significance, HSA looked longer at the body ROI ($M_{diff} = 1.7$ %, $p < .10$).

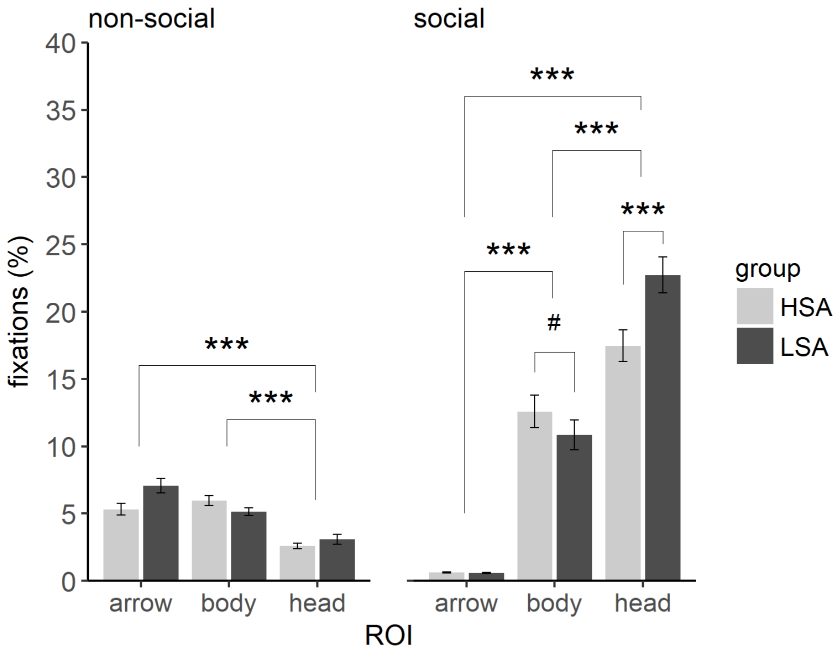

FIGURE 5.3: **Fixation duration per trial.** Average fixation durations in percentage of valid trial fixations on the three Region Of Interests (ROI; arrow, body and head), regarding task (non-social and social) and group (High Socially Anxious (HSA) and Low Socially Anxious (LSA)). (# $p < .1$, * $p < .05$, ** $p < .01$, *** $p < .001$).

In the non-social task, participants showed significant differences in total fixation times between head and body ROIs ($M_{diff} = 2.7$ %, $p < .001$) and head and arrow ROIs ($M_{diff} = 3.4$ %, $p < .001$). No difference was found between the arrow and body ROIs. While executing the social task participants paid almost no attention towards the arrow ROI, as shown by an average fixation percentage of only 0.6 %. Significantly more attention was directed at the body and head ROI (arrow/body $M_{diff} = 19.5$ %, $p < .001$; arrow/head $M_{diff} = 11.1$ %, $p < .001$). Finally, with a significant difference of 8.4 % (p < .001) between body and head ROI, most fixations were on the head ROI.

The analysis also revealed that participants fixated significantly less on the task-irrelevant ROI in the social task (arrows) than in the non-social task (heads) (M_{diff} =2.2 %, $p < .05$).

5.3.2 Behavioral data

Rating times

The statistical analysis of rating times revealed a significant group effect ($F(1,56) = 8.82$, $p = .004$, $\eta_p^2 = .14$). Participants of the HSA group took significantly longer to rate the direction, independent of task condition (M_{diff} = 173.30 ms).

Rating accuracy

Mantel-Haenszel test returned no significant difference for participants' accuracy regarding group or task condition ($\chi^2(1) = 1.01$, $p = .316$). On average participants gave correct answers on 45 % of the trials.

5.3.3 Follow-up questionnaire

Analysis of the follow-up questionnaire, found no significant difference in the difficulty ratings (M = 4.02, SD = 1.51), between-group, order, and rated task. In other words, both tasks were perceived as equally difficult. ANOVA analysis on the perceived accuracy revealed a significant interaction effect of group (HSA/LSA) and rated task (non-social/social) ($F(1, 54) = 7.56$, $p = .008$, $\eta_p^2 = .12$). Post hoc analysis showed that HSA rated their accuracy on the social task as significantly worse, compared with LSA participants ($M_{diff} = 0.74$, $p < .05$).

5.4 Discussion

As predicted attention was allocated first to the task-relevant parts of the presented sceneries. When participants had the task to estimate the direction which people were facing (social task), first fixations were on average faster on the task-relevant heads of the people as on the task-irrelevant arrows. Similarly, during the non-social task, of estimating arrow direction, first fixations were on average faster towards the arrows than to the heads of the people.

Independent of the task, participants directed little attention towards the task-irrelevant stimuli. However, in the non-social task, some attention was still directed towards the peoples' heads, at least significantly more than towards the arrows in the social task. This shows that social stimuli are always drawing attention, even when they are irrelevant to the current task.

As models of social anxiety would predict that individuals with social anxiety show hypervigilance towards social stimuli, it was predicted that first fixation latencies towards social stimuli should be shorter for participants high in social anxiety. This effect was only partially present in the data. In the non-social task did HSA shift their gaze faster to the heads, then the LSA participants. The reason that the effect was not found for the social task was quite likely due to the study design actively directing attention towards the social stimuli in the social task condition. Therefore, diminishing the priming effects of the social anxiety hypervigilance.

Following the hypervigilance-avoidance hypothesis, initial hypervigilance is followed by an avoidance of the social stimuli. In the current study, this should be present in fewer fixations on the social features of the presented sceneries. And, indeed, participants with higher social anxiety levels fixated less on the peoples' heads then LSA participants. This effect was only detected in the social task condition, which might be because in the non-social task attention was directed away from the social stimuli, and the remaining number of fixations were not sufficient to show the effect. An unexpected result was, that HSA fixated more on the body region, as LSA. Albeit this effect being only marginally significant, it would make sense that HSA directed their attention towards the body to execute the task, rather than looking at the heads.

Interestingly results of the follow-up questionnaire showed group differences for the perceived performance. Despite the actual performance being the same for all participants, HSA rated their perceived performance on the social task worse, than LSA. This fits nicely in social anxiety models, which predict that HSA are more critical about their social performance (Clark and Wells, 1995).

To sum up, the results support the hypothesis, that social anxiety leads to initial hypervigilance and later avoidance of social stimuli. Furthermore, it has been shown that the task can influence attention allocation, but social stimuli are always attended.

Overall, the study supports the notion, that eye movement measurements are ideally suited to research attention behavior of socially anxious participants. Furthermore, the study shows that complex scenes are also suited to investigate attention regarding social stimuli.

In future research, the next step should be to immerse participants into the same environments via Virtual Reality (VR) equipment and see if results can be reproduced. Other interesting future investigations could include (socially) threatening contexts and different facial expressions of the presented people. Furthermore, it would be essential to add free viewing possibilities to measure unrestricted viewing behavior.

6. General Discussion

This thesis aimed to deepen further the knowledge of avoidance behaviors exhibited in social anxiety. As described in detail in the theoretical background, avoidance behaviors are thought to be an essential factor in maintaining the developed social anxieties. In this thesis, the focus lied not on the apparent avoidance of not even entering social situations at all, but on the subtler behaviors in which socially anxious individuals engage to avoid the negative evaluation of others (Beidel, Turner, and Dancu, 1985; Clark and Wells, 1995; Rapee and Heimberg, 1997). The model by Rapee and Heimberg (1997) exemplifies, that avoidance behavior directly leads to negative social evaluations by others, thereby fulfilling the greatest fears of the individual suffering Social Anxiety Disorder (SAD). Avoidance behavior is, therefore, an essential maintaining factor for SAD, because it averts elaborate apprehension of the situation and inhibits the rejection of negative beliefs (Turk et al., 2001). However, as the vigilance-avoidance theory shows, it is difficult to look at avoidance without looking at approach as well.

With the three described studies, three different approaches were used to get a better understanding of what those avoidance behaviors are, and to which extent they are exhibited. Overall the focus lay on approach and avoidance through attention allocation regarding social stimuli. However, the thesis also looked at affective components, in the form of negative facial expressions. Next to attention allocation, with the help of Virtual Reality (VR), it was also possible to investigate full body movements, under completely controlled experimental conditions.

By using a highly immersive VR apparatus, the first described study took the first step in establishing a new VR task for the implicit research on social approach-avoidance behaviors. By moving freely through a VR environment, participants experienced near real-life social situations. By tracking body and head movements, physical and attentional approach-avoidance processes have been studied. As has been laid out before, investigating approach-avoidance behavior regarding affective stimuli is vital in broadening the understanding of SAD. For the physical approach-avoidance behaviors, many researchers rely on Approach-Avoidance Tasks (AATs) based on simple hand and arm movements, or interpersonal distance measures, which return inconsistent results and lack ecological validity.

Furthermore, in other studies in the field, the focus was mainly on behavior during direct interaction with social stimuli. The conducted VR experiment took another approach, by presenting social stimuli as virtual bystanders. The social stimuli were thereby not part of the executed task, which enabled to research the question on how behavior not explicitly related to others is affected socially.

In the second described study a different approach was chosen, to get a more focused look at attention re-allocation regarding social stimuli. As mentioned before, faces are the most critical cue in that context, as the impression from others is the defining characteristic of SAD. Facial expressions are an essential source of information of how other people react to oneself, by showing their emotions and their intentions (Blair, 2003; Darwin, 1965; Erickson and Schulkin, 2003; Mansell et al., 1999). Furthermore, emotions are biologically relevant for reacting to cues in the environment, as stated in the already mentioned motivational priming hypothesis (Lang and Bradley, 2010). Taking the importance of faces in consideration, the gaze-cueing paradigm was selected, as a promising method to study social attention allocation, with an additional focused on emotional facial expression.

Moreover, to investigate the importance of the context, the paradigm was applied in two different contexts, which were created using context conditioning. This enabled the paradigm to investigate, how attentional behaviors changed in a threatening environment. Congruent to the first study, this study included negative facial expressions, to investigate if individuals suffering SAD show exaggerated avoidance behavior regarding negatively valenced social stimuli. As the thesis is mainly concerned about avoidance, the paradigm was not directed on the initial attention, but attention relocation. Following the vigilance-avoidance hypothesis, the reallocation should contain avoidance and not the initial vigilance towards the threatening stimuli. In addition to the behavioral component, the study included the measurement of neuronal components, to get another objective measure of attention allocation.

For the third study, the measurements of eye movements enabled the investigation to what extent social attention is task dependent and how this is influenced by social anxiety. The compared tasks directed attention either towards social or towards non-social stimuli. Moreover, and in contrast to the second study, stimuli in the experiment were complex situations with several people in different environments. Furthermore, the used stimuli were created using 3D modulation software. Thereby it was possible to create controlled complex situations with heightened stimuli validity, and the scenes could be used in future research to conduct the same study in VR.

As described in the theoretical background section in the Social anxiety disorder paragraph, studies so far have shown that socially threatening stimuli, mainly in the form of angry faces, lead to avoidance behavior. Moreover, highly social anxious individuals show increased avoidance tendencies. From the three studies, the first and the third study show evident exaggerated social avoidance behaviors of High Socially Anxious (HSA). In the VR task, HSA displayed generally enhanced avoidance behavior regarding the virtual person, in the form of physical avoidance and by directing attention away from them. The physical avoidance was present in keeping more distance and moving faster past the bystander. Regarding attention, HSA spend less time looking at the head of the virtual person, during the less restricted first part of the task. Similarly, the study investigating attention allocation with the tracking of eye movements showed that HSA avoided looking at people's heads, instead directing their attention to the body to execute the task.

Both approaches show that the task profoundly influences the attention allocation. The task influence expands on what has already been described regarding the detection paradigm, in paragraph Social Anxiety and attention in the Theoretical Background section (Chapter 2). In the detection paradigms, the task instruction is to detect the social cue. Here it has been argued that directing the attention towards the social stimuli blocks the detection of avoidance thereof. The solution was to only use (detection) tasks that do not explicitly instruct participants to detect the social cues. In the virtual social approach-avoidance task, the social cue (virtual bystanders), was not made the focus of the task for similar reasons. Moreover, this influence of task instruction on social attention was experimentally investigated in study 3. Surprisingly, and in contrast, to the detection paradigms, social avoidance was only found when participants executed the task which directed attention towards the social cue (people).

Firstly, this demonstrates that, whether one should direct attention towards social attention or not, depends on the task itself. Secondly, it shows that social anxiety involves complex cognitive mechanisms. For social approach-avoidance behavior this could mean two things: On the one hand, directing attention towards the social cue can induce a ceiling effect. For example, the initial hypervigilance of HSA might no longer be detectable, because Low Socially Anxious (LSA) must direct their attention towards the social stimuli as well. The naturally occurring avoidance of social stimuli might be diminished by high task compliance of HSA. On the other hand, when directing attention away, or at least not directly towards the social stimulus, the attention allocated towards them might not be enough to show significant differences.

Next to the task instruction, another critical factor which must be considered is dependence on task complexity, or in other words task difficulty. In this regard, the attentional control theory (Eysenck et al., 2007) states that the perception of anxiety leads to a resources scarcity in working memory. More directly Eysenck and colleagues postulated that anxiety impairs performance on two levels, the processing efficiency and its effectiveness (Eysenck and Calvo, 1992; Eysenck et al., 2007). The processing efficiency level can be described as the allocated measure of cognitive resources needed for task execution. The effectiveness is the resulting number of correct responses compared to incorrect responses. The model states that anxiety generally affects the efficiency level. However, the effectiveness level is only impaired, when the anxiety demands so many cognitive resources, that there is not enough left for the optimal task execution. One way to assess processing efficiency is the measure of reaction times.

In the past, studies investigating whether social anxiety leads to reduced social performance, returned mixed results (Rapee and Heimberg, 1997). While some studies found impaired social performance of HSAs on many levels (Twentyman and McFall, 1975), other studies found impairment only on few levels (Arkowitz et al., 1975; Borkovec et al., 1974) or no impairment at all (Burgio, Glass, and Merluzzi, 1981; Clark and Arkowitz, 1975; Rapee and Lim, 1992). In their paper, Rapee and Heimberg (Rapee and Heimberg, 1997) interpret those mixed results as an indication for the context being a moderator. The context is of course also influenced by the task at hand. As stated by Judah and colleagues (2013b), the mixed results also fit predictions of the attentional control theory. Some more recent studies directly tested whether the attentional control theory also applies to social anxiety (Amir and Bomyea, 2011; Judah et al., 2013b; Judah et al., 2013a; Wieser et al., 2009; Liang, 2018; Boal, Christensen, and Goodhew, 2018). Results from the study by Amir and Bomyea (2011) show that HSA performed worse than controls on an operation span task assessing working memory performance, but only when words were neutral. They performed equally well with social threat words. In their paper, Judah *et al.* (2013b) propose that HSA show impaired performance only on none threatening words because due to their anxiety they allocate attention towards the threat, thereby limiting general processing efficiency. In the same paper, Judah and colleagues (2013a) present a study, where they manipulated the working memory load and tested its impact on attention allocation regarding socially threatening facial expressions. HSA succeeded in avoiding the social threat under low working load but had problems disengaging under high working memory load. This shows that attentional resources moderate the attentional processes of HSA. Another approach to probe the attentional control theory for SAD comes from Wieser *et al.* (2009). They used a mixed-antisaccade task with emotional face stimuli, were participants responded towards peripherally presented faces, with either pro- or antisaccades. In this task, HSA performed well on prosaccades but had difficulties disengaging from facial expressions (antisaccades). One study used the dot-probe task to investigate attention effects of working memory load in social anxiety (Boal, Christensen, and Goodhew, 2018) and found no differences between social anxiety levels on the effect of working memory load. However, as stated before (see Chapter 2 the dot-probe task has its limitations and does not reliably measure the allocation of attention.

Judah and colleagues (Judah et al., 2013b) have used the same task, but added Electroencephalography (EEG) measures to assess neural activity in addition to behavior. Furthermore, they modified the task also to manipulate self-focus. Study results showed reduced processing efficiency at the neural and behavioral level for

HSA. They did not fully replicate findings by Wieser *et al.* (Wieser et al., 2009), but HSA showed a generally delayed saccade onset, with a smaller amount of errors. Results of neural measures support the behavioral data and further showed that self-focus plays a role in attentional control deficits. All three studies are in line with the attentional control theory and show that HSA have deficits in attentional control.

The attentional control theory also fits together with the general cognitive models (Clark and Wells, 1995; Rapee and Heimberg, 1997) and the vigilance-avoidance theory, which postulates that hypervigilance towards social threat in socially anxious individuals is followed by avoidance, as a defensive mechanism to avoid or minimize threat (Bögels and Mansell, 2004; Mogg et al., 1997). Combined with the attentional control theory, the initial hypervigilance towards threat could be explained by the lack of control and the subsequent avoidance is then reached with extra effort from the individual. Furthermore, as described before (see Chapter 2) many studies only find differences between HSA and controls, when the experiment includes a social threat. It is plausible that for HSA the impended social threat does further demand cognitive resources and make it harder for HSA to compensate during the task. Of course, this would have to be further researched, to make an informed statement.

Two of the three conducted experiments found that HSA exhibited exaggerated avoidance behaviors. Regarding the initial hypervigilance towards social stimuli, the VR approach-avoidance task did not find any specific effects of HSA. However, all participants' gaze was generally directed more to angry compared to neutral faces. At the same time, all participants avoided the angry people more, which could show that after the initial vigilance, avoidance is not limited to attention, but also reflected in physical modalities. The only clear attention-based evidence for the vigilance-avoidance hypothesis comes from the third study. When participants were instructed to rate the overall direction of arrows, thereby directing the attention away from the social stimuli, HSA did shift their gaze faster to the heads than controls, thereby showing initial hypervigilance towards the primary social stimuli. As has been mentioned in the theoretical background it has already been indicated, that eye movement measures are currently the best way to assess attention allocation. The conducted eye-tracking study gives further evidence for this assumption, as it is highly sensitive to subtle differences in attention allocation.

Next to its focus on approach-avoidance behavior in SAD in general, the thesis was also interested in the influence of angry facial expressions on individuals suffering SAD. Therefore, the presented faces in the first two studies included angry facial expressions. Based on the past research it was expected that HSA would show exaggerated avoidance behaviors towards those stimuli. For example, results with the AAT, that higher levels in social anxiety lead to increased avoidance tendencies (pushing a joystick away from self) regarding emotional facial expressions compared to neutral faces (Laham et al., 2015; Marsh, Ambady, and Kleck, 2005; Roelofs, Elzinga, and Rotteveel, 2005; Stins et al., 2011). Alternatively, evidence from eye movement studies, which found that HSA participants fixated longer on threatening faces when they were presented along with other faces (Lazarov, Abend, and Bar-Haim, 2016; Liang, Tsai, and Hsu, 2017). However, neither the VR approach-avoidance task nor the gaze cueing paradigm picked up on any such behavior. In the VR experiment, all participants showed increased avoidance behavior when moving past angry people. However, there was no specifically increased avoidance behavior of HSA. As the virtual people with angry facial expressions were also rated as angrier, it is unlikely that they were not perceived as negative.

One reason for the lack of the expected results could be that the used tasks are just not suited. However, results on the matter, in general, are quite mixed (see Chapter 2) and as stated before there is some evidence, that socially anxious individuals fear evaluation independently of its valence (Byrow, Chen, and Peters, 2016; Chen et al., 2012; Weeks et al., 2008; Weeks, Jakatdar, and Heimberg, 2010; Weeks and Howell, 2012; Weeks, 2015). In that regard, it might be that the social stimuli at hand were not evaluative enough. In other research, some effects are only present when the experiment included a social threat. In other words, the social stimuli would have to be in themselves more evaluative or gain evaluative valence via external manipulation.

Overall, it can be said that social anxiety involves highly complex cognitive mechanisms. People suffering SAD obtain many dysfunctional beliefs, which specifically refer to negative self-evaluation (Beck, Emery, and Greenberg, 1985; Stopa and Clark, 1993). Therefore, it is not surprising, that avoidance behaviors are not solely built on the perceived valence of a stimulus. Next, to the lack of HSA showing specific behavior regarding negative facial expressions, the negative self-evaluation is also reflected in Study 3 (see Chapter 5). In this eye movement study, HSA rated their performance worse than the LSA did theirs. Interestingly, this was only the case for the perceived performance on the social task, where they had to point out the general direction people were facing, instead of the arrows (non-social task). This does not just show that HSA evaluate their self as more negative, but also that it is not in concordance with their actual performance. Results showed that all participants performed with the same accuracy and rated the tasks as equally difficult. Still, HSA perceived their performance for the social task as worse than the LSA did theirs.

As detailed before, the attentional control theory (Eysenck et al., 2007) states that anxious people compensate for the loss in efficiency by increased effort and use of processing resources. HSA had to spend more time to achieve a given level of performance. In the social task condition, the distraction was more prominent, which resulted in lower processing efficiency. This is not reflected in the rating times, but it might be that HSA themselves perceive this and therefore rate their performance on the social task as worse, than controls. However, it is essential to keep the possibility of the attentional control theory (Eysenck et al., 2007) in mind when designing experiments to study the behavior of HSA. When participating in an experiment, participants fell that they are under evaluation. It is therefore plausible that this real evaluation might be more important, than the evaluation of some strangers' face on the computer.

6.1 Conclusion and outlook

The thesis had the primary goal to investigate how and what avoidance behaviors are exhibited by HSA. It has been shown, that HSA exhibit physical and attentional avoidance behavior. The presented studies have also shown, that social anxiety is a very complex disorder. It is not merely based on the fear of a particular stimulus but involves higher cognitive processes, which go behind pure fright and flight responses. It is therefore evident that more research is needed. A question for the future is, what is the best way, or the best tool, to study avoidance behaviors in social anxiety. Looking at the three studies described in this thesis the gaze cueing paradigm seems ill-suited at least for studying the avoidance behaviors of SAD. As described in the studies' discussion, there are many ways to improve the study design. Which could eventually lead to better results. Overall, it seems that especially the approaches of the first and the third study are promising tools to investigate social anxiety successfully. As has been indicated by past research, eye movement measurements are ideally suited to research attention behavior of socially anxious participants. It has also been shown, that instead of only using excerpts (faces), complex scenes are ideally suited to investigate attention regarding social stimuli.

Moreover, highly immersive VR has been proven to be a powerful research tool. Advances in the VR technology offer new ways to engage the subject and will be essential in exploring social avoidance behaviors and anxiety disorders in general. Of course, a combined approach of the two research methods would be even better. Accuracy and validity of the gaze data detained from the VR social approach-avoidance task would highly benefit from added eye tracking. However, as already mentioned, the complex scenes from the third described study are created using VR tools and are therefore VR ready. Which means, they could be easily presented in VR using a Head Mounted Display (HMD), with an integrated eye tracking module.

Furthermore, for future research, there are several ways to improve the used study designs. The VR social approach-avoidance task and the eye tracking approach could be applied to more complex situations. For example, could the displayed people show other facial expressions (i.e., disgust), show evaluative behavior (verbal or non-verbal), or get a negative backstory. Moreover, it would be essential to get other objective measures of the peripheral physiology, such as skin conductance and heart rate. Another interesting aspect would be to investigate HSA behavior with different study designs, adding social stress as this has been shown to be a successful approach to get exaggerated behaviors of social anxiety. Extending this line of research, it would be of great interest, to see why the social threat is so vital for numerous studies, in order to see differences between HSA and controls. One way to approach this would be to use different levels and triggers of social threat (e.g., must give a talk, return something, ask for the seat).

Next to the different ways on how to use the VR social approach-avoidance task in research projects, it could also be used as Behavioral Avoidance Test (BAT), to get an objective measure of social anxiety. This could be useful for assessing SAD on a behavioral level for long term studies on SAD treatment and measure for therapeutic success. As exposure therapy is the best way of treatment and VR is the best alternative to in-vivo treatment (Diemer and Zwanzger, 2019; Carl et al., 2019; Chesham, Malouff, and Schutte, 2018), combining VR exposure therapy and the VR BAT would, therefore, be a great opportunity.

This thesis, with its three different approaches to studying social avoidance, was written to shed some light on the maintaining factors of SAD. As always with research, the efforts only gave some insights but opened a whole bucket of new questions. However, in the author's opinion, it is essential to follow this line of research.

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Annex

A. Written informed consent Study 1

Julius-Maximilians-
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Lehrstuhl für Psychologie I
Biologische Psychologie, Klinische Psychologie und Psychotherapie

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Probandeninformation
„Bewegung in virtueller Realität 2"

Sehr geehrte Probandin, sehr geehrter Proband,

vielen Dank, dass Sie sich bereit erklärt haben an dieser wissenschaftlichen Untersuchung am Lehrstuhl für Psychologie I der Universität Würzburg teilzunehmen. Mit diesem Schreiben wollen wir Sie über die Art der Untersuchung, deren Ablauf und die verwendeten Methoden aufklären. Ziel unserer Studie ist es, **Faktoren die Bewegung in virtueller Realität beeinflussen** zu untersuchen.

Vor und nach der Untersuchung möchten wir Sie bitten, einige **Fragebögen** auszufüllen. Diese beziehen sich auf einige allgemeine Angaben zu Ihrer Person, auf Ihre momentane Stimmung und auf Ihr Verhalten in verschiedenen Situationen. Der zeitliche Aufwand wird sich für Sie auf ca. eine Stunde beschränken.

Die Teilnahme an der Untersuchung ist völlig **freiwillig**. Das bedeutet auch, dass Sie jederzeit ohne einen Nachteil für Sie die Untersuchung abbrechen können. Alle erhobenen **Daten** werden durch einen Code **anonymisiert** und **streng vertraulich** nach geltenden Datenschutzrichtlinien behandelt.

Der Versuch wird in **Virtueller Realität** stattfinden, d.h. sie werden durch eine 3D-Brille von Computern erzeugte, auf Wände projizierte Bilder sehen. In unserem 3D Multisensoriklabor sind alle Wände und der Fußboden Projektionsflächen. Sie werden also komplett in die virtuelle Welt versetzt und können sich im virtuellen Raum frei bewegen.

Die **Steuerung** Ihrer Bewegung in der virtuellen Welt erfolgt durch **reales gehen und drehen**. Wenn Sie einen Schritt nach vorne gehen, bewegen Sie sich auch virtuell nach vorn. Wenn Sie sich zur Seite drehen, drehen Sie sich auch virtuell zur Seite. In seltenen Fällen kann die Virtuelle Realität **Übelkeit oder Schwindel** auslösen, ähnlich wie eine 3D-Kinofilm. Falls dies passiert und Sie die Untersuchung abbrechen möchten, **teilen Sie uns das bitte sofort mit.**

Die Untersuchung setzt sich aus drei Teilen zusammen. Im **ersten Teil** werden Ihnen Ihre Aufgaben erläutert und einige Probeläufe durchgeführt.

Der **zweite Teil** ist der Hauptteil der Untersuchung und besteht aus mehreren Durchläufen. In jedem Durchlauf haben Sie zwei Aufgaben. Eine Benennungs-Aufgabe und eine Bewegungs-Aufgabe.

Im **dritten Teil** der Untersuchung werden Ihnen noch einige abschließende Fragen gestellt.

Wenn Sie noch Fragen haben, wenden Sie sich bitte nun an den Untersuchungsleiter.

Bitte erklären Sie nun mit Ihrer Unterschrift, dass Sie die Probandeninformation sorgfältig durchgelesen und verstanden haben, dass Sie sich mit dem beschriebenen Vorgehen einverstanden erklären und dass der Versuchsleiter ihre Fragen zu Ihrer Zufriedenheit beantwortet hat.

Würzburg, den _______________________ Unterschrift _____________________________

Name und Anschrift ____

____

____

Unterschrift des Versuchsleiters _________________________ Code________________

B. Written informed consent Study 2

Julius-Maximilians-
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WÜRZBURG

Lehrstuhl für Psychologie I - Prof. Dr. Paul Pauli
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Aufklärungstext der Studie
„She's still got the look?"

Sehr geehrte Versuchsteilnehmerin, sehr geehrter Versuchsteilnehmer,

Sie nehmen an der Studie „She's still got the look?" teil, bei der wir untersuchen möchten, welche Auswirkung Gesichtsausdrücke auf die visuelle Aufmerksamkeit haben. Sie werden aus der Teilnahme keinen unmittelbaren Nutzen für sich ziehen können. Wir hoffen jedoch, durch unsere Arbeit mehr über die Verteilung von Aufmerksamkeit erfahren zu können. Wenn Sie möchten, werden wir Ihnen nach der Untersuchung gerne die Hintergründe und Ziele dieser Untersuchung ausführlich schildern.

Vor der Untersuchung werden Sie einige Fragebögen ausfüllen, in denen wichtige Daten bezüglich Ihrer Person festgehalten werden. Dann wird der Versuchsleiter auf Ihren Kopf ein angefeuchtetes Netz mit 128 Elektroden anlegen, um Ihrer Gehirnaktivität zu messen. Die Flüssigkeit, in dem das Netz liegt, besteht nur aus Wasser, Baby-Shampoo und Kalium und ermöglicht eine optimale Erfassung ihrer Gehirnaktivität.

In der Untersuchung werden Sie auf einem Computerbildschirm Gesichter sehen. Ihre Aufgabe wird es sein, auf am Rand des Bildschirms erscheinende Buchstaben mit einem Tastendruck zu reagieren.

Die Teilnahme an der Untersuchung ist völlig freiwillig. Sie können jederzeit - ohne Angabe von Gründen - die Teilnahme abbrechen. Dadurch entstehen Ihnen keinerlei persönliche Nachteile. Für Ihre Teilnahme an der Untersuchung erhalten Sie wahlweise 1,5 Versuchspersonenstunden oder 9 €.

Alle Daten dienen ausschließlich Forschungszwecken, werden vertraulich behandelt und ohne Namensgebung unter einer Codenummer abgespeichert. Der Codierungsschlüssel wird nach Abschluss der Studie vernichtet. Bis dahin können Sie auch noch nach der Untersuchung die Löschung ihrer Daten verlangen.

Falls Sie noch weitere Frage haben, fragen Sie bitte jetzt.

2

Einverständniserklärung

Ich bin einverstanden, an dem Experiment „She's still got the look?“ teilzunehmen und dass die erhobenen Daten in anonymisierter Form wissenschaftlich ausgewertet werden.

Ich bin darüber informiert worden, dass ich jederzeit aus der Untersuchung ausscheiden kann, ohne dass mir persönliche Nachteile entstehen.

Mit meiner Unterschrift erkläre ich, dass ich das Vorhaben und diese Information verstanden habe, meine Fragen zufrieden stellend beantwortet wurden und ich freiwillig und aus eigenem Entschluss an der Untersuchung teilnehme.

Würzburg, den ____________________ Unterschrift _________________________

Name und Anschrift ____

____

Unterschrift des Versuchsleiters ______________________ Code_______________

C. Written informed consent Study 3

Julius-Maximilians-
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Einwilligungserklärung

Aufmerksamkeitsstudie

Durch meine Unterschrift bestätige ich:

Die Probandeninformation habe ich sorgfältig durchgelesen und verstanden. Mit dem beschriebenen Vorgehen bin ich einverstanden. Die Versuchsleiterin hat alle meine Fragen zu meiner vollen Zufriedenheit beantwortet.

Ich nehme freiwillig an der Aufmerksamkeitsstudie teil und bin damit einverstanden, dass die erhobenen Daten in verschlüsselter, d.h. in unpersönlicher Form (ohne Namens- oder Initialnennung), aufgezeichnet, in Computern gespeichert und wissenschaftlich ausgewertet werden. Ich bin auch damit einverstanden, dass die Ergebnisse der Studie in Gruppen zusammengefasst wissenschaftlich veröffentlicht werden. Ich bin darüber aufgeklärt worden, dass ich jederzeit, auch nach der Erhebung, eine Vernichtung der von mir erhobenen Daten verlangen kann, solange eine Zuordnung zu meiner Person noch möglich ist.

Ich bin darüber informiert worden, dass ich jederzeit ohne Angabe von Gründen und ohne einen Nachteil aus der Untersuchung ausscheiden kann. Alle erhobenen Daten werden anonymisiert und streng vertraulich nach geltenden Datenschutzrichtlinien behandelt.

____

Name, Vorname

____

Anschrift: Straße, PLZ, Ort

____

Datum

____

Unterschrift Proband

____

Unterschrift Versuchsleiter

Julius-Maximilians-
UNIVERSITÄT
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Probandeninformation

Aufmerksamkeitsstudie

Sehr geehrte Probandin, sehr geehrter Proband,

vielen Dank, dass Sie sich bereit erklärt haben, an dieser wissenschaftlichen Untersuchung am Lehrstuhl für Psychologie I der Universität Würzburg teilzunehmen. Mit diesem Schreiben sollen Sie über die Art der Untersuchung, deren Ablauf und die verwendeten Methoden aufklären. **Ziel der Studie ist es, zu untersuchen, wie unterschiedliche Reize abhängig von der zugrunde liegenden Aufgabe bewertet und visuell verarbeitet werden.**

Dazu werden Ihnen am Computer Bilder von Personen und Pfeilen in komplexen Umwelten gezeigt. Sowohl die Gesichter der Personen als auch die Pfeile zeigen in verschiede Richtungen. Für jedes Bild sollen Sie abhängig von der Aufgabe die dominante Pfeil/- oder Blickrichtung bestimmen. Dabei werden Ihre Einschätzungen und Ihre Augenbewegungen erfasst.

Im Anschluss an das Experiment werden Sie noch aufgefordert, einige Fragebögen auszufüllen. Dabei steht Ihnen die Versuchsleiterin natürlich für Fragen zur Verfügung.

Die Gesamtdauer der Untersuchung inklusive Fragebögen beträgt ca. 90 Minuten.

Die Teilnahme an der Untersuchung ist völlig freiwillig. Das bedeutet auch, dass Sie jederzeit ohne einen Nachteil für Sie die Untersuchung abbrechen können. Alle erhobenen Daten **werden anonymisiert und streng vertraulich nach geltenden Datenschutzrichtlinien behandelt.**
Wenn Sie noch Fragen haben, wenden Sie sich bitte nun an die Untersuchungsleiterin.

Bitte erklären Sie nun mit Ihrer Unterschrift, dass Sie die Probandeninformation sorgfältig durchgelesen und verstanden haben, dass Sie sich mit dem beschriebenen Vorgehen einverstanden erklären und dass Ihre Fragen zu Ihrer Zufriedenheit beantwortet wurden.

D. Demographic questionnaire

VP-Code: Datum:

Allgemeiner Fragebogen

Allgemeines

1. Geschlecht ☐ weiblich ☐ männlich
2. Alter in Jahren ________
3. Größe in cm: ________
4. Gewicht in kg: ________
5. Händigkeit ☐ links ☐ rechts ☐ Beidhändig

6. Was ist Ihr höchster Schulabschluss?
☐ kein Schulabschluss
☐ Hauptschulabschluss
☐ Mittlere Reife
☐ Abitur / Fachabitur
☐ Berufsausbildung
☐ Hochschulabschluss

7. Sind Sie berufstätig?
☐ ja, als ______________________
...ODER sind Sie
☐ Schüler,
☐ Student,
☐ in Berufsausbildung,
☐ Rentner/im Ruhestand,
☐ zur Zeit arbeitslos,
☐ ohne Beruf,
☐ Bundesfreiwilligendienst/im freiwilligen sozialen Jahr?

8. Nehmen Sie regelmäßig Medikament ein?
☐ nein
☐ ja, und zwar ______________________

9. Konsumieren Sie regelmäßig Alkohol, oder andere Drogen?
☐ nein
☐ ja - wenn andere Drogen, welche? ______________________

10. Haben Sie eine Sehschwäche? Ist diese ausreichend korrigiert?
☐ nein
☐ ja, ausreichend korrigiert
☐ ja, nicht ausreichend korrigiert

E. SA/LA - Social Anxiety Pre-Screening

VP-Code: Datum:

SA/LA

Bitte geben Sie an, inwieweit folgende Aussagen auf Sie zutreffen:

1. Ich habe eine ausgeprägte Angst davor, mich in sozialen Situationen oder Leistungssituationen zu befinden und ein Verhalten zu zeigen, das für mich peinlich oder demütigend sein könnte.

   trifft gar nicht zu ☐ ☐ ☐ ☐ ☐ trifft genau zu

2. Sich in sozialen Situationen oder Leistungssituationen zu befinden, löst bei mir fast immer starke Angst aus.

   trifft gar nicht zu ☐ ☐ ☐ ☐ ☐ trifft genau zu

3. Ich halte meine Angst vor sozialen Situationen oder Leistungssituationen für unbegründet und übertrieben stark.

   trifft gar nicht zu ☐ ☐ ☐ ☐ ☐ trifft genau zu

4. Ich vermeide soziale Situationen oder Leistungssituationen, wenn es mir möglich ist. Wenn ich sie nicht vermeiden kann, ertrage ich sie mit intensiver Angst und Unwohlsein.

   trifft gar nicht zu ☐ ☐ ☐ ☐ ☐ trifft genau zu

5. Ich fühle mich durch meine Angst vor sozialen Situationen oder Leistungssituationen in meinem Alltag beeinträchtigt.

   trifft gar nicht zu ☐ ☐ ☐ ☐ ☐ trifft genau zu

F. Follow-Up questionnaires Study 3

VP-Code: Nachbefragung-Nr.: **A** Datum:

Nachbefragung

1. Wie schwer fanden Sie die Aufgabe, die Richtung der Pfeile zu benennen?

Sehr einfach						Sehr schwer
☐	☐	☐	☐	☐	☐	☐

2. Wie schwer fanden Sie die Aufgabe, die Richtung der Gesichter zu benennen?

Sehr einfach						Sehr schwer
☐	☐	☐	☐	☐	☐	☐

3. Was schätzen Sie, wie häufig haben Sie die Richtung der Pfeile richtig benannt?

Sehr selten						Sehr häufig
☐	☐	☐	☐	☐	☐	☐

4. Was schätzen Sie, wie häufig haben Sie die Richtung der Gesichter richtig benannt?

Sehr selten						Sehr häufig
☐	☐	☐	☐	☐	☐	☐

5. Wie viel Zeit verbringen Sie derzeit im Schnitt mit Videospielen pro Woche?

☐ < 2 Stunden ☐ 10-20 Stunden

☐ 2-5 Stunden ☐ 20-40 Stunden

☐ 5-10 Stunden ☐ > 40 Stunden

6. Wie viel Erfahrung haben Sie mit 3D-Videospielen aus der Ego-Perspektive (z. B. Call of Duty, Counter-Strike, Skyrim)?

Gar keine									Sehr viel
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

VP-Code: Nachbefragung-Nr.: **B** Datum:

Nachbefragung

1. Wie schwer fanden Sie die Aufgabe, die Richtung der Gesichter zu benennen?

Sehr einfach						Sehr schwer
☐	☐	☐	☐	☐	☐	☐

2. Wie schwer fanden Sie die Aufgabe, die Richtung der Pfeile zu benennen?

Sehr einfach						Sehr schwer
☐	☐	☐	☐	☐	☐	☐

3. Was schätzen Sie, wie häufig haben Sie die Richtung der Gesichter richtig benannt?

Sehr selten						Sehr häufig
☐	☐	☐	☐	☐	☐	☐

4. Was schätzen Sie, wie häufig haben Sie die Richtung der Pfeile richtig benannt?

Sehr selten						Sehr häufig
☐	☐	☐	☐	☐	☐	☐

5. Wie viel Zeit verbringen Sie derzeit im Schnitt mit Videospielen pro Woche?

☐ < 2 Stunden	☐ 10-20 Stunden
☐ 2-5 Stunden	☐ 20-40 Stunden
☐ 5-10 Stunden	☐ > 40 Stunden

6. Wie viel Erfahrung haben Sie mit 3D-Videospielen aus der Ego-Perspektive (z. B. Call of Duty, Counter-Strike, Skyrim)?

Gar keine									Sehr viel
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

G. Publication list

Published Abstracts

Soehnchen, B., Kastner, A.K., Flohr, E. L. R., Looi, A., Wieser, M.J., Pauli, P. (2016). Follow the Eyes - Influence of Emotional Expression on Visuospatial Attention. *Cognitive Neuroscience Society*, New York, NY.

Söhnchen, B., Flohr, E. L. R., Kastner, A. K., Wieser, M. J., Pauli, P. (2015). Follow the Eyes - Influence of Emotional Expression on Visuospatial Attention. *Psychophysiology*, 52, p. 114. doi: 10.1111/psyp.12495

Söhnchen, B., Flohr, E. L. R., Kastner, A. K., Wieser, M. J., Pauli, P. (2015). Follow the Eyes - Influence of Emotional Expression on Visuospatial Attention. *EUREKA 10 th International Symposium*, Würzburg, Germany.

H. Affidavit / Eidesstattliche Erklärung

Affidavit

I hereby confirm that my thesis entitled Influence of social anxiety on social attention and corresponding changes in action patterns is the result of my own work. I did not receive any help or support from commercial consultants. All sources and / or materials applied are listed and specified in the thesis.

Furthermore, I confirm that this thesis has not yet been submitted as part of another examination process neither in identical nor in similar form.

Place, Date Signature

Eidesstattliche Erklärung

Hiermit erkläre ich an Eides statt, die Dissertation Einfluss der sozialen Angst auf die soziale Aufmerksamkeit und korrespondierende Veränderungen im Bewegungsverhalten eigenständig, d.h. insbesondere selbständig und ohne Hilfe eines kommerziellen Promotionsberaters, angefertigt und keine anderen als die von mir angegebenen Quellen und Hilfsmittel verwendet zu haben.

Ich erkläre außerdem, dass die Dissertation weder in gleicher noch in ähnlicher Form bereits in einem anderen Prüfungsverfahren vorgelegen hat.

Ort, Datum Unterschrift

I. Curriculum Vitae