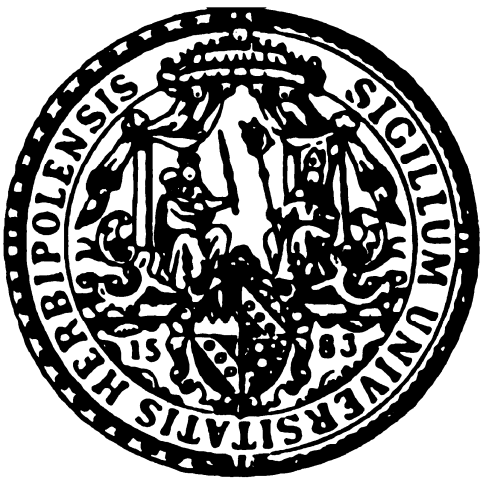
Preferential Processing of Phobic Cues

Attention and Perception in Spider Phobic Patients



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sowie sämtlichen Kolleginnen und Kollegen, denn…

„Nichts beflügelt die Wissenschaft so, wie der Schwatz mit Kollegen auf dem Flur."
Arno Penzias (*1933)

natürlich auch allen Studentinnen und Studenten, die mir geholfen haben

und allen Teilnehmerinnen und Teilnehmern an den Experimenten!

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Abstract

Cognitive views of the psychopathology of anxiety propose that attentional biases toward threatening information play a substantial role in the disorders' etiology and maintenance. For healthy subjects, converging evidence show that threatening stimuli attract attention and lead to enhanced activation in visual processing areas. It is assumed that this preferential processing of threat occurs at a preattentive level and is followed by fast attentional engagement. High-anxious individuals show augmented tendencies to selectively attend toward fear-relevant cues (Mathews, 1990) and exhibit elevated neural processing of threatening cues compared to non-anxious individuals (Dilger et al., 2003). Regarding attentional biases in high-anxious subjects, it remains unanswered up to now whether initial engagement of attention toward threat or difficulties to disengage from threat is an underlying mechanism. Furthermore, little is known whether the preferential (attentive) processing of threatening cues does influence perceptional outcomes of anxious subjects.

In order to directly study separate components of attentional bias the *first study* of this dissertation was a combined reaction time and eye-tracking experiment. Twenty one spider phobic patients and 21 control participants were instructed to search for a neutral target while ignoring task-irrelevant abrupt-onset distractor circles which contained either a small picture of a spider (phobic), a flower (non-phobic, but similar to spiders in shape), a mushroom (non-phobic, and not similar to spiders in shape), or small circles with no picture. As expected, patients' reaction times to targets were longer on trials with spider distractors. However, analyses of eye movements revealed that this was *not* due to attentional capture by spider distractors; patients more often fixated on all distractors with pictures. Instead, reaction times were delayed by longer *fixation durations* on spider distractors. This result does not support automatic capture of attention by phobic cues but suggests that phobic patients fail to disengage attention from spiders.

To assess whether preferential processing of phobic cues differentially affects visual perception in phobic patients compared to healthy controls, the *second study* of this dissertation used a *binocular rivalry* paradigm, where two incompatible pictures were presented to each eye. These pictures cannot be merged to a meaningful percept and temporarily, one picture predominates in conscious perception whereas the other is suppressed. 23 spider phobic patients and 20 non-anxious control participants were shown standardized pictures of spiders or flowers, each paired with a neutral pattern under conditions of binocular rivalry. Their task was to continuously indicate the predominant percept by key presses. Analyses show that spider phobic patients perceived the spider picture more often and longer as dominant compared to non-anxious control participants. Thus, predominance of phobic cues in binocular rivalry provides evidence that preferential processing of fear-relevant cues in the visual system actually leads to superior perception.

In combination both studies support the notion that phobic patients process phobic cues preferentially within the visual system resulting in enhanced attention and perception. At early stages of visual processing, this is mainly reflected by delayed attentional disengagement and across time, preferential processing leads to improved perception of threat cues.

German abstract (deutsche Zusammenfassung)

Kognitive Theorien nehmen an, dass Aufmerksamkeitsverzerrungen bezüglich bedrohlicher Reize eine substantielle Rolle bei der Entstehung und Aufrechterhaltung von Angst spielen. Für gesunde Personen konnte gezeigt werden, dass bedrohliche Reize die Aufmerksamkeit auf sich ziehen und verstärkt im visuellen System verarbeitet werden. Es wird angenommen, dass diese bevorzugten Verarbeitungsprozesse automatisch und präattentiv sind und von einer schnellen Aufmerksamkeitsausrichtung gefolgt werden. Hochängstliche Personen zeigen eine verstärkte Tendenz, ihre Aufmerksamkeit selektiv auf Gefahrenreize auszurichten (Mathews, 1990) und verarbeiten diese Reize auch auf neuronaler Ebene intensiver als nichtängstliche Personen (Dilger, et al., 2003). Bisher ungeklärt ist, ob bedrohliche Reize tatsächlich die Aufmerksamkeit initial auf sich ziehen oder ob die beschriebenen Aufmerksamkeitsverzerrungen besserdurch Schwierigkeiten, Aufmerksamkeit von Gefahrenreizen abzuwenden, erklärt werden können. Darüberhinaus wurde bisher kaum untersucht, ob sich eine bevorzugte Verarbeitung von angstrelevanten Reizen auch auf die Wahrnehmung ängstlicher Personen auswirken kann.

Um verschiedene Aufmerksamkeitskomponenten direkt zu untersuchen, wurden in der *ersten Studie* dieser Dissertation sowohl manuelle Reaktionszeiten als auch Augenbewegungen erfasst. 21 Patienten mit Spinnenphobie und 21 nichtängstliche Kontrollpersonen sollten während der Suche nach einem neutralen Zielreiz aufgabenirrelevante kreisförmige Reize explizit ignorieren, die kleine Bilder von Spinnen (phobisch), Blumen (nicht phobisch, aber mit spinnenähnlicher Form), Pilzen (nicht phobisch und keine spinnenähnliche Form) oder kein Bild enthalten konnten. Wie erwartet zeigte sich, dass die Reaktionszeiten der Patienten in den Durchgängen langsamer waren, in denen aufgabenirrelevante Spinnen auftauchten. Allerdings zeigte die Analyse der Augenbewegungen, dass die Spinnen initial nicht häufiger fixiert wurden, sondern die

Patienten häufiger auf alle Distraktoren mit Bild schauten. Allerdings verweilte der Blick der Patienten länger auf den Spinnenbildern, was die verlangsamten Reaktionen auf den Zielreiz erklären kann. Diese Befunde unterstützen nicht die Annahme einer automatischen Entdeckung phobischer Reize, sondern weisen vielmehr auf Schwierigkeiten phobischer Patienten hin, die Aufmerksamkeit von Spinnen zu lösen.

In der *zweiten Studie* dieser Dissertation wurde ein binokulares Rivalitätsparadigma eingesetzt, um zu untersuchen, ob eine bevorzugte Verarbeitung phobischer Reize die visuelle Wahrnehmung bei Patienten mit Spinnenphobie beeinflussen kann. Bei diesem Paradigma wird jedem Auge ein unterschiedliches Bild dargeboten, was zu einem Wahrnehmungswechsel führt, bei dem jeweils ein Bild die bewusste Wahrnehmung dominiert während das andere unterdrückt wird. 23 Patienten mit Spinnenphobie und 20 nichtängstlichen Kontrollpersonen wurden standardisierte Bilder von Spinnen und Blumen, jeweils gepaart mit einem neutralen Muster, stereoskopisch dargeboten. Die Aufgabe bestand darin, durchgehend die dominante Wahrnehmung durch Tastendruck zu kodieren. Patienten mit Spinnenphobie berichteten häufiger und länger, Spinnenbilder dominant wahrzunehmen. Diese Wahrnehmungsdominanz von phobischen Reizen bei binokularer Rivalität weist darauf hin, dass eine bevorzugte Verarbeitung bedrohlicher Reize im visuellen System dazu führen kann, dass diese Reize auch verstärkt wahrgenommen werden.

Zusammenfassend unterstützen die Befunde beider Studien die Annahme, dass Patienten mit Spinnenphobie phobierelevante Reize innerhalb des visuellen Systems bevorzugt verarbeiten, was sich in verzögerter Aufmerksamkeitsabwendung zeigt und des Weiteren zu einer verstärkten Wahrnehmung der bedrohlichen Reizen führt.

1. General introduction

1.1 Preferential processing of emotional cues

Humans and other animals are permanently surrounded by a multitude of (visual) stimuli. Fast and effective detection, extraction, and analysis of relevant - in particularly threatening stimuli - helps to initiate adequate approach or avoidance behavior and therefore increases the chance of survival or well-being (Lang, Bradley, & Cuthbert, 1997).

A large body of research documents the privileged role of emotional and most notably of aversive stimuli. Within several neural visual processing domains emotional-relevant stimuli were found to be processed preferentially. Established methods to measure attentional allocation often comprises *visual search* or so called *dot-probe* deployment paradigms. In healthy subjects, results from search tasks show that negative pictures (e.g., angry faces or spiders) are detected faster when presented in an array among neutral pictures than vice versa (Hansen & Hansen, 1988; Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001). In line with this, dot-probe paradigms show that probes which appeared at the location of a previously shown emotional-relevant stimulus are detected faster (MacLeod, Mathews, & Tata, 1986; MacLeod, Rutherford, Campbell, Ebsworthy, & Holker, 2002; Mogg & Bradley, 2006; Mogg, Bradley, Miles, & Dixon, 2004). In addition to behavioral findings of attentional biases toward emotional stimuli, brain-imaging studies in healthy subjects showed an increased neural processing of affective pictures within emotion circuits (e.g., amygdala) as well as in the visual cortex (Herrmann et al., 2008; Lang et al., 1998; Morris et al., 1998). Likewise, enhanced processing of emotional cues has been found to be reflected in early and late components of the EEG (Schupp, Junghöfer, Weike, & Hamm, 2003a).

In sum, there is sound evidence that emotional stimuli possess a privileged role in attention and visual processing which can be regarded as evolutionary adaptive in healthy subjects.

1.2 Attention and perception in spider phobia

In high-anxious individuals attentional allocation toward threat and its' preferential processing seems to be elevated (Mogg & Bradley, 1998, 2006; Öhman, Flykt, et al., 2001; Pflugshaupt et al., 2005; Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005; Williams, Watts, MacLeod, & Mathews, 1997) and thus, turn into a dysfunctional status when the subjects are confronted with their feared objects.

Specific phobias and spider phobia in particular (which is the focus of the present studies) are considered as an advantageous model to investigate anxiety-related information processing: the feared objects are clearly defined and stimulus material can be well standardized. Spider phobia is the most prevalent subtype of specific phobias as well as of animal phobias with a life-time prevalence of circa 5 %. Women are about 2 to 3 times more likely than men to be diagnosed with spider phobia (Becker et al., 2007; Becker et al., 2000; Frederikson, Annas, Fischer, & Wik, 1996; Wittchen & Jacobi, 2006) (for further information on "Why we study spider phobia" see Appendix 7.1).

Studies which monitored brain activity while spider phobic patients viewed phobic material showed that blood flow in emotion processing areas and within the visual cortex is increased compared to non-anxious subjects (Alpers et al., in press; Carlsson et al., 2004; Dilger, et al., 2003; Larson et al., 2006; Öhman, 2005; Straube, Mentzel, & Miltner, 2006). Also, studies on event-related potentials indicate that phobic pictures are processed more intensively in phobic patients (Kolassa, Musial, Mohr, Trippe, & Miltner, 2005). The enhanced neural processing in visual areas and increased attentional allocation toward phobia-relevant stimuli clearly suggests that these particular stimuli exhibit a privileged role in attention and perception of phobic subjects. Nevertheless, until today the specific underlying mechanisms of biased attention in phobic individuals and a possible impact on visual perception are not completely understood.

1.3 Attentional bias: engagement or disengagement?

Surprisingly, it is not exactly clear which processes underlay attentional biases. Thus, a growing research interest is focused on specific features of attentional biases. Two alternative mechanisms are discussed: enhanced *engagement* or delayed *disengagement* from threat. While initial attentional capture by fear-relevant stimuli (engagement) is commonly proposed to account for attentional bias (Mogg & Bradley, 2006; Mogg, et al., 2004), other findings suggest that the reported attentional effects may be caused rather by a difficulty to disengage attention from threat (Fox, Russo, Bowles, & Dutton, 2001; Fox, Russo, & Dutton, 2002). The latter perspective emphasizes the special need for decomposing features of attentional biases across time (Cisler, Ries , & Widner Jr., 2007; Mogg & Bradley, 2006).

Furthermore, attentional biases seems to be only consistently found when fear-relevant material directly competes with neutral information for attentional resources (see Williams, et al., 1997). More consistent findings demonstrate that threatening stimuli distract from fear-irrelevant stimuli (or tasks) than attract attention per se (Fox, et al., 2001; Rinck, Becker, Kellermann, & Roth, 2003; Thorpe & Salkovskis, 1997).

Crucially, the majority of existing studies cannot disentangle engagement and disengagement processes since the time-course of attention was not registered or examined. Therefore, the *first study* of this dissertation investigated whether phobic cues distract phobic patients from a concurrent task. A novel method, eye-tracking, was employed which allows for a decomposition of features across time. The aim of the study was to examine whether initial attention toward threat or difficulties to disengage attention from threat are responsible for attentional bias in phobia.

1.4 Enhanced processing of threat in phobia: impact on perception?

Although several studies show that processing of highly arousing or threatening cues is special compared to neutral ones already at early stages of stimulus analysis (Lang, et al., 1998; Schupp, Öhman et al., 2004; Schupp et al., 2007) and that this effect is even more pronounced in fearful subjects (Alpers, et al., in press; Carlsson, et al., 2004; Larson, et al., 2006; Öhman, 2005; Straube, et al., 2006), only few studies investigated whether enhanced processing affect sensory perceptual processes. A recent study provides first evidence that emotion can indeed improve basic visual perception (Phelps, Ling, & Carrasco, 2006). Nevertheless, it remains unclear whether the perceptual outcome is improved or at least altered for fear-relevant stimuli as a result of the well documented enhanced processing and attentional benefits.

The *second study* of this dissertation aimed to investigate the perception of phobic stimuli in spider phobic patients. A *binocular rivalry* paradigm was implemented which allows to investigate whether specific stimuli gain preferential access to conscious perception and whether this is sustained over a longer period of time. Binocular rivalry occurs when different pictures are presented to the two eyes and cannot be merged into one meaningful percept: As a result the pictures compete for perceptual dominance, such that one picture is temporarily visible while the other picture is suppressed. Based on the finding that emotional relevance can promote predominance in binocular rivalry (see Alpers & Gerdes, 2007; Gerdes & Alpers, in press) it is hypothesized that phobic stimuli may also dominate the perception of phobic subjects. Thus, the second study focuses on the question whether the documented preferential processing and attentional benefits of phobic cues in the visual system actually leads to (prolonged) enhanced perception.

1.5 Aim of the dissertation

Taken together, the present dissertation aims to contribute to a more precise understanding of separate components in biased attention and altered perception of phobic cues in specific phobia. The two studies sought to add further information on the questions, (a) whether engagement or disengagement is an underlying mechanism in phobic patients' attentional biases and (b) whether phobic cues predominate the conscious perception in phobic patients over prolonged time

2. Experiment I: *Distraction by task-irrelevant phobic cues*

2.1 Introduction

2.1.1 Attentional biases in anxiety

As mentioned above the rapid detection and preferential processing of biologically prepared fear cues should be specifically attuned to phobic cues in patients with specific phobias (Mineka & Öhman, 2002). It has been suggested, that an underlying preattentive mechanism helps to detect threat cues and is followed by the enhanced attention toward fear-relevant cues (Öhman, Flykt, et al., 2001). The specialized neural circuitry needed for such preattentive analysis of fear-relevant stimuli is indeed available in all mammals: There are direct neural connections from sensory nuclei of the thalamus to the amygdala, which is central to emotional processing (Davis & Whalen, 2001). This connection, often called the "low road" of visual processing (LeDoux, 1996), enables a fast and automatic processing of emotionally relevant information even without intact visual cortex (Anders et al., 2004).

Evidence for an initial low-level processing of threat cues in healthy subjects comes from visual search paradigms which suggests that fear-relevant animal pictures are detected more quickly among neutral objects (Öhman, Flykt, et al., 2001). This effect is thought to take place at a preattentive perceptual stage because speeded detection is found to be unaffected by the number of distractors. Data from several dot-probe studies have also been interpreted as evidence for enhanced engagement of attention to threat cues (for a review see Mogg & Bradley, 1998) This attentional bias seem to be selectively enhanced in individuals who are afraid of these specific cues. For example, in a recent study spider fearful participants responded faster than non-anxious control participants to dots that appearing at the location of a previously shown spider picture. This was interpreted as an attentional bias for spider stimuli (Mogg & Bradley, 2006). Similar findings by Rinck (2006) demonstrated that spider fearful participants first fixation was more often on spider pictures in a free-viewing task.

2.1.2 Hypervigilance versus disengagement hypotheses

In spite of supporting evidence and considerable theoretical persuasiveness, several other data question the relevance of initial attentional capture by fear-relevant stimuli. First, the initial attentional bias for fear-relevant animals may be less specific than originally thought. The attentional bias is not limited to fear-relevant animals, but extends to other animals independent of how much they elicit fear (Lipp, 2006; Lipp, Derakshan, Waters, & Logies, 2004; Tipples, Young, Quinlan, Broks, & Ellis, 2002).

Second, a number of well-conducted studies did not find initial attentional capture by threat-relevant pictorial material at all (Batty, Cave, & Pauli, 2005). Instead, there is evidence that fear-relevant pictures may interfere with performance. For example, one dot-probe experiment revealed that fearful participants slow down across trials irrespective of target content (Merckelbach, Kenemans, Dijkstra, & Schouten, 1993). The authors hypothesize that this may be because anxiety induced a general interference with the task execution. Specifically, Koster and colleagues (2004) suggest that existing dot probe effects may not be caused by attentional capture but rather by a difficulty to disengage attention from threat. This idea is further supported by a recent study by Salemink and coworkers (2007) who showed that trait anxiety is indeed related to a difficulty to disengage attention from threat rather than to speeded orienting towards it in the dot-probe task.

In general, the effects of initial attentional capture or hampered attentional disengagement are difficult to separate – and this separation is especially difficult in search paradigms where intentional (top-down) and automatic (bottom-up) attention are confounded.

2.1.3 Distraction by fear-relevant stimuli

The faster detection of fear-relevant stimuli among neutral distractors – as reported above (Öhman, Flykt, et al., 2001) – could also emerge from slowed detection of neutral targets, presented among fear-relevant distractors (Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004;

Rinck, et al., 2005). This effect could be interpreted as distractibility due to fear stimuli. Direct evidence for distraction comes from search paradigms where the distractor and not the target was fear-relevant. Here, reaction times were slowed on trials with task-irrelevant but threat-related distractor stimuli and this effect was present in healthy and fearful participants (Lipp, 2006; Lipp & Waters, 2007). These findings may rather reflect delayed disengagement from fear-relevant distractors than enhanced attentional capture. Measuring only reaction time does not allow to differentiate between these processes.

Recent eye-tracking studies with spider phobic patients also do not show consistently that attention is captured when a phobic cue has to be searched but that these cues distract. While failing to replicate the pop-out effect eye-tracking revealed that phobic participants were slower when a neutral object was to be searched and a task-irrelevant spider picture distracted them from this task (Miltner, et al., 2004). Another eye tracking study did not find attentional capture by threat cues during search tasks (Rinck, et al., 2005), but shows more robustly that fearful participants are distracted by threatening background pictures and slowed down in their search for neutral targets. However, one needs to keep in mind that in free viewing tasks healthy controls were repeatedly found to initiate their initial saccades more often towards emotionally arousing pictures of scenes than to neutral scenes (Alpers, 2008; Nummenmaa, Hyona, & Calvo, 2006) .

Taken together, when fear-relevant stimuli are task-relevant an initial capture of attention cannot be found consistently. Instead, preferential processing may be more apparent when there is a competition for attentional resources (Mathews & Mackintosh, 1998). Eventually, the more robust findings for an attentional bias are found when fear-relevant stimuli are presented as task-irrelevant distractors. Under this condition it seems to be difficult for phobic patients to disengage their attention from these stimuli and this results in be observable in impairment in task performance. Recording eye movements provides the opportunity to distinguish the different processes. So far, the question remains, whether threatening stimuli

distract from ongoing task execution due to enhanced engagement or slowed down disengagement of attention or whether both accompany the processing of threatening stimuli (for a further discussion see Rinck & Becker, 2006; Williams, et al., 1997). Even though there is now considerable evidence showing that phobic material distracts, the specific underlying processes behind slowed reaction times have not been examined in much detail.

2.1.4 Aim of the study and hypotheses

The purpose of this experiment was to investigate how phobia-related but task-irrelevant stimuli interfere with an ongoing search tasks. In the majority of previous studies, the stimuli served as targets on some trials and distractors on others within the same experiment and a semantic stimulus comparison was therefore always necessary. For this experiment, it was particularly important that the spider pictures as well as the neutral pictures never had to be responded to throughout the experiment. While participants searched for a color singleton and identified a target letter inside of it, task-irrelevant phobic or neutral stimuli were presented in the periphery. Thus, the task did not require any semantic processing of the distractors. If attentional capture can be demonstrated under these conditions, this would be convincing evidence that threatening distractors capture attention independent of the demand to differentiate between the distractor pictures. In addition to measuring reaction times eye movements were registered to dismantle the processes involved in the expected distractor effect. The experimental procedure based on the finding that abrupt-onset distractors can sometimes not be ignored during controlled saccades to a target: Distractors are automatically fixated upon and reaction times to the target are slowed down (Godjin & Theeuwes, 2003; Theeuwes, Kramer, Hahn, Irwin, & Zelinsky, 1999). A methodological vagueness of previous eye-tracking search tasks was that they only reported overall gaze durations on target regions but not locations and durations of discrete fixations (see Miltner, et al., 2004; Rinck, et al., 2005). To clearly interpret eye movement data in terms of attentional processes the focus of

this study was on the characteristics of the initial fixation on distractors. In sum, the aim was to further examine the effects of task-irrelevant phobic distractors and to separate, whether differences in reaction times to neutral targets result from attentional capture or by slower disengagement when phobic cues are erroneously attended to.

We hypothesize that phobic patients are hampered in the execution of a task when phobic distractor appear in the periphery. This should be reflected in slower reaction times to the fear-irrelevant target because attentional resources are directed to the phobic cues instead of the targets. Furthermore eye movement data should help to identify, whether this distraction results from initial attentional engagement toward the threatening distractors, a delayed disengagement or is made up of both. Furthermore, we expect that distractor pictures which are similar in shape to spiders are distracting phobic patients more than distractors that are clearly unambiguous and not similar to spiders.

2.2 Pilot studies

The first main study and the experimental design were built up on the findings of two preceding pilot studies. One pilot study clarified that the chosen paradigm and experimental set-up in general is appropriate to investigate the research question. To finally optimize the design of the main study, a second pilot study was conducted to rule out remaining limitations and some vagueness emerged from the first pilot study particularly regarding the size of the display arrangement.

2.2.1 Pilot study I

For the first pilot study (for a detailed description of the study see Appendix 6.2) a paradigm – similar to the main experiment - was adopted in which peripheral visual stimuli automatically (bottom-up) capture attention and distract the execution of voluntary goal-directed (top-down) eye movements. Previous research has shown that when searching for a color singleton, top-down control cannot always prevent attentional capture by an abrupt visual onset (Theeuwes, et al., 1999). If emotional content is automatically processed even in peripheral vision such distractors should have an enhanced effect if they content threatening material. Therefore, abrupt onset stimuli with fear-relevant content were presented during the search for a neutral but peculiar target. The question was whether the occurrence of additional distractors influences eye-movement behavior and reaction times and if this influence is especially enhanced by a threatening content of distractors. In this pilot study 22 diagnosed spider-phobic patients and 22 non-anxious control participants were instructed to search for a gray singleton that served as target among red circles while ignoring everything else and respond to a letter inside this singleton. The abruptly appearing distractor contained either a small picture of a spider (fear-relevant) or a flower (neutral).

To briefly summarize the findings, phobic patients' manual response times on targets were longer whenever additional distractors appeared on the screen. The analysis of the eye-

movement data revealed that the reaction time deceleration was mainly caused by the frequency of fixations on the distractors: Spider phobic patients fixated more often than controls on the task-irrelevant distractor stimuli before fixating on the target. However, this distractor effect in phobic patients was independent of the fear-relevant or neutral content.

Moreover, an intensively inspection of the results indicates two presumptions.

First of all, on spider distractor trials, there was a trend that spider phobic patients responded slower to the target than control participants. This tendency cannot be explained by a higher frequency of distractor fixations – phobic patients fixated even more often on flower distractors. But the inspection of duration of fixations on distractor provides an explanation: if once glanced on, spider phobic patients fixated spider pictures longer than control participants.

Taken together, these preliminary results indicate that phobic patients are initially distracted from an ongoing task by all peripheral picture cues. Further on, if their eyes met a spider pictures, their fixations dwelled longer on these pictures than controls. In a broader sense, these findings can be interpreted as an unspecific initial hypervigilance or enhanced distractibility followed by a specific delayed disengagement from phobic pictures in phobic patients.

However, this study possesses some potential limitations. Overall, it remains unclear whether the findings reflect a general higher distractibility of phobic patients, or whether they show a kind of overgeneralization based on physical similarity of flower and spider pictures.

Furthermore, it is not assured that a peripheral differentiation of distractor pictures was possible in all cases. If fixations on distractors where always necessary to discriminate threatening pictures from neutral ones, it would be not astonishing that no specific differences for flower and spider pictures could be found. For the main study we decided to present *four* different kinds of distractor stimuli. Beside spider and flower pictures, the distractor circles could contain mushroom pictures that have a clearly different shape than spiders and flowers.

Furthermore, distractors with no picture inside were presented. This bears the opportunity to differentiate whether spider phobic patients are generally distracted by abrupt-onset distractors or rather tend to be distracted by spiders and by objects that resemble spiders in terms of cue generalization. To assure that a differentiation of the distractor pictures is possible in the periphery without eye movements, a second pilot study was conducted in order to test different arrangement of target and distractor stimuli.

2.2.2 Pilot study II

The aim of this pilot study was to identify an optimal arrangement, which ensures that peripheral identification of the distractor picture is possible (for a detailed description of the pilot study II see Appendix 6.3). Particularly with regard to the main study mushroom pictures were added as distractors, which were distinct from spiders and flowers in shape.

Thirteen student individuals participated in this pilot study[1]. Similar to the pilot study I, display arrangements were presented (see Figure 1), but the circles were presented at three different distances from the center of the screen, resulting in the visual angles of 12.7° (large), 9.8° (medium), 7.4°(small). Each display consisted of five red circles with small letters inside, one gray circle with a letter and one red distractor circle which included one of the 24 different spider, 24 flower or 24 mushroom pictures. The task of the participants was to fixate the central fixation cross and identify the distractor picture without any movements of their eyes. All other circles had to be ignored during this experiment. During the whole task, eye movements were recorded to ensure that participants' fixations remain continuously on the central fixation cross. Altogether, the peripheral identification performance of M = 84.9 %

[1] There is no theoretical notion that spider fearful subjects should show a *lowered* identification performance than non-anxious subjects. In fact, it is more likely that they could have been better in identifying spider pictures. Therefore we chose non-selected students to assure that all participants were able to identify the pictures satisfyingly

(*SD* = 4.92) was satisfying. Additionally, signal detection indices were computed and compared between the visual angles. For the main study, the results of this pilot study (see Appendix 6.3.4) provide to apply a visual angle of 9.8° (medium) for the final display arrangement.

2.2.3 Conclusions relevant for the main study

Taken together, both pilot studies make important contribution to the experimental setup of the main experiment. For the distractor pictures, it turns out that it is important to present pictures which are similar as well as pictures which are not similar to spiders in appearance: This allows for investigating whether phobic patients' response to spider is comparable to picture that are similar to spiders in terms of generalization. Therefore spiders, flowers (similar to spiders in shape), and mushrooms (not similar to spiders in shape) and circles with no pictures served as distractors. Different visual angles of the display arrangement were also pretested to select a display arrangement which provides a sufficient identification rate of the distractor picture in peripheral vision and rule out that eye movements to the pictures are necessary to discriminate the pictures.

2.3 Method

2.3.1 Participants

For the main study, twenty-five spider phobic patients and 25 non-anxious control participants were recruited by advertisements in a local newspaper. Potential candidates were invited when they passed a phone-screening using the German Spider Anxiety Screening (SAS, Rinck et al., 2002) with a score above 18 for the spider phobic patient group (spider fearful groups had a range of 18-24 in normative samples) or below 5 for the non-anxious control group (non-anxious participants ranged from 0 to 3 in normative control samples). Exclusion criteria were psychoactive medication, acute drug intake, as well as any

neurological or mental disorder. Eligible participants were then interviewed by a trained research assistant using the Structured Clinical Interview for DSM-IV (SCID, Wittchen, Gruschwitz, Wunderlich, & Zaudig, 1997) and spider phobic patients were included when they met full DSM-IV criteria for spider phobia (APA, 1994). For the non-anxious control participants none of the criteria for specific phobia were fulfilled.

In spite of being diagnosed positively in the SCID one patient was later excluded because his scores were extremely low - and even not different to non-anxious control participant scores - on all spider phobia questionnaires. Two participants of each group were excluded because of acute intake of psychoactive medication, two patients and one control participant due to excessive body movement or technical problems during eye movement recording. Twenty-one participants remained in both groups. All had normal or corrected to normal vision and mean age did not differ between the groups, (phobic patients: M = 30.43, SD = 8.94; range 18-44; control participants: M = 36.10 years, SD = 12.09, range: 18-63, $t(40) = 1.73$, p = .092). One patient and 3 control participants were male (none of the results listed below were different if males were excluded).

The mean scores of the spider phobia questionnaires (Fear of Spiders Questionnaire (FSQ) and Spider Phobia Questionnaire (SPQ) , German versions, Rinck, et al., 2002), as well as state and trait anxiety (State and Trait scales of the German version of the Spielberger State-Trait Anxiety Inventory (STAI), Laux, Glanzmann, Schaffner, & Spielberger, 1981) and the actual affect are shown in Table 1. As expected, the spider phobic patients scored significant higher on the FSQ, $t(40) = 14.56$, $p < .001$; and on the SPQ: $t(40) = 15.61$, $p < .001$. The patients scored higher on the FSQ than patients norms, p =.031, whereas the control participants did not differ from non-anxious normative data, p = .870 (according to Rinck, et al., 2002). There were no significant differences in trait or state anxiety (STAI) between the groups and both groups were in the normal range. Positive and negative affect (Positive and Negative Affect Scale (PANAS), Krohne, Egloff, Kohlmann, & Tausch, 1996) were

compared prior and after the experiment with separate repeated measurement between-subject ANOVAs. Regarding the positive affect the groups did not differ on the positive affect scale prior or after the experiment, whereas for the negative affect a significant interaction of group and time ($F(1, 40) = 6.35$, $p = .016$) indicated that the phobic patients had higher scores on the negative affect scale than the control participants after the experiment (see possible confounds below).

Table 1: Mean questionnaire scores (standard deviations, and *t*-statistics) separately for the non-anxious control participants (n = 21) and the spider phobic patients (n = 21).

	Phobic patients	Non-anxious participants	*t*-tests (*df* = 40)	
Questionnaire	*M* (*SD*)	*M* (*SD*)	*t*	*p*
SAS	21.48 (2.16)	1.14 (1.52)	35.24	< .001
SPQ	70.86 (19.98)	1.95 (3.19)	14.56	< .001
FSQ	21.71 (5.41)	3.33 (2.03)	15.61	< .001
STAI-T	37.86 (9.02)	35.81 (6.97)	.82	.415
STAI-S	38.76 (9.91)	34.95 (7.92)	1.38	.177
PA- t1	31.24 (5.34)	31.38 (5.28)	.087	.931
NA- t1	13.86 (3.09)	12.48 (3.47)	1.36	.181
PA- t2	25.19 (4.77)	28.76 (7.15)	1.90	.064
NA- t2	15.19 (4.86)	10.81 (1.47)	3.95	< .001

Note. SAS = Fear of Spiders Screening (Rinck, et al., 2002) ; FSQ = German version of the Fear of Spiders Questionnaire; Szymanski & O'Donohue, 1995; (see Rinck, et al., 2002); SPQ = German Version of the Spider Phobia Questionnaire; Watts & Sharrock, 1984; (see Rinck, et al., 2002); STAI–T = State–Trait Anxiety Inventory – Trait form; STAI-S: State–Trait Anxiety Inventory – State form (Laux, et al., 1981); PA = Positive affect scale, NA = Negative affect scale of PANAS = German version of the Positive and Negative Affect Schedule (Krohne, et al., 1996), t1 = prior the experiment, t2 = after the experiment.

2.3.2 Stimulus material

The stimulus material consisted of two different displays with gray circles and red circles (see Figure 1). The first display contained 6 small gray circles (3.7° in diameter) each with a small gray number (0.3° by 0.4°) inside. These six circles always appeared at clock positions 1, 3, 5, 7, 9 and 11 o'clock arranged on an imaginary circle with a radius of 9.8° (see also appendix - Pilot study one) and a red fixation cross in the middle. The second display also consisted of 6 small circles on these positions, but five circles were red and only one circle was gray. The gray circle contained a target letter (C or reversed C) and the red circles contained small other letters (S, H, E, P, and F).

In addition, there were red distractor circles which contained either no picture or a small gray-scale picture of a spider, a flower or a mushroom. Overall, 24 different pictures of each category were used. These distractor circles appeared at one of six locations (at positions 2, 4, 6, 8, 10, or 12 o'clock), but at least with a 30° angle distance to the gray target circle.

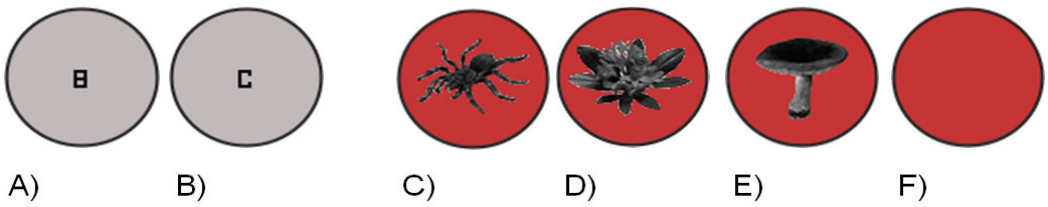

Figure 1: Examples of A) a circle with small number (mask - first display), B) a target circle and distractor circles (second display) with C) a spider distractor D) a flower distractor E) a mushroom distractor and F) an empty distractor.

2.3.3 Experimental task

The trial structure is depicted in Figure 2. Before each trial there was a fixation cross that disappeared after it was fixated for at least 1.5 s. Then, the first display with a central fixation cross and six gray circles appeared. After the participant had looked at this fixation cross for another 1.5 s all circles but one simultaneously changed to red and the number inside the circles changed to the different letters. The target letter was located in the remaining gray circle and the participants were explicitly instructed to directly move their eyes to the single gray circle and indicate as fast as possible the letter's orientation with the left or right control key respectively. Because the circles were presented in the periphery and the target letters were small, it was necessary for the participant to execute a saccade to the gray circle in order to correctly identify the target letter. In each of these displays one additional red circle as distractor appeared simultaneously with the search display. The presentation duration of the search-displays was terminated by the participant's manual response to the target letter. The inter-trial-interval was 500 ms.

In the first block of 24 trials no distractor circles appeared so that baseline reaction times to targets for both groups could be obtained. This was followed by a second block with 96 trials in which the additional red abrupt-onset distractors appeared. There was either no picture in it or a small gray-scale picture of a spider, a flower or a mushroom was placed inside of the distractor. Positions of targets and distractors were counterbalanced across the trials and the presentation order within the blocks was randomized.

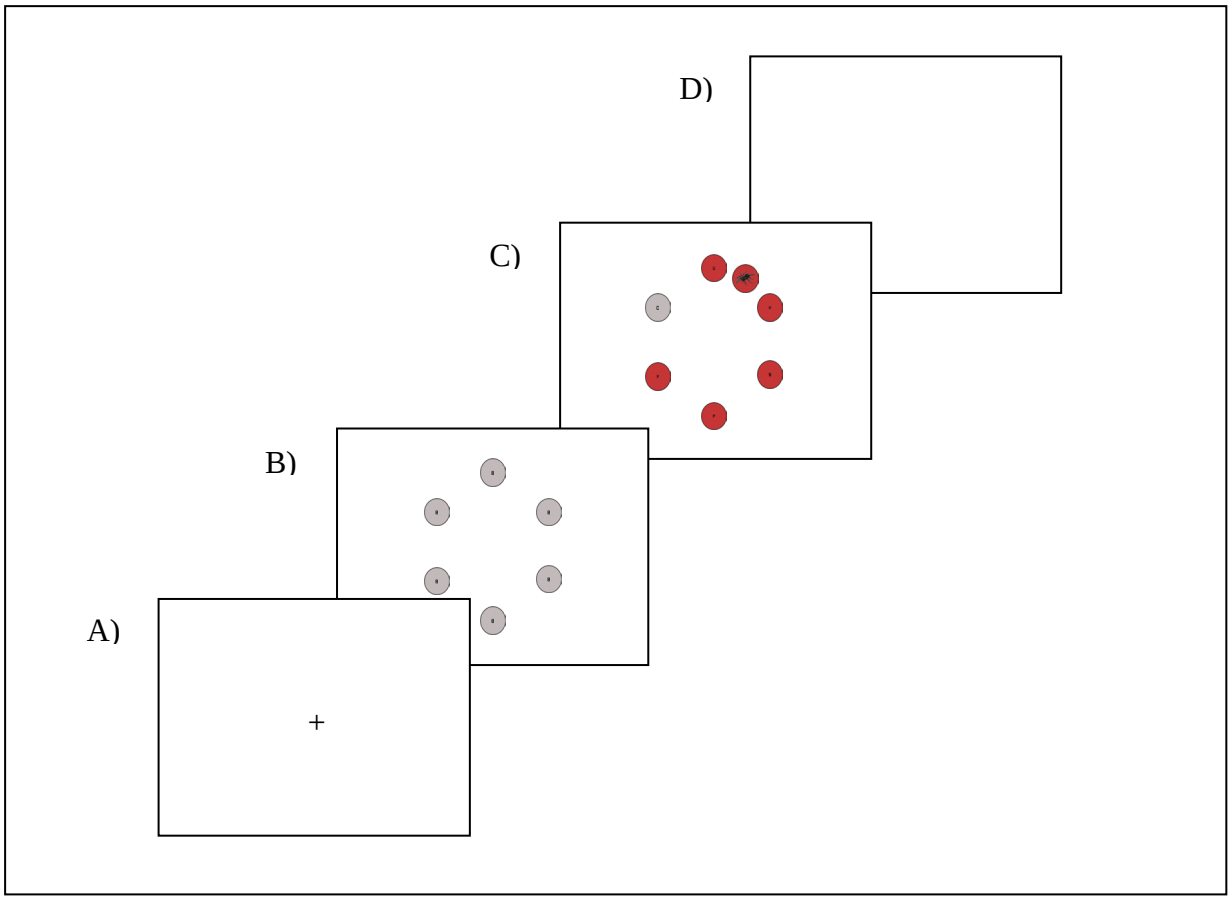

Figure 2: Example of trial sequence: A) fixation cross, B) first display, C) second display, D) inter trial interval.

2.3.4 Apparatus

2.3.4.1 Software

Presentation of instructions and stimuli as well as recording of reaction times was controlled by the software Presentation® (Version 0.90, www.neurobs.com). A 17-inch flat screen monitor with a resolution of 1024 by 768 was used.

2.3.4.2 Recording of eye movements

Participants were seated 50 cm in front of the monitor and eye movements were recorded with an infrared system (iView X, SensoMotoric Instruments, Teltow, Germany) with a temporal resolution of 238 Hz and a spatial resolution of approximately 0.5-1º. The integrated forehead and chin rest minimized head movements and the system was calibrated individually prior to the experimental task (for the experimental set-up see Figure 3).

Figure 3: Experimental set-up: infrared eye-tracking system with integrated forehead and chin rest.

2.3.5 Procedure

All procedures were approved by the ethics committee of the German Psychological Association (DGPs) and written informed consent was obtained. The patients were offered access to a self-help intervention after their participation, the control group received a 10 € compensation for their participation. There were two sessions for each participant. First, the SCID (Wittchen, et al., 1997) was performed and the participant filled in sociodemographic and trait questionnaires. For eligible participants the second session began with the state questionnaires. Before calibrating the eye-tracking system, instructions and 12 practice trials were presented. After the calibration and another 12 practice trials the main part started. Afterwards the participants rated the distractor picture categories on valence (-4 to +4, anchored as “very negative” and “very positive”) and arousal (1 to 9, anchored as “not at all intense” and “very intense”).

2.3.6 Data analysis

For all analyses the α-level was set at .05. Degrees of freedom were Greenhouse-Geisser corrected but the original degrees of freedom are listed. For significant effects revealed by the ANOVAS, follow-up *t*-tests (two-tailed) were conducted.

As measures of effect size, partial eta squared (η_p^2) for the ANOVAs and Cohen’s d for the *t*-test are reported.

2.3.6.1 Picture ratings

Mean valence and arousal ratings were compared in separate between-subject ANOVAs with the within-subject variable distractor picture category (spider, flower, mushroom).

2.3.6.2 Reaction times to targets

The mean manual reaction times to targets were calculated separately for each distractor category. Errors were rare and discarded from analyses: phobic group M = 3.11 %, SD =2.76; control group M = 1.79%, SD =1.79. Reaction times below 300 ms and greater than 3000 ms were excluded as outliers.

To rule out baseline-differences in reaction times, two-tailed *t*-tests between the groups for the first block (no distractors) were calculated, and for the mean reaction times a between-subject ANOVA with the within-subject variable distractor category (spider, flower, mushroom, and empty) was calculated.

2.3.6.3 Eye movements

Fixations were defined as scanpath data limited to a maximum radius of 2.02° visual angle for at least 80 ms (BEGAZE Software, SensoMotoric Instruments, Teltow, Germany). The mean number of first fixations on distractors (error fixations) was determined for the distractor trials, as well as the mean duration of these fixations. For the numbers of fixations a between-subject ANOVA was run with the within-subject variable distractor category (spider, flower, mushroom, and empty).

2.3.6.4 Possible confounding variables

To control for differences in descriptive variables correlations and analyses of covariance were calculated.

2.4 Results

2.4.1 Picture ratings

For the valence ratings of spider, flower and mushroom pictures, there were main effects of picture category, $F(2, 80) = 32.36$, $p < .001$, $\eta_p^2 = .45$, and group, $F(1, 40) = 33.52$, $p < .001$, $\eta_p^2 = .46$, as well as a significant Picture Category X Group interaction, $F(2, 80) = 18.56$, $p < .001$, $\eta_p^2 = .32$. Spider phobic patients rated the spider pictures (M = -2.95, SD = 1.36) significantly more negative than the non-anxious control group (M = -.10, SD = .625), $t(40) = 8.75$, $p <.001$, $d = 2.69$, but there were no reliable group differences in the valence ratings of the flower and mushroom pictures. Within the groups, spider phobic patients rated the spider pictures as more negative than the flower ($t(20) = 7.14$, $p < .001$) and mushroom picture ($t(20) = 7.60$, $p < .001$), but there were no differences between flower and mushroom pictures.

The non-anxious control group rated the spider pictures as more negative than the flower pictures ($t(20) = 3.10$, $p = .006$), but there were no differences between spider and mushrooms or flower and mushroom pictures.

Arousal ratings also differed according to a priori expectations: There were main effects of picture category, $F(2, 80) = 16.98$, $p = .001$, $\eta_p^2 = .30$, and group, $F(1, 40) = 15.27$, $p < .001$, $\eta_p^2 = .28$, as well as a significant Picture Category X Group interaction, $F(2, 80) = 21.81$, $p < .001$, $\eta_p^2 = .35$. Spider phobic patients rated the spider picture significantly more arousing (M = 7.24, SD = 1.90) than the non-anxious control group (M = 3.24, SD = 2.00), $t(40) = 6.69$, $p < .001$, $d = 2.05$, but there were no differences in the arousal ratings of the flower pictures (phobic patients: M = 5.14, SD = 1.53; control participants: M = 4.19, SD = 2.04) or the mushroom pictures (phobic patients: M = 4.00, SD = 1.64; control participants: M = 3.29, SD = 2.10). Within the groups, spider phobic patients rated the spider pictures as more arousing than the flower ($t(20) = 6.08$, $p < .001$) and mushroom picture ($t(20) = 6.22$, $p < .001$), but

there were no differences between flower and mushroom pictures. Flowers were rated as slightly more arousing than the mushroom pictures ($t(20) = 2.52$, $p < .020$).

In contrast, the non-anxious control group rated the flower pictures as more arousing than the spider ($t(20) = 3.05$, $p = .006$) and mushroom pictures ($t(20) = 2.58$, $p = .018$) and there were no significant difference between spider and mushroom pictures.

2.4.2 Manual reaction times

2.4.2.1 Baseline reaction time to targets

During the initial 24 trials without distractors the manual reaction times to targets did not differ between the groups (phobic patients: $M = 774$ ms, $SD = 129$; control participants: $M = 823$ ms, $SD = 206$).

2.4.2.2 Distractor trial reaction time to targets

The mean reaction times are shown in Figure 4. The ANOVA for the mean reaction times to targets on distractor trials showed a significant main effect of distractor category, $F(3, 120) = 16.90$, $p < .001$, $\eta_p^2 = .30$, and a significant Distractor Category X Group interaction, $F(3, 120) = 7.02$, $p = .001$, $\eta_p^2 = .15$. The follow-up *t*-test shows that patients' were significantly slower to respond to the neutral target on trials with spider distractor than control participants' (phobic patients: $M = 955$ ms, $SD = 210$; control participants: $M = 839$ ms, $SD = 114$), $t(40) = 2.24$, $p = .031$, $d = .69$. The reaction times did not differ between groups on trials with flowers (phobic patients: $M = 924$ ms, $SD = 193$; control participants: $M = 846$ ms, $SD = 143$), mushrooms (phobic patients: $M = 867$ ms, $SD = 148$; control participants: $M = 839$ ms, $SD = 114$), or empty distractors (phobic patients: $M = 841$ ms, $SD = 172$; control participants: $M = 809$ ms, $SD = 122$).

Within groups, spider phobic patients' target reaction times were slower on trials with spider and flower distractors than on trials with empty distractors (spider – empty: $t(20) = 4.28$, $p < .001$, $d = .59$, flower – empty: $t(21) = 5.79$, $p < .001$, $d = .45$). Reaction times to targets were

faster on trials with mushrooms compared to spiders, $t(20) = 4.03$, $p = .001$, $d = .49$, and flowers, $t(20) = 3.51$, $p = .002$, $d = .33$, but only slightly faster on trials with empty distractors, $t(20) = 1.86$, $p = .078$, $d = .16$. Unexpectedly, there were no significant differences between spider and flower trials.

Control participants' reaction times were also slightly but significantly slower on all trials with picture distractors than on trials with empty distractors (spider – empty: $t(20) = 3.04$, $p = .006$, $d = .25$; flower – empty: $t(20) = 3.70$, $p = .001$, $d = .28$; mushroom – empty: $t(20) = 3.88$, $p = .001$, $d = .26$), but there were no differences in reaction times between the picture categories.

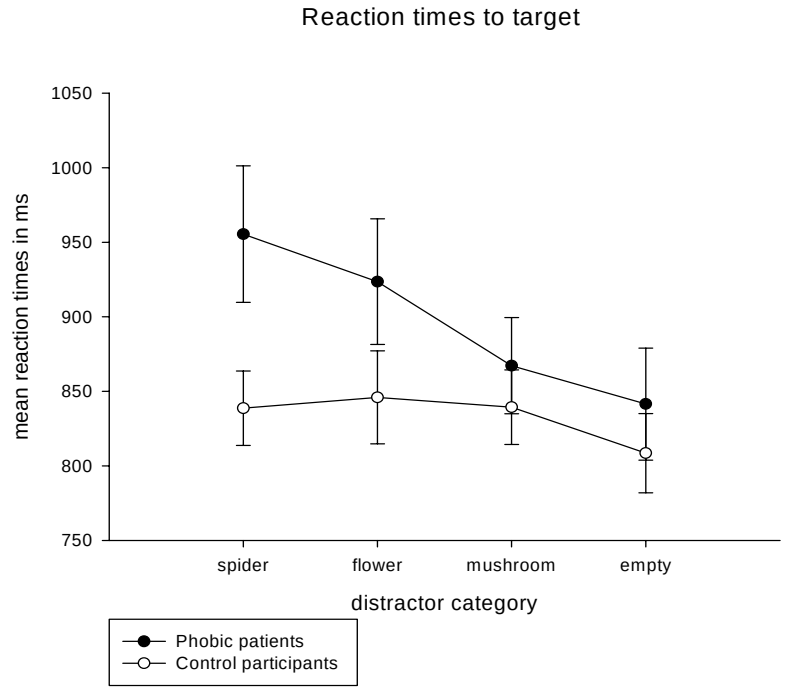

Figure 4: Mean manual reaction times (and standard errors) to targets on distractor trials.

2.4.3 Eye movement data

2.4.3.1 Number of error fixations

The number of error fixations on distractors clearly differed between groups (see Figure 5, left chart) but the pattern does not correspond well with the manual reaction times to targets. There was a main effect for distractor category, $F(3, 120) = 55.97$, $p < .001$, and group, $F(1, 40) = 12.86$, $p = .001$, $\eta_p^2 = .58$, and a significant Group X Distractor Category interaction, $F(3, 120) = 8.11$, $p < .001$, $\eta_p^2 = .17$. The follow-up *t*-tests indicate that spider phobic patients made more error fixations on all distractors than the control participants (spider: $t(40) = 3.59$, $p = .001$, $d = 1.11$; flower: $t(40) = 3.50$, $p = .001$, $d = 1.08$; mushroom: $t(40) = 3.19$, $p = .003$, $d = .98$; empty: $t(40) = 2.34$, $p = .024$, $d = .72$). Both groups made more fixations on all picture distractors compared to empty distractors (phobic patients: all $p < .001$; control participants: all $p < .001$). Unexpectedly, phobic patients executed even somewhat more frequently error fixations to flower than to spider distractors, $t(20) = 2.20$, $p = .04$, $d = .20$, and not significant more error fixations on spider than on mushroom distractors.

Within the non-anxious control group, there were no differences for the number of error fixations between the picture categories.

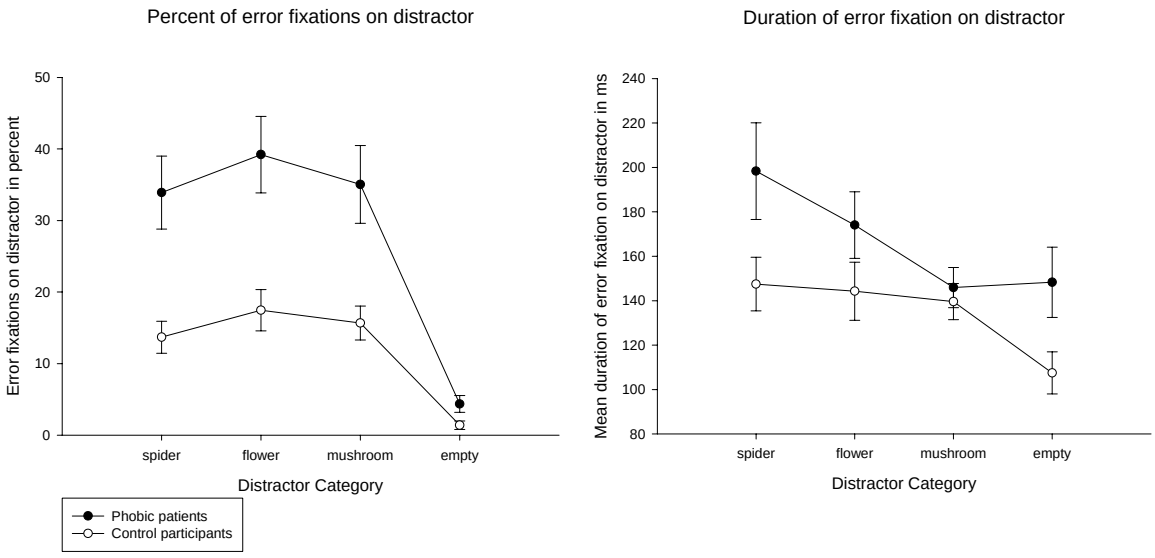

Figure 5: Eye movement results: Mean number (and standard errors) of error fixations on distractors in percent (left chart) and mean duration (and standard errors) of error fixations on distractors in ms (right chart).

2.4.3.2. Duration of error fixations

In order to clarify what causes the longer reaction times on spider trials in the phobic patient group the mean duration of error fixations on distractors was compared. The mean duration of fixation time on distractor pictures are presented in Figure 5, right chart. Because fixations on distractors only occurred on a limited number of trials in the non-anxious control group (see Figure 4, left chart) resulting in unequal cell sizes an ANOVA was not appropriate. Therefore, *t*-tests between and within the two groups were calculated for each distractor category. These *t*-tests indicate that, when error fixations landed on spider distractors, phobic patients' fixations lasted significantly longer (M = 201 ms, SD = 104) than those of the control participants (M = 148 ms, SD = 52), $t(38) = 2.03$, $p = .049$, $d = .65$. There were no significant differences between the groups for the mean duration on flower, mushroom or empty distractors.

Within the phobic patients, the mean duration on spider and flower distractors did not differ significantly, whereas spider distractors were fixated longer than mushroom ($t(20) = 2.49$, p =

.022, d = .67) and empty distractors, $t(11) = 2.39$, p = .036, d = .64. Flower distractors were fixated longer than empty distractors ($t(11) = 2.24$, p = .047, d = .43), but not significant longer than mushroom distractors.

Within the control group, there were no significant differences for the mean duration between the distractor categories, all $p > .14$.

2.4.4 Possible confounding variables

Significant correlations can be observed between the negative affect score after the experiment and the reaction time on spider and flower distractor trials (all $r(42) >= .38$, all ps <= .014). The between- subject ANCOVA for the reaction time and the covariate negative affect showed that the Distractor Category X Group interaction remained significant, $F(3, 117) = 4.45$, p = .015, η_p^2 = .10. Taken together, the reported results were not significantly influenced by group differences other than by fear of spiders.

2.5 Discussion

The present study - which clearly confirms the preliminary findings of the pilot study - shows that phobic patients are distracted from ongoing tasks by abruptly appearing task-irrelevant phobic cues. Reaction times and eye movements of diagnosed spider phobic patients were compared with non-anxious control participants. The purpose was to highlight possible differences in the initial and subsequent allocation of attention in the presence of phobic distractor pictures presented in the visual periphery. Phobic patients were distracted from a search task when task-irrelevant distractors with a small picture inside appeared on the screen. This effect was most pronounced for distractors depicting a spider. Eye movement data revealed that this difference in reaction time to neutral targets was not due to an initial attentional capture by spider cues – whenever the distractor contained any kind of a small picture the likelihood increased that patients looked at it. The enhanced distraction by spider cues seems to mainly originate from an extended duration of error fixations on spider pictures. Thus, slowing of reaction times can be explained by slowed disengagement from spiders.

2.5.1 Distractor effects

The findings correspond well with previous data that has suggested that spider phobic patients may be easily distracted by spider cues. The reaction time data show that phobic patients were mainly slowed on trials, where the distractor contained a spider picture. Similarly slowed reaction times to neutral targets were found in previous search task paradigms when spiders were presented as distractors (Lipp & Waters, 2007; Miltner, et al., 2004; Rinck, et al., 2005). Such a distractor effect was even found here when neither the identification of a spider nor its comparison with other semantic categories was involved in the task instructions.

A theoretical framework for the findings that spider phobic patients are distracted by task-irrelevant picture cues – and especially by spider cues is offered by the attentional control theory (Eysenck, Derakshan, Santos, & Calvo, 2007). This theory proposes that anxiety disrupts the balance between goal-directed and stimulus-driven attentional systems. Such an imbalance reduces inhibitory control of attention towards task-irrelevant stimuli – especially so if they are salient or conspicuous distractors. The sudden onset distractors (with pictures in them) that were presented are clearly salient distractors and therefore phobic patients cannot always prevent the allocation of attention toward these distractors – especially if the distractors contain spider pictures.

Interestingly, the present data extend previous findings in terms of cue generalization. Across distractor picture categories the reaction times were slowed down in a linear fashion: Phobic patients' reaction times were the same as the control group's when the distractor did not contain a picture, they were slightly slower on trials with mushrooms (not similar to spiders in shape), they were clearly slower on trials with flowers (similar to spiders in shape), and slowest on trials with spider pictures.

2.5.2 Initial capture of attention and disengagement

Because it is often suggested in the literature that threat is detected preattentively and followed by a shift of attention toward the threatening stimulus (e.g. Öhman, Flykt, et al., 2001), it was examined whether the first fixations after the search display's onset would be directed toward the abrupt-onset spider distractors in patients. Considering previous eye-tracking studies, a deployment of the first saccade has not been shown convincingly when spiders were the search target (Miltner, et al., 2004; Rinck, et al., 2005), but initial eye-movements were clearly more often issued toward spiders when they were presented as a distractor (Miltner, et al., 2004) or when no task was required (Rinck & Becker, 2006).

Contrary to this hypothesis, the eye movement data of the present study showed that the phobic patients' frequency of error fixations on distractors was not any more likely when the distractor picture was a small spider than any other picture content. Initial attentional capture was equally likely whenever a small picture was located inside the distractor cues. Thus, attentional capture was completely independent of fear-relevance. Therefore, attentional capture cannot explain the specific distraction effect found for reaction times on trials with spider distractor.

Although some of the previously reported studies provide evidence for an initial attentional capture by threat-relevant cues (Mogg & Bradley, 2006; Öhman, Flykt, et al., 2001; Rinck, et al., 2005) and one study showed that a hemodynamic response in the amygdala can be observed even in the absence of awareness (Carlsson, et al., 2004), there are also fMRI studies where no clear evidence for automatic activation could be found (Alpers, et al., in press; Pessoa, 2005; Pessoa, McKenna, Gutierrez, & Ungerleider, 2002).The non-specific attentional capture observed here can best be explained as a state of hypervigilance when pictures that could possibly represent a spider are presented in the periphery. Importantly, this does not seem to result in any interference in the absence of pictures within the distractor - patients did not differ from control participants when no pictures appeared in the distractor circle.

This hypervigilance cannot explain why reaction times to targets were slowest in the presence of spider distractors. Only the analysis of additional eye movement components explained the spider specific group differences: When patients erroneously issued a fixation on the distractor, the duration of these fixations were significantly longer on spider pictures than those of controls. Even if these findings should be cautiously interpreted, because of the rare fixations on distractors, one can interpret this as a deficit in the disengagement of attention from spiders in spider phobic patients. Therefore, being distracted from an ongoing search

task can arise from an unspecific attentional capture by pictures followed by a phobia-specific difficulty to disengage attention from the spider.

2.5.3 Specific conditions for the observed effects

While most previous studies required a semantic comparison of target and distractor stimuli, the task here was explicitly to ignore all distractors throughout the experiment. To study the effects of phobic cues without constant evaluative demands on these may be more similar to natural conditions. While phobic patients often report that they take note of spiders in their natural environment this is not because they are prompted externally to search for them. In addition, during the task the distractors were presented in the periphery which is probably comparable to naturalistic situations.

In general, differences in specific task instructions and in display arrangements have to be considered when results from different studies are compared. In this paradigm, the presentation of peripheral distractors might have rendered the pictures difficult to identify and therefore diminished possible initial attentional capture effects, but at least the pilot study with students demonstrated, that all distractor pictures could still be identified at this distance. Even if patients voluntarily decided to distinguish whether or not a spider was present it would not have been necessary for them to issue a fixation on the distractor.

Therefore, it can be suggested that the impulse to more often fixate the distractor pictures was not completely intentional but may be partly based on automatic responses. Other studies have not reported how well participants were able to discern the target/distractor displays in peripheral vision. However, typical displays in search tasks with about 20 similar distractors (e.g., Rinck, et al., 2005) are certainly more complex than the material used here and also contain peripheral presentation.

2.5.4 Unspecific hypervigilance and specific disengagement deficit

The hypervigilance that was observed in phobic patients probably operates at a preattentive level, similar to other preferential perception of emotional material in other paradigms where voluntary control is difficult (Alpers & Gerdes, 2007). This idea is reflected in several hypervigilance theories which assume that the preattentive alarm system is hyperactive and transmits abnormally frequent and intense false threat alarms in patients with anxiety disorders (Sawchuk, Meunier, Lohr, & Westendorf, 2002). Mogg and Bradley (1999) stated that a lower threshold for responding to emotionally ambiguous stimuli characterizes the stimulus evaluation system in anxious individuals. Therefore, activation of threat responses should already occur to information containing ambiguous stimuli – such as the flowers in this study which can be confused with spiders. However, there were not more error fixations on spiders or flowers than on mushrooms, although the latter were certainly less ambiguous. However, the durations of error fixations (and therefore the reaction times) reflect the similarity to spiders: the longest error fixations were on spider distractors, somewhat shorter on the flower distractor, again shorter on mushroom distractors, and finally shortest on trials with empty distractor.

It has been suggested by others that anxiety causes a shift into a hypervigilance mode (Lange, Tierney, Reinhardt-Rutland, & Vivekananda-Schmidt, 2004). In this mode the cognitive system prioritizes the initial automatic encoding of threat stimuli which results in larger difficulties to disengage from distractors that contain a fear-relevant cue (Mathews & Mackintosh, 1998). Several studies which also aimed to dismantle different attentional processes suggested that threat stimuli do not necessarily capture but hold attention (Fox, et al., 2001; Fox, et al., 2002; Salemink, et al., 2007).

In the same way, a hypervigilance theory of Eysenck (1992) proposes that anxious people scan their environment excessively and have a broadened attention span prior the detection of a salient stimulus; when a salient stimulus is detected the attention will be focused for an

intensively processing. This narrowing may explain why patients stuck with the spider distractors before moving on to the target. In the animal model this defensive behavior has been described as attentive immobility which occurs after a potential predator is detected (Fanselow, 1994; Fanselow & Lester, 1988). In humans, this may be associated with a more thorough analysis of the imminent threat. The fast allocation of attention to all unexpected picture cues and the following close observation of the spider may serve a strategic goal to be "better safe than sorry" (Mineka, 1992).

2.5.5 Disengagement and avoidance

The delayed disengagement observed here is probably not an entirely voluntary process because it is not plausible that patients expose themselves to threatening pictures any longer than needed; proceeding and responding to the target would have been the most efficient strategy to remove the spider picture from the screen. However, the results of the present study do not necessarily contradict other findings which showed that anxious subjects avoid looking at threatening stimuli when they are free to move their eyes around during extended free viewing conditions (Hermans, Vansteenwegen, & Eelen, 1999; Mogg, et al., 2004; Pflugshaupt, et al., 2005; Rinck & Becker, 2006; Rohner, 2002). In these studies, avoidance can usually not be observed until after the first second of exposure to the cue and therefore much later than the time frame which was examined here. Furthermore, Wieser and his colleagues (Wieser, Pauli, Alpers, & Mühlberger, in press) could not even show avoidance behavior during long exposure to threatening stimuli.

2.5.6 Limitations

The presented study has some potential limitations. First, the number of error fixations was overall rather small, resulting in relatively few trials for the following analyses of fixation duration. However, the variance observed was not very large and the crucial analyses clearly had enough power to document significant differences.

Second, as in all studies using pictures of spiders, it is difficult to find neutral material matched for physical characteristics. Therefore all pictures were presented in grayscale. Moreover, flowers with relatively similar shapes and mushrooms that were clearly different to spiders were included.

Third, it remains unresolved whether spider phobic patients behave differently because they were explicitly recruited for fear of spiders or because they were informed right from the start, that spider pictures will be presented in the task. This anticipation could have biased their behavior in the experiment but this is obviously not unique to this study.

Furthermore, the lack of spider-specific findings for the initial fixations may be caused by the peripheral presentation. It is not possible to completely rule out that it was difficult to distinguish the picture content. However, as reported above, a pilot study suggested that the pictures can be identified even if presented in the periphery.

2.5.7 Conclusion

This is the first eye-tracking study which examined how patients with a specific phobia of spiders respond to completely task-irrelevant spider distractors. The results indicate that initial attentional engagement toward phobic cues is less specific than often suggested - it was rather found that patients were hypervigilant to all categories of pictorial distractors. Instead, a specific difficulty to disengage attention from phobic distractors was revealed for phobic patients. In sum, this study clearly helps to disentangle biases in early attentional processing which underlie reaction time differences previously observed in phobic patients in response to phobic stimuli.

2.5.8 Outlook on experiment II

The first experiment showed augmented attention of spider phobic patients to phobic pictures due to delayed disengagement. The emotionally relevant stimuli force a longer dwelling time despite the demand for a goal directed behavior –the execution of a fear-

irrelevant search task. This attention to the phobic cue probably enables an intensive which might help to prepare for protective behavior consequences.

The following second experiment therefore addresses the issue of the perceptual consequences of a stronger sensory processing of phobic cues. Two experimental manipulations were selected: First, the phobic cues were presented under concurrent viewing conditions because attentional biases were found to be more pronounced if fear-relevant material competes with neutral information for resources. Second, we used a new paradigm which provides the possibility to investigate conscious perception for a prolonged time.

3. Experiment II: *Perception of phobic cues in binocular rivalry*

3.1 Introduction

3.1.1 Multistable perception under binocular rivalry

Binocular rivalry provides a useful tool to further investigate which visual information gains access to conscious perception in the course of continuous presentation. When two different pictures are presented to each eye and cannot be merged into one meaningful percept, it results in a perceptual alternation between the two pictures. Whereas one picture temporarily dominates, the other picture is suppressed and not consciously accessible (see Alpers & Gerdes, in press; Gerdes & Alpers, in press).

3.1.2 Neural processes underlying binocular rivalry

Research on the neural basis of binocular rivalry is amazingly advanced but there are still two main theories on the neural processes that are involved in switching between the two percepts (see Blake, 2001; Blake & Logothetis, 2002; Engel, Fries, König, Brecht, & Singer, 1999; Tong, 2001). To briefly summarize, the eye rivalry theory suggests that the competition occurs because of inhibitory connections between monocular channels before information from the two eyes is combined within the primary visual cortex (Haynes, Deichmann, & Rees, 2005; Polonsky, Blake, Braun, & Heeger, 2000). Contrary to this, the stimulus rivalry theory suggests that the fluctuations between dominance and suppression are determined only after both monocular channels are jointly analyzed. Thus, according to the latter theory, binocular rivalry reflects competition between two incompatible representations instead of between the two eyes (Logothetis, Leopold, & Sheinberg, 1996; Sheinberg & Logothetis, 1997).

While there is evidence for both perspectives the multitude of controversial findings suggests that dominance and suppression is determined along several stages of visual processing and

extend to areas beyond the visual cortex (LeDoux, 2000; Polonsky, et al., 2000; Tong, Meng, & Blake, 2006; Tononi, Srinivasan, Russell, & Edelman, 1998). Because there is not a single neural switch which determines rivalry competition, it is possible to conceive that there are several stages where template recognition of threatening cues, or emotional arousal in general, and attention may influence which stimulus of two eventually makes the race.

3.1.3 The role of attention in binocular rivalry

Processes involved in perceptual reversals are mostly independent from intentional control (Leopold & Logothetis, 1999; Meng & Tong, 2004) or distraction (Leopold, Fitzgibbons, & Logothetis, 1995). But there are some examples for top-down modulation by attention on the dominance of one stimulus over another one (Carter et al., 2005; Chong & Blake, 2006; Mitchell, Stoner, & Reynolds, 2004) or on the alternation rate (Paffen, Alais, & Verstraten, 2006). Moreover, previously cued objects are more likely to dominate during subsequent rivalry (Mitchell, et al., 2004). Nevertheless, voluntary control is not the leading cause for alternation, which continues in the absence of any particular intent on the part of the observer and cannot be stopped entirely.

3.1.4 The role of emotion in binocular rivalry

While predominance is clearly bolstered by certain physical characteristics of a picture, e.g., in bright pictures with well defined contrasts (for a review, see Blake & Logothetis, 2002) semantic characteristics such as a good Gestalt of stimuli were also shown to result in more predominance (Yu & Blake, 1992). There are several, older studies which have demonstrated that stimulus content beyond physical features influence binocular rivalry (see Walker, 1978). One of the first was Engel (Engel, 1956) who showed that upright faces predominate over inverted faces. More recently, there has been great interest in how emotional arousal can promote rivalry. Although their main concern was not to compare emotional and neutral pictures under binocular rivalry, two studies showed that extremely

pleasant or unpleasant facial expressions predominated over less extreme expressions (Coren & Russell, 1992; Ogawa & Suzuki, 2000). In carefully addressing several critical methodological problems of earlier studies (see Gerdes & Alpers, in press) - such as unbalanced physical characteristics and possible biases of self-report - a series of former studies showed that pictures with emotional scenes predominate over neutral scenes (Alpers & Pauli, 2006), that emotional facial expressions (photographs and schematic drawings) predominate over neutral expressions (Alpers & Gerdes, 2007), and aversively conditioned patterns (CS+) predominate over identical but inverted CS- (Alpers, Ruhleder, Walz, Mühlberger, & Pauli, 2005). Using steady-state evoked potentials (Alpers, et al., 2005) and a probe detection task (Alpers & Gerdes, 2007) the validity of our participants' self-reports was documented.

Interestingly, two recent fMRI studies have shown that emotional facial expressions under conditions of binocular suppression, i.e., when their processing was restricted to sub-cortical pathways, still resulted in significant amygdala activation (Pasley, Mayes, & Schiltz, 2004; Williams, Morris, McGlone, Abbott, & Mattingley, 2004). The increased activity conveyed via subcortical pathway (see LeDoux, 2000) may prime and aid processing in the visual cortex where rivalry is decided.

3.1.5 Individual differences and binocular rivalry

The older literature on binocular rivalry has frequently addressed the question whether individual differences of observers can influence dominance in binocular rivalry. It was found that cultural background and past experience (Bagby, 1957; Goryo, 1969), individual preferences and differences and several personality traits can affect the perception of stimuli which are specifically relevant for the observer (Aafjes, Hueting, & Visser, 1966; Gilson, 1984; Hodges & Fox, 1965; Kohn, 1960; Moore, 1966; Nachson & Rotenberg, 1977; Shelley & Toch, 1962). Therefore, the experimental approaches of these studies were strongly

criticized (see Walker, 1978). According to this critique, remarkable physical differences of stimuli and inconsistent definitions of dominance and influence of response bias may limit the findings.

3.1.6 Aims of the study and hypotheses

Although presenting pictures with emotional content is a well established procedure in research on specific phobias, no study has previously examined the effects of phobic stimulus material in binocular rivalry. It was shown that in binocular rivalry emotional arousing pictures predominate the conscious perception. Thus, we expect that under binocular presentation, phobic fear would influence dominance of phobia-relevant material because this material is particularly arousing for phobic patients (Öhman & Soares, 1994; Pissiota et al., 2003). Furthermore, during the competition for attention, phobic cues receive enhanced visual attention and distract from task execution. Therefore, we expect that when competing for perceptional resources, phobic cues should be perceived advantageously as well. Thus, spider phobic patients and non-anxious participants may differ in how they perceive spiders during binocular rivalry. A predominance of phobic pictures in phobic patients under binocular rivalry would demonstrate that enhanced processing and prolonged attention actually lead to a preferential and sustained perception of fear-relevant pictures.

3.2 Method

3.2.1 Participants

Twenty-three spider phobic (20, i.e., 87% were female) and twenty non-anxious control participants (11, i.e., 55% were female) were recruited by advertisements in local newspapers asking for study volunteers. Potential candidates were invited when they passed a phone-screening using the fear of spiders screening (SAS, Rinck, et al., 2002) with a score above 18 for the spider phobic patient group (spider fearful groups had a range of 18-24 in normative samples) or below 5 for the non-anxious control group (non-anxious participants ranged from 0 to 3 in normative control samples). All participants were interviewed by trained research assistants using a structured clinical interview (SCID, Wittchen, et al., 1997) on an initial session. Participants of the spider phobic patient group were diagnosed according to the criteria for specific phobia, animal type (spiders) (DSM–IV, APA, 1994). For the non-anxious control group it was required that they did not meet any criteria for specific phobia. Exclusion criteria for both groups were other mental disorders and current medical or neurological treatment. Wearing glasses was another exclusion criterion because this interferes with the stereoscope. All participants had normal vision or used contact lenses to correct to normal vision (2 subjects of the non-anxious control group and 8 of the patient group). The mean age of the patients was M = 34.0 years (SD = 12.12, range: 21 – 66), the mean age of the control participants was M = 28.8 years (SD = 6.73 range: 18-45) which did not differ significantly, $t(35) = 1.65$, $p <= .109$.

3.2.2 Questionnaires

The questionnaire scores and *t*-tests are shown in Table 2. As expected, the spider phobic patients scored significantly higher on all spider fear questionnaires (German versions of Fear of Spiders Questionnaire and Spider Phobia Questionnaire, Rinck, et al., 2002; Fear and Disgust of Spiders Questionnaire, Schaller, Gerdes, & Alpers, 2006) compared to the non-anxious control participants. No group differences were found for the scores on the Positive Affect Negative Affect Scale (PANAS, Krohne, et al., 1996) and on the State-Trait Anxiety Inventory - trait version (STAI-T, Laux, et al., 1981).

Table 2: Mean questionnaire scores of phobic patients and non-anxious participants (Means, standard deviations, *t*-tests).

Questionnaire	Phobic patients	Non-anxious participants	*t*-tests		
	M (*SD*)	*M* (*SD*)	*t*-value	*df*	*p*
SPQ	61.17 (22.17)	1.30 (2.47)	11.99	40	.001
FSQ	18.50 (5.77)	3.00 (2.05)	11.38	41	.001
FEDIS Fear	67.43 (38.69)	7.70 (20.80)	6.17	41	.001
FEDIS Disgust	82.61 (34.26)	22.80 (23.15)	6.60	41	.001
STAI-S	41.29 (7.62)	37.35 (5.18)	1.92	39	.062
PA	29.64 (4.50)	30.35 (5.62)	-.46	40	.651
NA	11.68 (2.70)	10.25 (2.00)	1.94	40	.060

Note. FSQ = German version of the Fear of Spiders Questionnaire (see Rinck, et al., 2002; FSQ Szymanski & O'Donohue, 1995); SPQ = German Version of the Spider Phobia Questionnaire (see Rinck, et al., 2002; SPQ Watts & Sharrock, 1984); FEDIS = Fear and Disgust of Spiders Questionnaire – Fear Scale; Disgust Scale (Schaller, et al., 2006); STAI-S: State–Trait Anxiety Inventory – State form (Laux, et al., 1981); PA: positive affect scale NA: negative affect scale; (German version of PANAS Krohne, et al., 1996).

3.2.3 Material and apparatus

Written instructions and the stimuli were presented on a 19'' monitor (1024 x 768) and controlled by Presentation® (Version 10.0, www.neurobs.com) which also registered the participants' responses. The stimulus material consisted of 20 different flower and 20 different spider pictures displayed in gray-scale (see Kolassa, et al., 2005) which were similar in terms of size, contrast and complexity (see Figure 6 for examples). They were paired with a gray-scaled standard pattern of similar size. All stimuli were presented in a black circle frame (r = 4.3 cm) which supports the spatial alignment of the two eyes during stereoscopic viewing. Pretesting the pictures and the standard pattern under binocular vision ensured that the pattern had physical characteristics that produce a medium competitive strength compared to the picture stimuli and was clearly distinguishable.

Each trial consisted of one flower or one spider picture paired with the pattern. Each of the picture stimuli appeared once on either the left or the right side. Participants sat with their head fixed on a chin-rest 20 cm from the screen. When viewed through a mirror stereoscope (see Figure 7) the individual pictures with the circle subtended degrees of visual angle of 4 degrees which is large enough for a clear percept and at the same time reduces the probability of piecemeal rivalry (Blake, O'Shea, & Mueller, 1992).

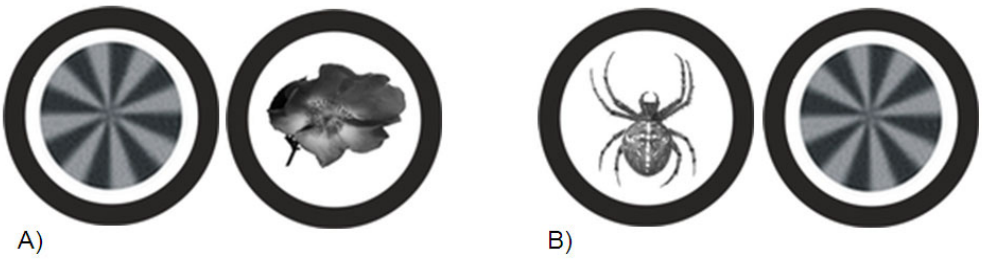

Figure 6: Example for pairs of stimuli: A) a standard pattern projected to the left eye and a neutral picture projected to the right B) a spider picture projected to the left eye and a standard pattern to the right.

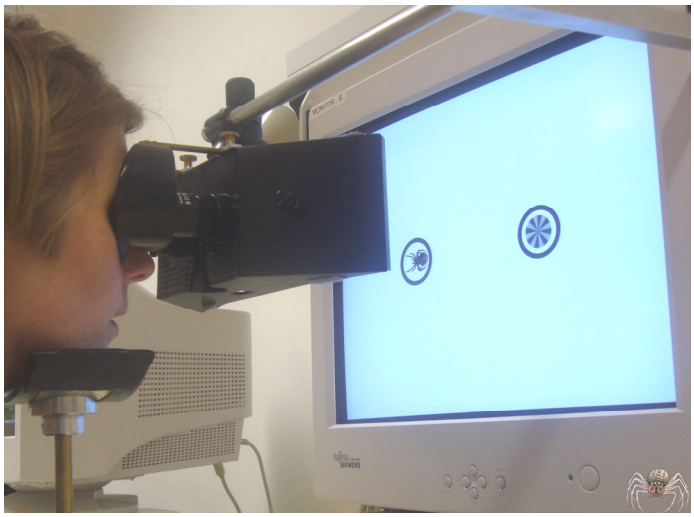

Figure 7: Experimental set-up: Two pictures were presented dichoptically to the two eyes through a mirror stereoscope. A chin rest was used to maintain head stability at the same viewing distance.

3.2.4 Procedure

The experimental procedure was reviewed and approved by the ethics committee of the German Psychological Association (DGPs). First, written informed consent was obtained and the participants filled out the questionnaires.

Participants were then instructed to look through the mirror stereoscope. At first two fusible characters (left "+", right "< >") were presented to homologue areas of the two retinas which helped to accommodate the distance between two stimuli to each participant's eye-distance (there were pre-programmed alternative settings with successive steps of 10 pixels). For all further instructions identical text material was projected to both eyes as to create normal vision. This was also the case for eight congruent picture presentations showing examples of each picture category and the pattern. The participants were instructed to indicate continuously whether the picture – regardless if it was a spider or a flower – or the pattern was exclusively visible or they perceive mixed pictures of both.

After explaining the coding of percepts eight additional practice trials with pairs of identical pictures (as in normal vision) followed. These trials included flowers, spiders or the pattern and mixed pictures which were constructed by overlaying them in Photoshop® (50% transparency) as to simulate mixed percepts. Participants were instructed to code each picture as exclusively being a "picture" or "pattern" using two keys (left and right cursor key) on the computer keyboard (the coupling of picture or pattern with the left or right cursor key was counterbalanced) and a third key to code mixed percepts (cursor down). Participants were asked to continuously code their percept during the following experimental trials by pressing the corresponding key and to promptly respond by pressing another key in each case of observing a change. Importantly, there was never any reference to the phobic material in the coding instructions.

Altogether, there were 80 trials with rivaling pictures of a flower or a spider and the pattern presented in random order. Each trial lasted for 8 seconds with an inter-trial interval of 3 seconds. Participants continuously coded what they perceived by key presses. After the experiment, the participants were asked to rate all flower and spider pictures on valence (1 to 9), anchored as "very negative" and "very positive") and on arousal (1 to 9, anchored as "not

at all intense" and "very intense"). For this manipulation check the pictures were viewed without the stereoscope and presented until a response occurred.

3.2.5 Data reduction

3.2.5.1 Main outcome measures

Two measures of predominance were used: initial dominant percept and the cumulative dominance duration. To calculate the duration of an unambiguous dominant or mixed percept during each trial, the timing between one key-press and the next was summarized separately for each of the keys. Then, the cumulative duration of exclusive picture, pattern and mixed percepts were calculated separately for flower and spider trials. Because the durations of the three perception categories are statistically dependent, a predominance ratio was calculated which includes the duration of the exclusive percept of the picture (flower or spider) and the pattern (all periods of mixed percepts or being undecided being irrelevant).

This predominance ratio was calculated as followed:

$$\frac{(\text{cumulative duration of exclusive picture percepts}) - (\text{cumulative duration of exclusive pattern percepts})}{(\text{cumulative duration of exclusive picture percepts}) + (\text{cumulative duration of exclusive pattern percepts})}$$

Similarly, the mean number of trials where picture, pattern or mixed percepts were reported as the initial percept of a trial and the corresponding predominance ratio for the mean number of trials was calculated.

3.2.5.2 Exploratory analyses and control measures

To inspect the time until the first exclusive percept occurs, the mean latencies to initial dominant percepts of spider and flower pictures were calculated. In order to test whether there are changes in coding behavior or perception across time, the predominance ratios for the cumulative mean duration of each ten consecutive trials were calculated (resulting in four trial sections), separately for spider and flower trials. Additionally, the mean duration of dominant

percepts for flower and spider trials and the corresponding ratios were computed (see section *Main outcome measures*). This was done to examine the mechanism underlying behind the expected differences in predominance between the groups.

3.2.5.3 Statistical analyses

Picture ratings for valence and arousal were compared in separate ANOVAs with the between factor Group and a within factor Picture Category (spider and flower) and follow-up *t*-tests. The predominance ratios of cumulative duration and initial percepts, as well as the ratios of mean number and mean duration of dominant percepts were compared in separate ANOVAs with the between factors Group and the within factor Trial Type (spider and flower) and follow-up *t*-tests. For the predominance ratios of cumulative duration subdivided into four subsequent trial sections, a repeated measures ANOVA with the between factors Group and the within factor Trial Type (spider and flower) and the four trial sections was conducted. All degrees of freedom for repeated measures effects were Greenhouse-Geisser corrected but the original degrees of freedom are listed. As a measure of effect size, partial eta squared (η_p^2) for the ANOVAs is reported.

3.3 Results

3.3.1 Picture ratings

The stimulus material effectively evoked the expected emotional responses in spider phobic patients. For the valence ratings of spider and flower pictures, there was a main effect of picture category, $F(1, 41) = 67.32$, $p < .001$, $\eta_p^2 = .62$, and group, $F(1, 41) = 28.71$, $p < .001$, $\eta_p^2 = .41$, as well as a significant picture category by group interaction, $F(1, 41) = 33.97$, $p < .001$, $\eta_p^2 = .45$. Follow-up *t*-tests showed, that the spider phobic patients rated the spider pictures ($M = 2.29$, $SD = 1.36$) significantly more negative than non-anxious participants ($M = 5.27$, $SD = 1.15$), $t(41) = 7.78$, $p < .001$, but there were no group differences in the valence ratings of the flower pictures (phobic patients: $M = 6.44$, $SD = 1.44$; non-anxious participants: $M = 5.96$, $SD = .84$). Both groups rated the spider pictures as more negative than the flower pictures (phobic patients: $t(23) = 8.26$, $p < .001$; non-anxious participants, $t(19) = 2.70$, $p = .014$).

Arousal ratings also differed according to a priori expectations: There were main effects of picture category, $F(1, 41) = 41.33$, $p = .001$, $\eta_p^2 = .50$, and group, $F(1, 41) = 26.15$, $p < .001$, $\eta_p^2 = .39$, as well as a significant picture category by group interaction, $F(1, 41) = 46.61$, $p < .001$, $\eta_p^2 = .53$. The spider phobic patients rated spider pictures as significantly more arousing ($M = 7.06$, $SD = 1.60$) compared to non-anxious participants ($M = 2.68$, SD = 1.70), $t(41) = 8.69$, $p < .001$, but there were no significant differences in the arousal ratings of flower pictures (phobic patients: $M = 3.15$, $SD = 1.92$; non-anxious participants: $M = 2.80$, $SD = 1.94$). Within the groups, spider phobic patients rated the spider pictures as more arousing than the flower pictures $t(23) = 8.14$, $p < .001$, whereas there were no significant differences between the picture categories in non-anxious participants, $t(19) = .38$, $p = .707$.

3.3.2 Initial percept in rivalry

The mean numbers of initial percepts are shown in Figure 8, the corresponding mean predominance ratios are shown in Table 3. In spider phobic patients the spider picture more often appeared as initial percept (relative to the pattern) than in non-anxious participants. The ANOVA for the initial percept predominance ratios of spider and flower trials revealed a significant interaction of trial type by group, $F(1, 38) = 6.23$, $p = .017$, $\eta_p^2 = .14$. Follow-up *t*-tests showed, that the predominance ratio of spider trials differed significantly between the groups; $t(39) = 2.83$, $p = .007$, the predominance ratio of flower trials did not differ significantly between the groups.

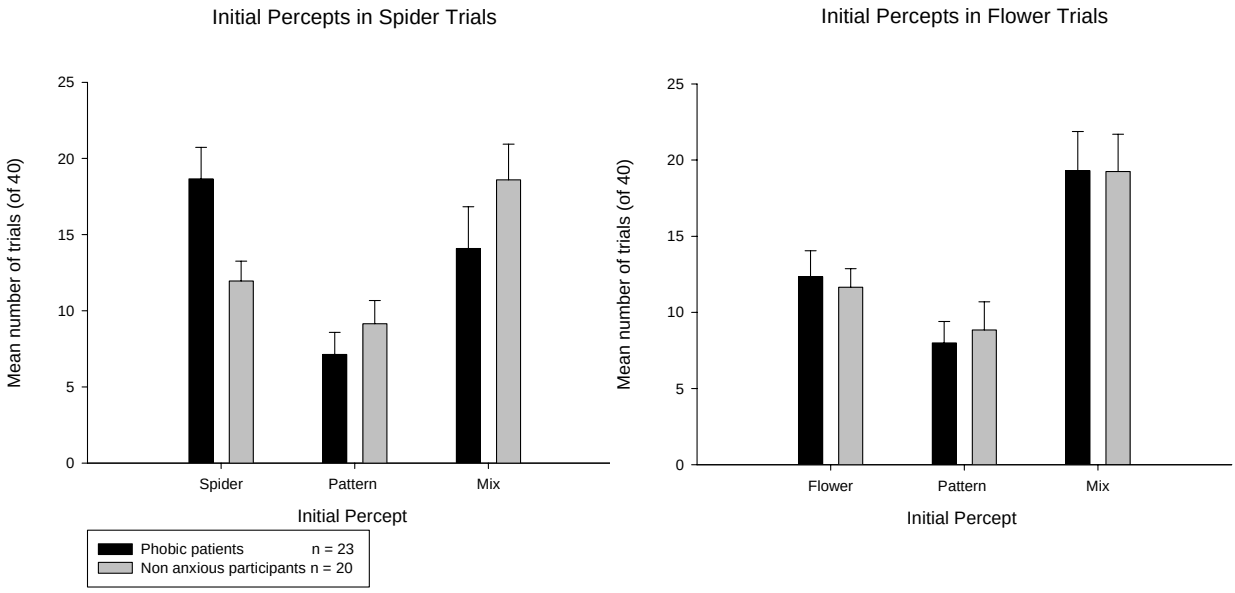

Figure 8: Left panel: Mean number (and standard error) of initial percepts of picture, pattern and mixed percepts in spider - pattern trials separately for phobic patients and non-anxious participants. Right panel: Mean number (and standard error) of initial percepts of picture, pattern and mixed percepts in flower - pattern trials separately for phobic patients and non-anxious participants.

3.3.3 Cumulative duration of percepts

The cumulative duration of each percept is shown in Figure 9; the mean predominance ratios derived from these times are shown in Table 3. In spider phobic patients the spider picture predominated over the pattern more than in non-anxious participants. The ANOVA for the predominance ratios of spider and flower trials revealed a significant main effect of trial type, $F(1, 39) = 11.24$, $p = .002$, $\eta_p^2 = .23$, and a significant interaction of trial type and group, $F(1, 39) = 7.47$, $p = .009$, $\eta_p^2 = .16$. The follow-up *t*-tests showed significant group differences for the predominance ratio of spider trials, $t(39) = 3.13$, $p = .003$, whereas the predominance ratio of flower trials did not differ significantly between the groups.

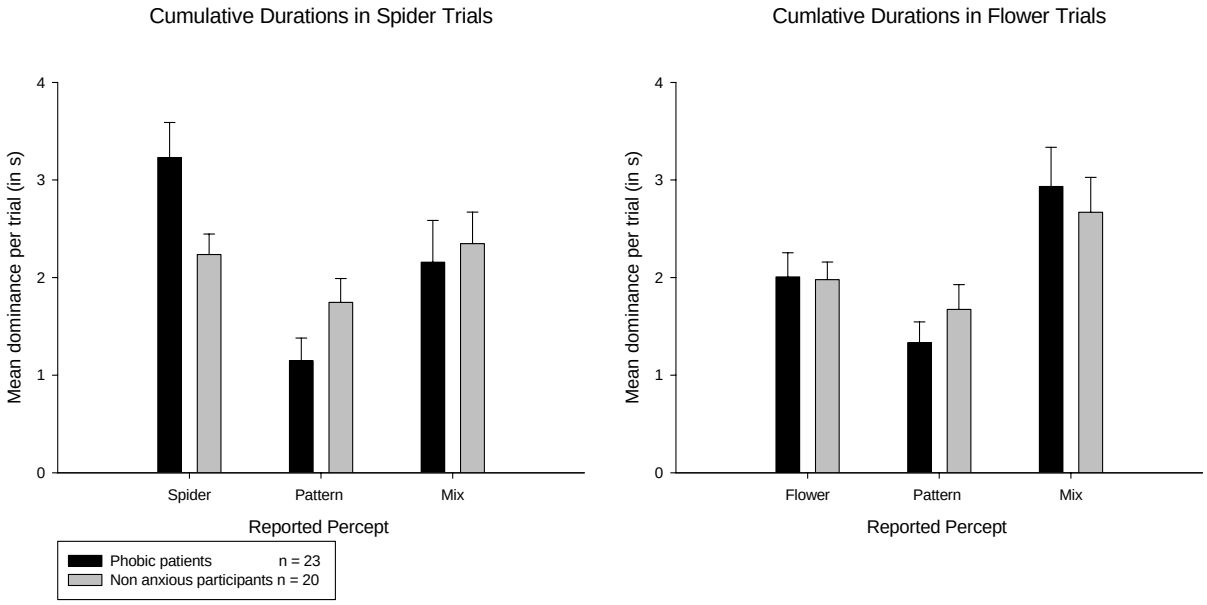

Figure 9: Left panel: Mean cumulative duration (and standard error) of picture, pattern and mixed percepts in spider pattern trials separately for phobic patients and control participants. Right panel: Mean cumulative duration (and standard error) of picture, pattern and mixed percepts in flower pattern trials separately for phobic patients and control participants.

Table 3: Mean Predominance Ratios (and Standard Deviations) of initial percept and cumulative duration.

		Phobic patients	Non-anxious participants
	Trial type	*M* (*SD*)	*M* (*SD*)
Ratio of initial percept	Spider	51 (.38)	.17 (.38)
	Flower	.22 (.50)	23 (.38)
Ratio of cumulative duration	Spider	.49 (.36)	.17 (.30)
	Flower	.23 (.48)	.14 (.29)

3.3.4 Exploratory analyses

3.3.4.1 Latency to initial percept

The mean latencies to initial percepts are shown in Table 4. The ANOVA for the latency to initial percept separately for dominant picture, pattern or mixed percepts in spider and flower trials revealed a significant main effect of percept, $F(2, 58) = 13.99$, $p < .001$, $\eta_p^2 = .33$, and a significant interaction between percept and group, $F(2, 58) = 4.75$, $p = .022$, $\eta_p^2 = .14$. Follow-up *t*-tests showed significant group differences for the latency to initial spider percepts, $t(39) = 2.23$, $p = .032$. Spider phobic patients' initial percept of exclusive spider pictures occurs later than those of non-anxious participants.

3.3.4.2 Duration of percepts

The mean durations of dominant percepts are shown in Table 4. The ANOVA for the ratio (mean duration of dominant picture percepts divided by the sum of mean duration of dominant picture and pattern percepts) for spider and flower trials revealed a significant main effect of trial type, $F(1, 37) = 5.98$, $p = .019$, $\eta_p^2 = .14$, and a significant interaction between trial type and group, $F(1, 37) = 7.74$, $p = .008$, $\eta_p^2 = .17$. Follow-up *t*-tests between the groups showed, that this ratio differs between the groups only in spider trials, $t(38) = 2.43$, $p = .020$.

Spider phobic patients' percepts of dominant spider pictures (competing with the pattern) lasted longer than non-anxious participants' percepts. Also, within the spider phobic patients this ratio was higher in spider trials, than in flower trials, $t(18) = 3.65$, $p = .002$. Within the non-anxious control group, there were no significant differences between spider and flower trials.

Taken together, the enhanced cumulative duration of dominant spider pictures in phobic patients resulted from both a higher frequency of dominance and a longer duration of dominant spider percepts in patients.

Table 4: Mean and Standard Deviations of the latency to initial percept in milliseconds and mean duration of dominant percepts in seconds of phobic patients and control participants

			Phobic patients	Non-anxious participants
	Trial type	Percept	*M* (*SD*)	*M* (*SD*)
Latency to initial percept (ms)	Spider	Picture	699 (326)	497 (247)
		Pattern	372 (228)	332 (223)
		Mix	606 (470)	872 (543)
	Flower	Picture	580 (367)	460 (263)
		Pattern	407(296)	330 (273)
		Mix	829 (417)	886 (518)
Mean duration of percept (sec)	Spider	Picture	4.36 (1.48)	3.45 (1.58)
		Pattern	3.68 (1.68)	3.27 (1.47)
		Mix	3.72 (2.10)	3.21 (1.61)
	Flower	Picture	4.07 (1.58)	3.65 (1.70)
		Pattern	3.97 (1.71)	3.50 (1.75)
		Mix	4.09 (1.68)	3.56 (1.48)

3.3.4.3 Effects across time

To test whether the effects change during the course of the experiment, the trials were subdivided into four consecutive trial sections. Separately for spider and flower trials, the predominance ratio for the cumulative duration of ten consecutive trials resulting in four trial sections was calculated (see Table 5). The repeated measures ANOVA for these ratios neither revealed a significant main effect of trial section nor an interaction between trial section and trial type or trial section, trial type and group (all Fs < 1.4; all ps > .25). However, the reported interaction of trial type and group remained significant, $F(1, 21) = 10.30$, $p = .004$, but was not altered over time.

Table 5: Mean and Standard Deviations of the predominance ratios for the cumulative duration of four consecutive trial sections.

			Phobic patients	Non-anxious participants
	Trial type	Trial section	M (SD)	M (SD)
Predominance ratios for the cumulative duration	Spider	1	.30 (.36)	.06 (.39)
		2	.40 (.36)	.08 (.31)
		3	.52 (.34)	.20 .(26)
		4	.30 (.43)	.16 (.36)
	Flower	1	.07 (.31)	.09 (.33)
		2	.09 (.39)	.04 (.35)
		3	.14 (.32)	.08 (.44)
		4	.16 (.43)	.11 (.32)

3.4 Discussion

This is the first study to examine how spider phobic patients perceive spiders in binocular rivalry. The results clearly demonstrate that under conditions of binocular rivalry spider pictures predominate more in spider phobic patients than in non-anxious control participants. The predominance ratios showed significant more first percepts of spider pictures and in longer durations of exclusive perception of spiders (compared to exclusive pattern percepts) throughout the trials. This dominance of spiders in the perception of spider phobic patients demonstrates that phobic material is preferential processed in the visual system.

3.4.1 Emotion and binocular rivalry

First of all, these results fit well with and extend previous findings that emotional pictures predominate in binocular rivalry (Alpers & Gerdes, 2007; Alpers & Pauli, 2006; Alpers, et al., 2005). The study clearly replicates that highly arousing emotional stimuli predominate over neutral stimuli. The former studies have demonstrated this effect for healthy subjects. The present study could extent these findings to clinically diagnosed spider phobic patients: Spider pictures are specifically highly arousing and negative for them and specifically the spider pictures dominate their perception.

Therefore, the effect is not restricted to selected subjects and not to particular stimuli characteristics. In addition, these findings support older hypotheses that individual differences modulate the perception in binocular rivalry (Bagby, 1957; Gilson, Brown, & Daves, 1982; Kohn, 1960). With a significantly improved methodology this study confirms early reports that personal relevance of stimuli leads to improved perception. Furthermore, this study is the first study presenting phobic pictures under conditions of binocular rivalry.

With respect to the underlying neural processes of binocular rivalry, these findings imply that the competition for conscious perception takes place at stages where brain regions involved in emotion processing (e.g. amygdala, see Amaral, Price, Pitkanen, & Carmichael, 1992;

LeDoux, 2000) are able to affect this competition. The influence of emotion processing on visual competition may be possible on the basis of direct neural links between sensory pathways of the amygdala to the visual cortex (Amaral & Price, 1984; Amaral, et al., 1992). That way, enhanced activation of emotion circuits may influence activation in the visual cortex and thus promote the conscious perception of relevant stimuli. The switching between percepts is for the most part beyond voluntary control, so these data also support the idea that emotional relevance of visual stimuli can automatically influence early stages of visual information processing. Furthermore, findings that amygdala activation is evoked even during the suppression of emotional stimuli support this idea as well (Pasley, et al., 2004; Williams, et al., 2004).

Another possibility for the underlying mechanism of influences of emotional pictures on visual perception could be that enhanced perceptual processing on the high road (LeDoux, 1996) is further promoted by selective allocation of attention (Pessoa, Kastner, & Ungerleider, 2002). According to this, the observed predominance could be driven by top-down influences. Several neuronal circuits are involved in top-down control of visual processing, and it has been documented that a complex network of frontal and parietal brain regions drives top-down biasing (Pessoa, 2005; Windmann, Wehrmann, Calabrese, & Güntürkün, 2006).

Indeed, there is growing evidence that attention can influence binocular rivalry to some extent (Mitchell, et al., 2004; Paffen, et al., 2006). Enhanced attentional allocation toward phobic cues (Bar-Haim, Lamy, Pergamin, Bakermans-Kranenburg, & van IJzendoorn, 2007) might act as a mediator during the competition for conscious perception, with particular effects on the initial dominance (Chong & Blake, 2006). A recent study showed that V1 activity is modulated by attentional load (Bahrami, Lavie, & Rees, 2007). Consequently, even if the competition is decided early in visual processing (V1) attentional influences could support the predominance of phobic pictures.

A recent study addressed the relationship between binocular rivalry and trait anxiety, because serotonin neurotransmitter systems are thought to be involved in both anxiety and in the alternation rate in binocular rivalry (Nagamine et al., 2007). In this study high-anxious participants showed greater perceptual alternation rate and rhythmicity than low anxious participants while viewing rivaling neutral gratings. To exclude influences of such general differences in perceptual switching, the mean number of dominant percepts was inspected here but there were no basic group differences. Thus, the groups examined here differ solely in stimulus specific perception which is not caused by general perceptual differences. In addition, this elucidates that emotional content of pictures enhances the duration of dominant phases as well as the frequency with which the percept occurs.

3.4.2 Preferential processing of phobic cues

In line with other paradigms used to study visual processing in anxiety disorders, the present results confirm that phobic stimuli are preferentially processed in spider phobic patients. Moreover, the study shows that this preference is sustained over a longer period of time if no active avoidance is possible. At first, this observation adds to the growing evidence of preferential processing of threatening material obtained from behavioral paradigms demonstrating a threat superiority effect in visual search tasks (Blanchette, 2006; Öhman, Flykt, et al., 2001) as well as increased attentional allocation toward threatening pictures (Miltner, et al., 2004; Rinck, et al., 2005). While these studies demonstrate that fear-relevant content possesses perceptual advantages over neutral contents for rapid detection and attentional engagement at short exposure times the present paradigm documents preferential processing in the visual system over prolonged periods of exposure to the pictures.

Compared to more established paradigms in anxiety research, the binocular rivalry design is able to depict that the enhanced processing of phobic stimuli actually results in superior conscious perception. However, it is not likely, that the predominance of spider pictures in

spider phobia resulted exclusively from intentional control over the percept. First, binocular rivalry is considered to be relatively immune to conscious control (Meng & Tong, 2004). Second, it is not plausible that spider phobic patients would intentionally expose themselves to their feared objects for longer than necessary. In experimental designs where fearful subjects were able to avoid, e.g. in free-viewing paradigms, they tend to avert their gaze from the phobic pictures after a while (Rinck & Becker, 2006).

Nevertheless, the latency to the first conscious percept of a spider is not shortened, so the initial predominance arises not necessarily from early automatic or attention processes. Threatening pictures are assumed to capture attention automatically and hence very quickly (Öhman, Flykt, et al., 2001). The delayed onset of initial percepts of spiders in phobic patients suggests that eventually slowed down attentional disengagement rather than initial engagement served as an underlying moderator of the findings. Whereas findings of initial attention capture effects are inconsistent, there is a growing consensus, that disengagement of attention from phobic cues is more difficult for phobic patients (Miltner, et al., 2004). Experiment I of this thesis has also shown that if once detected, the attention of phobic patients dwells longer on the spider (Gerdes, Alpers, & Pauli, 2008). Later, they tend to avoid the threatening pictures, at least if the experimental design allows for that (Rinck & Becker, 2006).

3.4.3 Methodological issues

The study design has several methodological advantages over previous binocular rivalry studies examining interindividual differences and adds to well established paradigms in anxiety research. Comparing the perception of different groups for which the stimuli have different significance eliminates nearly all influences of the stimulus material beyond meaning. Physical differences as size, brightness, contrast or color which are known to affect predominance and suppression (Blake, 1989; Kaplan & Metlay, 1964) have the same effect in

both groups. Identical picture pairs were presented to the groups; therefore the described differences can be attributed to interindividual differences in the emotional relevance of the pictures. The presentation of flower and spider stimuli each with a neutral abstract pattern further reduces the probability that response bias influence the results. Even if the groups differ in their response criterion - e.g. what they label as exclusive or mixed percept, it is not likely that this should occur only in spider trials because the perception coding did not imply a differentiation between spider or flower pictures but the coding of exclusive picture or pattern percepts. Furthermore, investigating participants with diagnosed spider phobia and non-anxious control participants ensured that the phobia-relevant stimulus material provokes differences in the emotional response. Overall, stimulus material and the study design seem adequately to disclose possible influences of emotion. Compared to traditional paradigms in anxiety research, the perception under binocular rivalry directly shows that emotional arousing pictures actually influence perception processing and result in an enhanced conscious perception.

Nevertheless, future research should address the underlying mechanisms of the perceptual dominance of arousing pictures in binocular rivalry. Additional physiological measurements e.g. imaging the central nervous system activity would help to decide, on which neural stages the competition for perceptual consciousness is affected by emotional processes. Furthermore a systematic modulation of attention for example by adding a concurrent task (see for example (Paffen, et al., 2006) may help to clarify to what extend attentional influences are involved in binocular rivalry and emotion. This would be interesting for research on binocular rivalry and on emotion processing. Another improvement of the existing study would be simultaneous EEG recordings which could map the actual conscious perception in addition to the subjective report (for an example in non-anxious participants see Alpers, et al., 2005). This would further exclude influences of different response criteria of the groups.

Although this binocular paradigm cannot definitively clarify the origin or associated neural underpinnings of the competition, the results provide a substantial contribution to both the perception of emotional stimuli under conditions of binocular rivalry and to the debate of a prioritized role of threat in early visual processing.

4. General discussion

The intent of this dissertation was to examine influences of phobic stimuli on visual processing in spider phobia, in particular on attention and perception. For that purpose, two designs were applied with neutral and phobic cues competing for attentional and perceptional resources. The present two experiments clearly show that under competition with neutral cues phobic cues are prioritized within visual processing domains. Interactions of automatic emotional activation, prolonged boosting of visual processing and subsequent activation of attentional processes lead to sustained engagement of attention and this interplay is further reflected in sustained predominance of phobic stimuli in the conscious perception of phobic individuals.

Consequently, due to these disengagement deficits and enhanced perception of phobic cues, phobic patients are intensively exposed to a multitude of information about possible danger which may trigger or maintain elevated levels of fear (Matthews, 2002).

4.1 Attention

The aim of Experiment I was to disentangle different components of attention during the time course and therefore shed light on the compound of the attentional bias found for phobic patients. This was achieved by the inspection of reaction times *and* eye movements. It could be demonstrated that phobic cues primarily distract phobic patients from an ongoing search task. Differences in the initial and subsequent allocation of attention in the presence of phobic distractor pictures were highlighted and it could be demonstrated that the distraction from the search task was most pronounced for distractors depicting a spider. Eye movement data revealed that the reaction time slowing to neutral targets was not due to an initial attentional capture by spider cues – but mainly originate from an extended duration of fixations on spider picture distractors. Thus, slowing of reaction times can be explained by slowed disengagement from spiders. Taken together the data support the following view: phobic

patients are characterized by an enhanced distractibility by all picture distractors which stands in line with the proposed deficits in attentional control (Eysenck, et al., 2007). If a phobic cue catches ("accidentally") attention, resources are absorbed, resulting in delayed responses to other tasks. However, this study found that mainly delayed disengagement rather than initial engagement is responsible for those performance deficits in the reaction time task. As an enhanced dwelling on the phobic cue enables longer processing time, the phobic cues can be processed more deeply and intensively. Such an attentional bias reflects that cognitive resources are maintained on the source of potential danger and this may lead to an enhancement of anxiety states (Fox, et al., 2001).

4.2 Perception

The aim of the second study was to investigate the conscious perception of phobic cues – particularly with regard to longer exposure times.

This study examined how spider phobic patients perceive spiders in binocular rivalry. The results clearly demonstrate that under ambiguous viewing conditions spider pictures predominate in spider phobic patients as indicated by significant more first percepts and longer durations of exclusive perception of spiders. The assumed preferential processing of phobic material in the visual system is indeed reflected in an augmented conscious perception. Theoretically, both studies were able to bring clear evidence for a preferential processing of phobic cues in phobic subjects within the visual system under conditions of competition.

Whenever phobic stimuli compete with less important neutral stimuli, they "emerge victorious", be it a competition for attentional allocation (Experiment I) or perceptual dominance (Experiment II).

One can assume that initially a preferential processing is reflected in delayed disengagement from highly emotional cues. Further on, the extended attentional allocation is accompanied by noticeable consequences in the perceptional outcome.

The dwelling time on spider pictures which is enhanced in spider phobic patients, might reflect or is comparable to the "post-encounter" defensive mode which exist in rodents: after detecting a predator in the environment, for the rat, freezing is the dominant response. Probably, it also reduces the chance of detection and removes the releasing signals for attack if detected (Fanselow, 1994).

Although the two findings indicate that mainly processes after initial perceptual analysis are strongly altered by the emotional meaning of the pictures, these effects could be interpreted as automatically or unintentionally. It is not plausible that the delayed attentional disengagement (Experiment I) - when the (instructed) aim was to perform the requested task as fast as possible - as well as the perception under binocular rivalry (Experiment II) are under voluntary control of the subjects. Furthermore, it can be assumed that phobic patients would intentionally rather prefer to avoid an intensive examination and confrontation of their abhorred fear trigger, but it remains open, whether a strategic counteraction – for example in terms of emotion regulation - could influence the findings.

4.3 Limitations

One reasonable limitation of both experimental designs is that only phobic stimuli were compared to neutral ones. The assumption of a specifity of the findings must be taken into question, because several findings indicate that highly positive stimuli as well might play a very special role in attention (Alpers, 2008; Nummenmaa, et al., 2006) and perception (Alpers & Gerdes, 2007). Even brain areas which are known to be involved in emotion processing were found to be activated by both negative and positive stimuli, however results are less consistent for the latter ones (Garavan, Pendergrass, Ross, Stein, & Risinger, 2001; Hamann & Mao, 2002; Paton, Belova, Morrison, & Salzman, 2006; Zald, 2003). Furthermore, Hamm (2007) has recently reported that phobic patients' brain activation to phobic cues is comparable to those of other highly arousing but not phobia-relevant stimuli.

Challenging the specifity of these findings would also challenge the findings of most of all hitherto existing studies in phobia research because until now the used stimulus material was commonly restricted to fear-relevant or phobic and neutral cues (e.g., Öhman, Flykt, et al., 2001; Öhman & Soares, 1994; Straube, et al., 2006; Vuilleumier & Schwartz, 2001).

Another limitation regarding our stimulus material relates to the comparison of fear-relevant *animals* (spiders) with neutral *non animals* (flowers, mushrooms). As shown by Tipples and colleagues (2002) as well as by Lipp and coworkers (2004), in search tasks, all pictures of animals - irrespective of their fear relevance - are detected faster among plants than vice versa. Hypothetically, the often-described search advantage for fear-relevant animals could simply be caused by the animal versus not animal picture comparison. However, the samples of these studies consisted of non-anxious participants and it is not likely that the group differences reported here is mainly caused by an unspecific animal effect exclusively pronounced in the spider phobic patient group.

Nevertheless, future research with presentation of visual stimuli should bear in mind this critique and extent the stimulus categories with additional phobia-irrelevant but highly arousing pictures and comparable other animal categories as for example other arthropods.

4.4 Future directions

A further promising extension of the present studies would be to present animated stimulus material instead of pictures. Alongside presumptive difficulties in standardization, the use of real spiders (Thorpe & Salkovskis, 1998a), film clips (Paquette et al., 2003; Vansteenwegen et al., 2007) or virtual spiders (Garcia-Palacios, Hoffman, Carlin, Furness, & Botella, 2002) would increase the ecological validity of research. This could be a very important step, because perceived uncontrollability and looming movements of spiders are thought to be an essential part and a good predictor of phobic fear (Armfield, 2006; Armfield & Mattiske, 1996; Riskind, Moore, & Bowley, 1995).

Regarding underlying brain mechanisms, the confirmed enhanced attention and preferred perception of spiders stands in line with the assumed interaction of emotional and visual cortical networks (Amaral, Behniea, & Kelly, 2003; Amaral, et al., 1992), but a preattentive processing of threatening cues according to Öhman (2007) and LeDoux (1996; LeDoux, 2000) via a subcortical pathway could neither be confirmed nor disproved. To test more directly underlying neural correlates of the presented outcomes, accompanying applications of brain imaging methods and electro-cortical measurements are required. Application of functional resonance imaging or electroencephalogram during binocular rivalry would help to confirm the subjective report of the perception of patients with objective parameters (Alpers, et al., 2005; Williams, et al., 2004). The application of those methods would be enriching for research in attentional biases as well, because it would allow inspecting processes preceding going along with and following attentional allocation (Schupp, Cuthbert et al., 2004; Schupp, Junghöfer, Weike, & Hamm, 2003b; Straube, Weiss, Mentzel, & Miltner, 2007).

Prospectively, research on spider phobia should focus on the emotion specifity of the phobic response. As mentioned before, spider phobia is commonly used as a human model for fear and anxiety disorders and the clinical classification of specific phobia considers exclusively the fear component. But there is an increasing consensus, that both fear and disgust are common emotional reactions to small animals, especially to spiders (Davey, 1994b; Gerdes, Uhl, & Alpers, in press; Schaller, et al., 2006). Nevertheless, disgust is relatively neglected in most of the studies dealing with spider phobia. It was shown that beliefs of phobic subjects are often based on disgust rather than fear about spiders, (de Jong, Andrea, & Muris, 1997; de Jong & Muris, 2002; de Jong, Peters, & Vanderhallen, 2002) and that phobic patients report elevated levels of fear and disgust toward phobic stimuli (Edwards & Salkovskis, 2006; Tolin, Lohr, Sawchuk, & Lee, 1997). Disgust rather than fear actually predicts the avoidance of spiders (Woody, McLean, & Klassen, 2005) and an expectancy bias toward disgust-relevant consequences was the single best predictor of spider fear (van Overveld, De Jong, & Peters,

2006). However, there are also some indications that a differentiation of fear and disgust in anxiety does not make any further important contributions and that it is unlikely that disgust plays a central role in the etiology or maintenance of spider phobia (Thorpe & Salkovskis, 1998b).

Nevertheless, the differentiation of disgust and fear as important parts of emotional reactions toward fear-relevant stimuli could be important, particularly because these emotions both are considered as distinct basic emotions (Darwin, 1965; Ekman & Oster, 1979). Fear and disgust exhibit several differences in behavioral correlates, distinct facial expressions, autonomous and central nervous underlyings (for a detailed differentiation see, Woody & Teachman, 2000). These fundamental distinctions nearly enforce future research on spider phobia to carefully consider disgust related influences in addition to fear. An exclusive focus on fear and anxiety in studying anxiety disorders or other disorders bears the risk to miss influences which might arise from other emotional states what may lead to a misinterpretation of findings. A possibility to improve phobia research could be at least to collect additional data on the predominant emotion of the subjects in response to spiders.

Despite many promising results in terms of the interaction of fear, perception and attention in recent years, there are only few studies directly investigating the actual role of these processes in the etiology and maintenance of anxiety disorders, whereas they are often called “important factors” (for an overview see Yiend, 2004). A first step to come up to the causal basis of the association of negative emotions and attentional bias toward negative information was conducted by MacLeod and colleagues (2002). In a non-anxious sample, they experimentally induced differential attentional responses to emotional stimuli and examined the consequences on the following emotional vulnerability. Their results demonstrated that inducing an attentional bias toward negative stimuli led to greater distress in a subsequent task. This can be interpreted as first evidence that attentional bias may indeed play a causal role in anxiety pathology. Similar approaches were newly started for other

cognitive biases (Mathews & Mackintosh, 2000; Mathews & McLeod, 2002). First attempts to directly manipulating biases in high-anxious subjects showed that the training of (interpretation) biases provides a way to potentially reduce fear (Mathews, Ridgeway, Cook, & Yiend, 2007). Thus, a systematic development of such paradigms as useful extension of therapeutic interventions seems promising.

Another future direction of phobia research may focus on effects of therapeutic intervention on the processing of phobic cues. Recent findings suggest that exposure and cognitive- behavioral therapy may affect dysfunctional neural circuitry in anxiety (Paquette, et al., 2003) and activity in subcortical structures as the amygdala (Goossens, Sunaert, Peeters, Griez, & Schruers, 2007).

It is reasonable that therapeutic interventions affect characteristics of attention and perception outcomes as well (see Lavy, Van den Hout, & Arntz, 1993). Therefore, an important next step should be to test the sensitivity of the paradigms for therapeutic changes. On the long run, perception of phobia-relevant cues and attentional biases might be used as predictors of treatment outcome, the likelihood of relapse after therapy, or for the identification of etiological and maintaining factors.

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6. Appendix

6.1 Why we study spider phobia

Fear of spiders is highly prevalent and widespread: 32% of females and 18% of males are anxious, nervous or frightened when confronted with a spider (Davey, 1994a).

Spider phobia is the most prevalent subtype of specific phobias as well as of animal phobias with a life-time prevalence of ~ 5 % whereas women are about 2 to 3 times more likely than men to be diagnosed with spider phobia (Becker, et al., 2007; Becker, et al., 2000; Frederikson, et al., 1996; Wittchen & Jacobi, 2006). The high incidence of fear or phobia of spiders is often explained in terms of preparedness. According to Seligman (Seligman, 1971), it exists a phylogenetically derived readiness to learn the association of aversive events with specific (fear-relevant) stimuli as for example spiders or snakes which are thought to have been dangerous to evolutionary ancestors. Reactions toward such stimuli are thought to be initialized prioritized and preattentive. The preparedness theory does not predicate that the fear must be innate. For example, laboratory-raised rhesus monkeys are less afraid of snakes compared to those raised in the wild (Mineka, Keir, & Price, 1980) but they acquire this fear easily (Mineka, Davidson, Cook, & Keir, 1984) and retain it permanently (Mineka & Keir, 1983; Mineka, et al., 1980). Experimental evidence for prepared learning in humans comes from conditioning experiments (Öhman, Erixon, & Lofberg, 1975). If pictures of spiders and snakes served as conditioned stimuli that predicted mildly aversive shock, participants showed stronger and lasting skin conductance responses (an index of emotional activation) than if flower or mushroom pictures were paired with the shock. In addition, the conditioned fear to these stimuli was significantly more resistant to extinction (Öhman, et al., 1975). Because only 50 % of phobic individuals remember an aversive conditioning experience as the onset of their phobia (Öst & Hugdahl, 1981), other theories were drawn on to explain the etiology of specific phobia. It is assumed that in addition to conditioned learning, fears can be

learned through observing of fear responses of others or through acquiring threatening information about a stimulus (Rachman, 1977). Indeed, it could be demonstrated that rhesus monkeys who were reared in laboratory exhibited fear to toy snakes after watching another monkey showing fear responses to the same snake (Mineka, et al., 1984). A further attempt to explain that particularly spiders are feared provides the disgust hypothesis (Davey, 1992). According to this hypothesis extremely negative emotional responses to spiders are culturally transmitted (Davey, 1994b) because these animals were historically associated with disease and infection from medieval times onward. Indeed, in addition to fear, disgust may also play a special role in *fear of spiders* (Schaller, et al., 2006). Despite multi-faceted considerations of the etiology of spider phobia, it is unequivocally pronounced that the majority of human beings perceives spiders even in comparison to other "creepy-crawlies" as extremely fear eliciting and disgusting (Gerdes, et al., submitted). Although phobic subjects suffer from several severe impairments in their daily life and their fear reaction are reported to be immense, only few subjects with specific phobia seek professional treatment, even though treatments for arachnophobia are highly effective (e.g., Hellström & Öst, 1995; Öst, Ferebee, & Furmark, 1997).

In general, the research on specific phobia has clinical importance as well because specific phobia often precede emotional distress and should be considered as risk factor for several other anxiety disorders, depression, somatoform disorder and substance abuse (Becker, et al., 2007; Kessler, Chiu, Demler, Merikangas, & Walters, 2005).

Overall, research on anxiety disorders and specific phobias is relatively common and frequent. A recent study examined publications over the last 25 years which are dealing with anxiety disorders. In general, anxiety disorder research continuously rose (Boschen, 2008). Research on specific phobia did not grow, but remained most stable over the investigated time period. 1322 publications concerning specific phobias were found and the authors referred specific phobia as a prototypical anxiety. Specific phobia and particular spider phobia is

considered as an advantageous model to investigate anxiety and anxiety disorders. On the one hand, specific phobias are common and therefore phobic subjects are relatively easy to recruit. At the same time specific phobias have the lowest comorbidity rates (~24%) of all anxiety disorders (Becker, et al., 2007) which minimizes other influencing factors. For laboratory research it is beneficial that the feared objects are clearly defined and appropriate stimulus material for experimental applications is can be created. Furthermore, the stimulus material can be well standardized, because even very simple and schematic representation of spiders have a high recognition value and were shown to be sufficient to elicit differential responses in spider-phobic and control persons in subjective ratings and ERP components (Kolassa, Musial, Kolassa, & Miltner, 2006).

Most important, several studies showed that spider cues can definitively be regarded as fear-relevant cues for both healthy subjects and especially stronger for phobic subjects. As described above, spider pictures were processed in a special way: psychophysiological responses as peripheral activation (Globisch, Hamm, Esteves, & Öhman, 1999; Öhman & Soares, 1994; van den Hout, De Jong, & Kindt, 2000) and neural responses (Carlsson, et al., 2004; Dilger, et al., 2003; Fredrikson, Wik, Annas, Ericson, & Stone-Elander, 1995; Johanson et al., 1998; Kolassa, et al., 2005; Miltner et al., 2005; Pissiota, et al., 2003; Schienle, Schäfer, Walter, Stark, & Vaitl, 2005) were repeatedly shown to be especially increased during the presentation and processing of phobic cues. In sum, the benefits of studying spider phobia is obvious: phobic subjects are still underrepresented in seeking for treatment, research on specific phobia is currently not growing and phobic fear can serve as an advantageous persuasive model to investigate various aspects of anxiety and anxiety disorders.

6.2 Pilot study I

6.2.1 Participants

Twenty-five spider phobic patients and twenty-five healthy controls were recruited to participate to a study of spider phobia by advertisement in a daily newspaper. As a first part of this study, they were interviewed by research assistants using the using the Structured Clinical Interview for DSM-IV (SCID, Wittchen, et al., 1997). Participants were included in the spider phobic patient group when they met full DSM-IV criteria for spider phobia (APA, 1994), whereas for the non-anxious control group no criteria for specific phobia had to be fulfilled. Further exclusion criteria for both groups were medical or neurological treatment and other actual psychiatric diagnoses. Three participants of each group were excluded because of intake of psychotropic drugs (2 persons) or excessive movements during the eye movement – acquisition (4 persons), so 22 participants remained in each group for further analysis. All participants had normal or corrected to normal vision. The mean age of the spider phobic group was 32.14 (*SD* = 10.71; range 22-65) and 81.8 % were female. The mean age of the control group was 41.55 years (*SD* = 14.64; range: 21- 66) and 50 % of the participants were female. The mean age of the control groups was significantly higher than of the patient group, $t(42) = 2.43$, $p = .019$. The mean scores on questionnaires on spider fear (Fear of Spiders Questionnaire (FSQ) and Spider Phobia Questionnaire (SPQ) , German versions, Rinck, et al., 2002), as well as on trait anxiety (Trait scale of the German version of the Spielberger State-Trait Anxiety Inventory (STAI), Laux, et al., 1981) and on positive and negative affect (Positive and Negative Affect Scale (PANAS), Krohne, et al., 1996)) and *t*-tests between the groups are shown in Table 6.1.

Table 6.1: Mean questionnaire scores (standard deviations, and *t*-statistics) separately for the non-anxious control participants (n = 22) and the spider phobic patients (n = 22).

	Phobic patients	Non-anxious participants	*t*-tests (*df* = 42)	
Questionnaire	*M* (*SD*)	*M* (*SD*)	*t*-value	*p*
SPQ	68.29 (25.17)	1.18 (1.97)	10.43	< .001
FSQ	18.43 (6.27)	4.41 (1.87)	12.47	< .001
STAI-T	46.57 (22.72)	33.13 (6.67)	2.66	.011
PA	30.32 (4.11)	27.55 (6.12)	1.77	.085
NA	15.23 (4.19)	10.50 (3.35)	4.14	< .001

Note. FSQ = German version of the Fear of Spiders Questionnaire; Szymanski & O'Donohue, 1995; (see Rinck, et al., 2002); SPQ = German Version of the Spider Phobia Questionnaire; Watts & Sharrock, 1984; (see Rinck, et al., 2002); STAI–T = State–Trait Anxiety Inventory – Trait form (Laux, et al., 1981); PA = Positive affect scale, NA = Negative affect scale of PANAS = German version of the Positive and Negative Affect Schedule (Krohne, et al., 1996).

6.2.2 Apparatus and stimulus material

The presentation of instructions and stimuli and the recording of reaction times were controlled by a high precision software (Presentation® Version 0.90, www.neurobs.com) running on an Intel Celeron Processor (500 MHz). A 15-in. monitor with a resolution of 1024 * 768 was used. The stimulus material consisted of two different display arrangements with grey and red circles. The first display contained 6 grey small circles (3.7° in diameter) each containing a small gray figure premask (0.4°*0.2). These six circles always appeared at clock positions 1, 3, 5, 7, 9 and 11 arranged on a circle with a radius of 12.6° with a red fixation cross in the middle. After fixating the fixation cross for at least 1000 ms all grey circles but one changed simultaneously to red and the premask figures changed to letters (S, H, E, P, F). The letter inside the remaining grey circle was the target and consisted of either a C or a reversed C, with the orientation determining the response. Because the circles were presented parafoveal and the letters were small, it was necessary to make a fixation on the gray circle to respond to the target letter. In these second displays one additional red circle could appear

with an abrupt onset either simultaneously with the display or briefly delayed (with a stimulus onset asynchrony (SOA) of 150 ms) at the six possible locations but at least with a 30° angle distance to the target circle. These distractor circles contained either small grey flower or spider pictures, which were similar in terms of size, color, contrast and complexity. The duration of the inter- trial-interval was around 1500 ms.

Thus, the experimental task consisted of 24 trials without distractor, 24 trials with flower distractors and 24 trials spider distractors. All distractor trials appeared once simultaneously and once with the delayed onset, resulting in 120 trials overall. Positions of targets, distractors were counterbalanced across the trials and the presentation order was random.

During the experiment eye-movements were recorded with an infrared eye tracking recording system (iView X, SensoMotoric Instruments, Teltow, Germany) with a 238 Hz resolution while viewing the displays. Eye movements were calibrated individually before the experimental task.

6.2.3 Data reduction and analysis

Reaction times. The mean manual reaction times were averaged for each distractor category (spider and flower) separately for the groups. Furthermore we calculated their mean reaction time on control trials to consider potential baseline differences.

Eye movements. Fixations were defined as interruption of scan path for a minimum interval of 80 ms within an area with a maximum radius of 25 pixels.

The mean number of first fixation on distractor pictures was calculated, as well as the mean latency of these fixations. Additionally we averaged the overall duration of fixations on target and distractor pictures.

The calculations were done separately for each distractor category (spider and flower) separately for the groups and compared in an overall ANOVA and follow-up *t*-tests. Because

of the lack of sufficient trials with fixations on distractors for both groups (mean) the reported results relates exclusively to the distractor trials with no onset delay.

Picture ratings. Picture ratings for valence and arousal were compared in separate ANOVAs and follow-up *t*-tests.

For all the results the degrees of freedom for repeated measures effects were Greenhouse-Geisser corrected but the original degrees of freedom are listed. As measures of effect size, partial eta squared (η_p^2) for the ANOVAs are reported.

6.2.4 Results

6.2.4.1 Picture ratings

For the valence ratings of spider and flower pictures, there were main effects of picture, $F(1, 42) = 91.12$, $p < .001$, $\eta_p^2 = .68$, and group $F(1, 42) = 29.82$, $p < .001$, $\eta_p^2 = 42$ as well as a significant interaction effect of group and picture, $F(1, 42) = 37.46$, $p < .001$, $\eta_p^2 = .47$.

Spider phobic patients rated the spider pictures ($M = 2.08$, $SD = 1.30$) as more negative than flower pictures ($M = 6.31$, $SD = 1.40$), $t(21) = 9.86$, $p < .001$. Non-anxious control participants rated spider picture ($M = 5.16$, $SD = 1.14$) as well slightly more negative than flower pictures ($M = 6.08$, $SD = 1.11$), $t(21) = 2.82$, $p = .010$. Comparing the groups, the spider phobic patients rated spider pictures significant more negative than the control group, $t(42) = 8.36$, $p < .001$ whereas there were no differences in the valence ratings of flower pictures, $t(42) = .61$, $p = .548$.

Arousal ratings also differed according to a priori expectations. There were main effects of group; $F(1, 42) = 43.75$, $p > .001$, $\eta_p^2 = .51$; and picture $F(1, 42) = 58.06$, $p < .001$, $\eta_p^2 = .58$, as well as a significant interaction, $F(1, 42) = 74.64$, $p < .001$, $\eta_p^2 = .64$. Spider phobic patients rated the spider picture ($M = 7.12$, $SD = 1.90$) as more arousing than the flower pictures ($M = 2.45$, $SD = 7.12$), $t(21) = 10.90$, $p < .001$. Non-anxious control participants rated spider pictures ($M = 1.97$, $SD = 1.31$) not significantly more arousing than flower pictures (*M*

= 2.27, *SD* = 1.91), *t*(21) = .77, *p* = .452. Comparing the groups, the spider phobic patients rated t spider pictures significantly more arousing than the control group, *t*(42) = 10.46, *p* < .001, whereas there were no differences in the arousal ratings of flower pictures, *t*(42) = .37, *p* = .717. Taken together, we conclude that the stimulus material was appropriate to provoke differential effects between the groups as requested.

6.2.4.2 Manual reaction times

Baseline trials. During the initial 24 trials without distractors the manual reaction times to targets did not differ between the groups (phobic patients: *M* = 810 ms, *SD* = 125; control participants: *M* = 828 ms, *SD* = 199; *t*(42) = .36, *p* =.719).

Experimental trials. The mean reaction times are shown in Table 6.2. The ANOVA for the mean reaction times showed no significant main effects, but a significant interaction between distractor type and group, *F*(1, 42) = 4.70, *p* = .036, η_p^2 = .10.

The follow-up *t*-test suggests that patients were slightly slower to respond to the target on spider distractor trials than control participants, *t*(42) = 1.54, *p* = .132. The reaction times did not differ significantly between the groups in trials with flower distractors; *t*(42) = .580, *p* = .565. Within the groups, spider phobic patient did not show significant reaction time differences between trials with spider and flower distractors, *t*(21) = .37, *p* = .715. Non-anxious control participants were faster on trials with spider distractor than on trials with flower distractors, *t*(21) = 2.51, *p* = .020.

6.2.4.3 Eye movement data

Error fixation on distractor. The mean frequencies of error fixations on distractors are shown in Table 6.2. The ANOVA for the frequency of first fixations on distractors did not completely confirm the findings on manual reaction times. There was a main effect of group, *F*(1, 42) = 8.89, *p* = .005, η_p^2 = .18, and distractor type, *F*(1, 42) = 6.91, *p* = .012, η_p^2 = .14, but no significant interaction. The follow- up *t*-tests indicate that spider phobic patients made

more first fixations on spider ($t(42) = 3.02$, $p = .004$) and flower distractors ($t(42) = 2.68$, $p = .010$) than the control group. Phobic patients even made more fixations on flower distractors than on spider distractors, $t(21) = 2.30$, $p = .032$, whereas within the control group there were no significant differences between the distractor types.

Duration of error fixations on distractors. Mean durations and *t*-tests results are shown in Table 6.2. The ANOVA for the duration of fixations on distractors explains the tendency of reaction time differences on spider distractor between the groups. There was a significant interaction between group and distractor type, $F(1, 32) = 6.36$, $p = .017$, $\eta_p^2 = .17$. Phobic patients fixations on spider distractors lasted significant longer than those of non-anxious controls.

Table 6.2: Mean (and Standard Deviations) of reaction times to target, percent of error fixations on distractors and duration of fixations on distractors separately for the groups and *t*-test results.

		Phobic patients	Non-anxious participants	*t*-tests		
	Distractor type	*M (SD)*	*M (SD)*	*t*	*df*	*p*
Reaction times on target (ms)	Spider	898 (169)	836 (149)	1.54	42	.132
	Flower	894 (165)	871 (165)	.580	42	.565
First fixations on distractor (%)	Spider	17.42 (13.77)	7.77 (9.73)	2.69	42	.010
	Flower	22.16 (16.83)	9.09 (11.40)	3.02	42	.004
Duration of first fixation on distractor (ms)	Spider	163.40 (39.76)	129.64 (22.39)	3.08	34	.004
	Flower	149.67 (29.51)	147.98 (42.15)	.146	37	.884

6.2.5 Conclusions

This pilot study showed that phobic patients' manual response times on targets were slower when additional distractors appeared on the screen. The analysis of the eye-movement data revealed that the reaction time slowing was mainly caused by the frequency of fixations on the distractors: Before fixating on the target, spider phobic patients fixated more often than controls on all task-irrelevant distractors. However, this distractor effect in phobic patients was found for spider and flower distractors.

A close inspection of the results indicates that on spider distractor trials, there was a trend that spider phobic patients responded slower to the target than control participants. This tendency cannot be explained by a higher frequency of distractor fixations – phobic patients fixated even more often on flower distractors. But the duration of fixations on distractor stimuli provides a possible explanation: spider phobic patients' fixation duration on spider distractors is longer than control participants'.

Taken together, these preliminary results indicate that initially, phobic patients are easily distracted from an ongoing task by spider and flower pictures. Further on, if their eyes met a spider pictures, their fixations dwelled longer on these pictures than controls. In a broader sense, these findings can be interpreted as an unspecific initial hypervigilance or enhanced distractibility followed by a specific delayed disengagement from phobic pictures in phobic patients. Overall, it remains unclear whether the findings reflect a general higher distractibility of phobic patients, or whether they show a kind of overgeneralization based on physical similarity of flower and spider pictures. Furthermore, it is not assured that a peripheral differentiation of distractor pictures was possible in all cases. If fixations on distractors where always necessary to discriminate threatening pictures from neutral ones, it would be not astonishing that no specific differences for flower and spider pictures could be found.

6.3 Pilot study II

The interpretation of the first pilot study comprised one major limitation. We could not assure that it was possible for the participants to distinguish initially between the flower and spider pictures. One the hand, it is possible that the display arrangement size (which was adopted from Theeuwes, et al., 1999)was not adequate and therefore peripheral identification and distinction was too difficult. On the other hand, flower and spider distractor pictures shared a lot of similar stimulus features. Therefore, it is not possible to differentiate, whether spider phobic patients showed a general enhanced distractibility or rather the spatial location of the distractors inhibited an initial and automatic attentional allocation toward spiders.

A second pilot study was conducted in order to test the identification performance under different presentation conditions. The aim was to figure out the best visual angle for the distractors while maintaining the necessity to execute eye movements toward the target circle to identify the orientation of the letter inside. Furthermore, a third category of distractor pictures (mushrooms) was added. Because of their physical characteristics, these pictures were clearly distinguishable from spider and flower distractors.

6.3.1 Participants

15 participants (12 female, 3 male) were recruited amongst the student population. Due to technical problems, 2 female participants were excluded from analysis.

The remaining group of 13 subjects had a mean age of 27.23 years (*SD* = 7.36, range 21 – 49). All participants had normal or corrected to normal vision and 12 participants were right handed. There is no theoretical notion that spider fearful subjects should show a *lowered* identification performance than non-anxious subjects. In fact, it is more likely that they could have been better in identifying spider pictures. Therefore we chose non-selected students to assure that all participants were able to identify the pictures satisfyingly. The participants

filled out a spider fear screening (SAS, Rinck, et al., 2002) and had a mean score of *M* = 7.00 (*SD* = 6.12, range: 0-19).

6.3.2 Procedure

The presentation of instructions and stimuli and the recording of button presses were controlled by a high precision software (Presentation® Version 0.90, http://www.neurobs.com) running on an Intel Celeron Processor (500 MHz). A 15-in. monitor with a resolution of 1024 * 768 was used.

Eye-movements were recorded with an infrared eye tracking recording system (iView X, SensoMotoric Instruments, Teltow, Germany) with a 238 Hz resolution while viewing the displays. Eye movements were calibrated individually before the experimental task.

Prior the main part of this experiment, the participants were instructed to use one of three different buttons to indicate whether one of the presented red circles contains a picture of a spider (button „cursor left“), a flower (button „cursor right“) or a mushroom (button „cursor down“). A minimum of nine practice trials had to be completed until the association between the picture categories and the corresponding buttons was accurately. The practice trials consisted of the written word „spider“, „flower“ or „mushroom“ and the instruction to press the according button. Each practice trail was followed by the feedback whether the button press was correct. After practicing the picture classification, display arrangements similar to the pilot study one were presented, but the circles were presented at three different distances (11.12 cm, 8.59 cm, 6.45 cm) from the center of the screen, resulting in the visual angles of 12.7° (large), 9.8° (medium), 7.4° (small). Each display consisted of five red circles with small letters inside, one grey circle with a letter and one additional red circle which included one of the 24 different spider, 24 flower or 24 mushroom pictures.

Randomized, each red circle with a picture was presented at each of the three visual angles, resulting in 216 trials altogether. Overall, the whole task took proximal 20 minutes for the participants.

6.3.3 Data reduction and analysis

Eye-movements. The eye-movement recording was conducted to assure that the participants did not move their eyes toward the circles during the identification task. All trials where the participants did not fixate the central fixation cross all over the time (contrary to the instruction) were excluded from further analysis.

Error fixations were defined as a deviance of minimal 25 pixels for more than 80 ms from the central fixation cross-area during the trial. The mean numbers of error fixations were separately computed for the three different radius sizes and the three picture categories and were compared in an overall ANOVA and follow-up *t*-tests.

Behavioral data. The mean rates of correct identifications were computed separately for the three different radius sizes and picture categories and were compared in an overall ANOVA and follow-up *t*-tests.

According to the signal detection theory the indices for sensitivity d' ($d' = z$ [p(hits)] – z [p(false alarms)]) and response criterion ß ($\beta = y$[p (hits)] / y[p(false alarms)]) separately for the distractor pictures and the three visual angles were computed (Velden, 1982).

The mean sensitivity and response criterion were compared in separate ANOVA and follow-up *t*-tests. A correlational analysis was conducted with the level of spider fear and the identification performance.

6.3.4 Results

Error fixation rate. Overall, the mean frequency of error fixations was *M* = 17.91 % (*SD* = 11.09). The error fixations were separately computed for the three different radius sizes and the three picture categories (see Table 6.3.).

For the mean frequency of error fixations, an ANOVA with the factors visual angle (small, medium, large) and picture category (spider, flower, mushroom) was conducted. A significant main effect of visual angle indicated that the most error fixations were made within the largest visual angle, whereas the lowest error rate was found for the small visual angle, $F(2, 24) = 20.37$, $p < .001$, $\eta_p^2 = .63$.

A main effect of distractor picture ($F(2, 24) = 7.74$, $p = .004$, $\eta_p^2 = .39$) indicated that in comparison to spider or flower on trials fewer fixation errors were made on mushroom trials. There was no significant interaction between visual angle and picture category.

Separate ANOVAs for the three visual angles showed significant main effects for the picture category within the small ($F(2, 24) = 7.42$, $p = .004$) and the large visual angle, $F(2, 24) = 4.23$, $p = .032$. Error fixation rate was highest on spider trials and lowest on mushroom trials. No differences between the picture categories were found for the medium visual angle (see Table 6.4).

Table 6.3: Mean frequency of error fixations (and Standard Deviation) in percent separately for the visual angles and distractor picture categories.

	Distractor picture			
	Spider	Flower	Mushroom	Total
Visual angle	*M* (SD)	*M* (SD)	*M (SD)*	*M (SD)*
Small (7.38°)	25.6 (15.4)	32.7 (15.9)	21.2 (13.6)	26.5 (13.6)
Medium (9.82°)	16.3 (14.9)	17.3 (10.9)	11.9 (8.8)	15.2 (10.6)
Large (12.69°)	13.1 (13.4)	14.1 (13.9)	9.0 (10.7)	12.1 (12.1)
Total	18.4 (14.0)	21.4 (11.9)	14.0 (8.8)	

Table 6.4: Results of follow-up *t*-tests for the mean frequency of error fixations.

	t-value (*df* = 12)	*p*-value
Comparison of distractor pictures		
Spider - Flower	1.46	.171
Spider - Mushroom	2.19	.049
Flower - Mushroom	4.73	<.001
Comparison of visual angles		
Small - Medium	4.51	.001
Small - Large	4.86	<.001
Medium - Large	2.26	.043

Identification rate. The mean rates of correct identifications were computed separately for the three different radius sizes and picture categories (see Table 6.5.).

An ANOVA for the mean identification rates with the factors visual angle (small, medium, large) and distractor picture category (spider, flower, mushroom) showed significant main effects of visual angle ($F(2, 24) = 21.89$, $p < .001$, $\eta_p^2 = .65$) and picture category ($F(2, 24) = 30.73$, $p < .001$, $\eta_p^2 = .72$), as well as a significant interaction between visual angle and picture category, $F(4, 48) = 3.28$, $p = .04$, $\eta_p^2 = .22$.

Comparing the mean identification rates of the three visual angles independent from picture category – there were no significant differences between the small and the medium visual angle in identification performance, whereas the identification performance within the large visual angle was significant lower compared to the small ($t(12) = 7.13$, $p < .001$) and the medium visual angle, $t(12) = 5.82$, $p < .001$.

Comparing the picture categories, mushroom pictures were identified better than spider ($t(12) = 2.79$, $p = .016$) and flower pictures, $t(12) = 6.34$, $p < .001$. Spider pictures were better identified than flower pictures, $t(12) = 2.97$, $p = .012$.

Table 6.5: Mean percentage (and Standard Deviations) of correct identified distractor pictures separately for the three visual angles and distractor picture categories.

	Distractor picture			
Visual angle	Spider	Flower	Mushroom	Total
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Small (7.38°)	95.5 (4.2)	76.8 (14.4)	97.7 (4.4)	90.6 (5.4)
Medium (9.82°)	91.0 (7.3)	73.3 (16.3)	96.0 (3.5)	87.1 (6.2)
Large (12.69°)	75.5 (15.4)	65.9 (13.3)	91.8 (7.8)	78.0 (6.0)
Total	86.7 (8.5)	71.3 (12.7)	95.0 (3.1)	

Table 6.5: Mean percentage (and Standard Deviations) of correct identified distractor pictures separately for the three visual angles and distractor picture categories.

	Distractor picture			
Visual angle	Spider	Flower	Mushroom	Total
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
Small (7.38°)	95.5 (4.2)	76.8 (14.4)	97.7 (4.4)	90.6 (5.4)
Medium (9.82°)	91.0 (7.3)	73.3 (16.3)	96.0 (3.5)	87.1 (6.2)
Large (12.69°)	75.5 (15.4)	65.9 (13.3)	91.8 (7.8)	78.0 (6.0)
Total	86.7 (8.5)	71.3 (12.7)	95.0 (3.1)	

Signal detection. According to the signal detection theory the indices for sensitivity *d´* (*d´* = *z* [*p*(hits)] – *z* [*p*(false alarms)]) and response criterion *ß* (*β* = *y*[*p* (hits)] / *y*[*p*(false alarms)]) separately for the distractor pictures and the three visual angles were computed (Velden, 1982). The mean indices for sensitivity *d´* are shown in Table 6.6, the mean indices for response criterion *ß* are shown in Table 6.7.

The ANOVA for the mean sensitivity index *d´* revealed a main effect of picture type, $F(2, 24) = 73.13$, $p < .001$, $\eta_p^2 = .86$, and a main effect of visual angle, $F(2, 24) = 19.29$, $p < .001$, $\eta_p^2 = .62$, but no significant interaction. Follow-up *t*-tests revealed that the sensitivity index was higher for the small and medium visual angle compared to the large visual angle (both $p < .001$). The difference between the small and the medium visual angle was smaller, but still significant, $t(12) = 2.62$, $p = .013$.

The ANOVA for the mean response criterion *ß* revealed a main effect of picture type, $F(2, 24) = 4.91$, $p = .016$, $\eta_p^2 = .29$, and a main effect of visual angle, $F(2, 24) = 4.67$, $p = .043$, $\eta_p^2 = .28$, and a significant interaction, $F(2, 24) = 4.19$, $p = .045$, $\eta_p^2 = .26$.

Follow-up *t*-test showed that the observers were more carefully in judging the pictures on trials with the smallest visual angle compared to the large visual angle, $t(12) = 2.43$, $p = .031$. No differences were found between the small and the medium visual angle, $t(12) = 1.99$, $p = .07$.

Table 6.6: Mean sensitivity index *d'* (and Standard Deviation) separately for the three visual angels and distractor picture categories.

	Visual angle			
Distractor picture category	Small	Medium	Large	Total
Spider	3.52 (1.16)	2.98 (.85)	2.06 (.72)	2.85 (.69)
Flower	3.29 (1.16)	2.48 (.93)	1.67 (.69)	2.48 (.72)
Mushroom	5.04 (1.12)	4.02 (1.16)	3.31 (1.09)	4.13 (.86)
Total	3.95 (1.03)	3.16 (.83)	2.35 (.77)	

Table 6.7: Mean response criterion *ß* (and Standard Deviation) separately for the three visual angels and distractor picture categories.

	Visual angle			
Distractor picture category	Small	Medium	Large	Total
Spider	.63 (.56)	1.42(1.58)	1.78 (1.49)	2.85 (.69)
Flower	36.46 (44.95)	12.35 (24.08)	9.25 (27.26)	2.48 (.72)
Mushroom	5.40 (11.22)	3.35 (8.23)	1.64 (1.75)	4.13 (.86)
Total	14.13 (15.49)	5.71 (7.96)	4.22 (8.86)	

Correlational analysis. A correlational analysis revealed no influence of the level of spider fear on identification performance (see Table 6.8.).

Table 6.8: Correlations of percentage of correct identifications with Fear of Spider Questionnaire-Score (Bonferroni- adjusted).

Distractor picture	Visual Angle	Correlation (*r)* with Spider Fear Screening (SAS) Score
Spider		
	Small	.14 *ns*
	Medium	.24 *ns*
	Large	.29 *ns*
Flower		
	Small	.35 *ns*
	Medium	.40 *ns*
	Large	-.07 *ns*
Mushroom		
	Small	.33 *ns*
	Medium	.07 *ns*
	Large	.59 *ns*

6.3.5 Conclusion

The indices for the medium visual angle of 9.82° were judged as best. On the one hand, the identification performance for all picture categories (*M* = 87.1 %, *SD* = 6.2) was high as well as the sensitivity index (*M* =3.16, *SD* = .83). There were no differences in response criterion between the small and the medium visual angle. Overall, there were the smallest differences between picture categories when they were presented at the medium visual angle compared to smaller or larger visual angles. The medium visual angle assured the need to move the eyes toward the target letter and the experimental design would be more comparable to the first pilot study. Most important, there were no significant correlations between identification rate and spider fear.

Curriculum Vitae

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Education

04/2004	Diploma in psychology (major in Clinical Psychology and Neuropsychology); Diploma thesis on "Binocular rivalry in different facial expression and the influence of social anxiety"
1997 - 2004	Psychology studies at Julius-Maximilians-University Würzburg
1996 - 1997	Sociology and education studies at Georg-August-University Göttingen
1995	German high-school diploma (Abitur) at Gymnasium „In der Wüste“, Osnabrück

Research Experience

since 08/2007	Research scientist: Project "Pain and Emotion” (DFG) at the department of Biological Psychology, Clinical Psychology, and Psychotherapy, Julius-Maximilians-University Würzburg
2005-2007	Dissertation scholarship at the department of Biological Psychology, Clinical Psychology, and Psychotherapy, Julius-Maximilians-University Würzburg
04/2004 – 12/2004	Research scientist: Project "Smoking control in official buildings and schools" at the department of Biological Psychology, Clinical Psychology, and Psychotherapy, Julius-Maximilians-University Würzburg
2002 – 2004	Research assistant concerning „Psychophysiological studies on emotion” at the department of Biological Psychology, Clinical Psychology, and Psychotherapy, Julius-Maximilians-University Würzburg

Würzburg, 06/17/2008

Antje BM Gerdes