

**Sensory Processing in High Anxiety Sensitive Persons
and Spider Phobic Individuals**

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1. FOREWORD

„Strach ma wielkie oczy“
- the fear makes the eyes wide open. This polish proverb reflects a popular observation that an increased fear triggers a contraction of musculus orbicularis oculi as well as a pupil dilatation. In fact, intensive



fear and anxiety drive the organism to concentrate as much resources as possible to cope with a potential threat. The phenomenon described above allows to improve the analysis of the perceptual field in order to detect and identify potentially relevant stimuli. However, in spite of scientific efforts, it is still not clear how our brain process threat-relevant cues and how a fearful state modulates this processing.

A main question investigated in the present study is, how the level of fear and anxiety modulates the pattern of sensory processing. At the beginning of the present work the reader will be familiarized with conceptual foundations and with previous findings related to this issue. Since anxiety and fear are considered to be two slightly different phenomena first chapters will discuss their characteristics and present the actual knowledge about how these emotions regulate the activity of our organism and modulate the sensory processing. These introductory considerations will focus mainly on characteristics of phobic individuals and high anxiety sensitive persons, chosen for the present experiment to investigate whether fear and anxiety differentially modulate the pattern of sensory processing. Furthermore, the study aimed at verifying whether this pattern changes during the anticipation of concern-relevant challenge. In order to gain this goal, additional tests were performed in high anxiety sensitive participants during the anticipation of hyperventilation and spider phobics during the anticipation of a living tarantula.

To investigate the influence of fear and anxiety on the sensory processing the present study utilized Event Related Potentials (ERPs). This method was proved to be useful to observe the timing of the sensory processing and its modulation by implicit or explicit focus of attention. To understand the role of Event Related Potentials in studying attention the reader will be familiarized with notions of implicit and explicit attention as well as with actual ERP findings dealing with this issue. What is most

important for the previous study, Event Related Potentials allow to investigate how the sensory processing is modulated by emotion. Moreover, contrary to many other methods applied in studies on emotion, Event Related Potentials allow to monitor the timing of this modulation and to observe the influence of emotion on very early processing stages. Accordingly, the introductory comments present the role of emotion in a human life and the influence of emotion on the sensory processing.

The introduction into conceptual foundations will be followed by the presentation of methodological procedures applied in the present study. The ERPs were collected from participants exposed to a series of randomly presented pleasant, unpleasant, neutral as well as concern-relevant pictures (panic-relevant medical emergency pictures and phobia-relevant spider pictures). More precisely, the study utilized two different passive picture viewing tasks that were proved to be an appropriate method to observe the emotional modulation of sensory processing. In the first run pictures were presented with a long duration (1500 ms per picture) whereas in the second part participants were exposed to the Rapid Serial Visual Presentation (332 ms per picture). After the introduction into experimental procedures the results obtained in the present study will be demonstrated and discussed.

2. CONCEPTUAL FOUNDATIONS

2.1. Selective Attention in Fear and Anxiety

2.1.1. Anxiety and Fear

In common language the terms “fear” and “anxiety” are often used as synonyms. However, in psychology these two words have been differentially defined. Fear occurs as a reaction to an explicit threat cue, increases with its greater proximity and terminates in the absence of threat. Anxiety is induced by the expectation of a potential threat and does not require the presence of a specific threatening stimulus. This differentiation is incorporated in “The ICD-10 Classification of Mental and Behavioural Disorders”. The ICD-10 distinguishes two categories of anxiety disorders. Disorders included in the first category (phobic anxiety disorders) are marked out by worries of a specific situation or object and thus by high fearfulness. The second category (other anxiety disorders) includes e.g. panic disorder and generalized anxiety disorder which are characterized by diffuse worries about potential dangers and thus by high anxiety.

All anxiety disorders are associated with increased physiological responsiveness to threat and facilitated sensory processing of threatening events. However, the above-mentioned categories of anxiety disorders differ according to the extent of the attentional bias and the severity of psychopathology. Since phobias result in an increased attention toward a specific stimulus, generalized anxiety disorder and panic disorder are marked out by a general hypervigilance toward potential threat. Moreover, individuals with panic disorder or generalized anxiety disorder are characterized by more negative affect and perceive threatening events as more unpleasant than specific phobics (Lang, McTeague, & Cuthbert, 2005).

Numerous findings regarding the characteristics of fear and anxiety come from studies on analog samples, i.e. participants from a general population who exhibit different levels of anxiety or fearfulness. In the present study the mechanism of selective attention will be investigated in two analog samples – participants with high anxiety sensitivity and individuals with high fear of spiders. The following chapters will characterize both groups and present the standard of knowledge about selective attention in fear and anxiety.

2.1.2. Anxiety and the Selective Attention

2.1.2.1. Fear of Anxiety in the Expectancy Model of Reiss and McNally

In their expectancy model Reiss and McNally (1985) specified two components responsible for the occurrence of fear and anxiety. They proposed that these emotions can result from high *danger expectancy* or high *fear of anxiety*.

The first component (danger expectancy) is evoked by stimuli associated with environmental danger. Accordingly, objects or situations associated with physical or social harm will result in high danger expectancy and trigger a fear response. Suppose a person is afraid of dogs and has to enter the house of a dog owner. High danger expectancy experienced in this situation will trigger his/her fear response. This fear might have been acquired in different ways. It can result from classical Pavlovian conditioning where a conditioned fear response is acquired when previous experiences with a dog (conditioned stimulus) resulted in pain or other harmful consequences (unconditioned stimulus). Furthermore, an individual can become scared of dogs by observational learning (e.g. watching a dog causing pain to another person), cognitive learning (e.g. an adult asking a child to be careful of dogs because they are dangerous and can produce pain) or covert conditioning (associations reinforced by imaginations or words).

The second component in the model of Reiss and McNally (1985), the fear of anxiety, results from *anxiety expectancy* and *the sensitivity to anxiety symptoms*. The anxiety expectancy increases with greater chance of encountering events associated with anxiety and thus greater chance to experience anxiety symptoms such as heart palpitations, chest pain, choking sensations, dizziness, etc. Whether the person shows a fear of anxiety depends not only on the expectancy that anxiety will occur (anxiety expectancy) but also on the sensitivity to anxiety symptoms.

Let's go back to the person scared of dogs. His/Her reaction triggered before entering the house of a dog owner might be affected not only by high danger expectancy but to some extent also by the high fear of anxiety – the expectancy of anxiety symptoms and the sensitivity to these symptoms.

Danger and anxiety expectancies are considered situation-specific factors whereas anxiety sensitivity is a person-specific variable. Anxiety sensitivity has been defined as the belief of a person regarding the harmful consequences of bodily sensations accompanying anxiety. Individuals with high anxiety sensitivity anticipate

that anxiety sensations may have negative implications. These people may suppose that heart palpitations indicate an evolving heart attack and feeling dizzy will be noticed and negatively evaluated by other people. In contrast, individuals low in anxiety sensitivity regard these sensations as merely unpleasant. The fear response produced by high anxiety expectancy will therefore differ as a function of anxiety sensitivity. High anxiety sensitivity together with high expectancy of anxiety results in a high fear of anxiety.

McNally (1999a) considers anxiety sensitivity as an individual variable which differs from general trait anxiety. The latter refers to a tendency to respond fearfully to different stressors, whereas anxiety sensitivity is restricted to the tendency to respond with anxiety to anxiety symptoms. To assess the level of anxiety sensitivity Reiss, Peterson, Gursky, & McNally, (1986) developed the Anxiety Sensitivity Index. This questionnaire includes 16 items that tap fears of anxiety (e.g. "It scares me when I am nervous.") and anxiety related symptoms (e.g. "Unusual body sensations scare me.") as well as concerns about possible negative implications of anxiety (e.g. "When I notice my heart is beating rapidly, I worry that I might have a heart attack."). According to factor analyses of ASI the concerns included into the concept of anxiety sensitivity can be divided to negative social, physical and mental consequences of anxiety (Zinbarg, Mohlman, & Honk, 1999).

There are various hypotheses regarding the origin of the fear of anxiety. Conditioning theories imply that the fear of bodily sensations is conditioned by the experience of panic attacks (Barlow, 1988; 1991; Bouton, Mineka, & Barlow, 2001). According to this perspective the sensations that previously accompanied a panic attack will be able to elicit the fear of anxiety and produce panic attacks in the future. However, this explanation is insufficient to account for high fear of anxiety in people who did not experience a panic attack. Therefore, it has been proposed that the fear of anxiety can be acquired not only through direct conditioning (an experience of a panic attack) but also via verbal and observational routes (McNally, 1990; Clark & Ehlers, 1993). This assumption was supported by retrospective studies performed with panic patients (Ehlers, 1993) and students with high anxiety sensitivity (Watt, Stewart, & Cox, 1998). These studies revealed that high fear of anxiety can result from the parental reinforcement or modelling of sick role behavior in response to anxiety.

2.1.2.2. Anxiety Sensitivity and Pathological Fear of Anxiety

Elevated anxiety sensitivity was suggested to constitute a risk factor for developing panic attacks and panic disorder (McNally & Lorenz, 1987).

A panic attack is characterized by a sudden occurrence of various bodily sensations and mental symptoms, such as heart palpitations, feeling dizzy, chest pain, air hunger, fear of dying, losing control, or going crazy. Such an attack can be triggered by feared events or objects but sometimes occurs without any specific reason. It can take a couple of minutes or even longer. The experience of panic attacks is a core symptom of panic disorder. To get a diagnosis of panic disorder a person must experience panic attacks that occur without an explicit trigger as if they come out of the blue. Moreover such a person must have developed a substantial anxiety or concern about the possibility of having other panic attacks and about their negative implications (DSM-IV: American Psychiatric Association, 1994). Panic patients often develop the complication of agoraphobia. Agoraphobia is characterized by the fear of being alone or going into public places based on a belief that in case of an unexpected panic attack these situations would be embarrassing and unsafe.

The relation between anxiety sensitivity and both panic attacks and panic disorder was investigated in a number of studies. Panic disordered patients were observed to score higher on the ASI than patients with other anxiety disorders (Taylor, Koch, & McNally, 1992). Moreover, higher scores on the ASI correlated with greater possibility to develop panic attacks in healthy individuals. The anxiety sensitivity was found to mediate the responses to panic provocation in subjects without prior panic attacks (for review see Stein & Rapee 1999; Harrington, Schmidt, & Telch, 1996). The study performed by Schmidt, Lerew, & Jackson (1997) demonstrated that cadets from the U.S. Air Force Academy scoring high on the ASI developed more spontaneous panic attacks than low anxiety sensitive subjects. In a 4-year prospective study performed by Hayward, Killen, Kraemer, & Taylor (2000) the scores in ASI were found to be a good predictor of panic attacks in a population of high school adolescents.

Cox, Borger, & Enns (1999) assumed that also other anxiety disorders may be maintained by a combination of danger expectancy, anxiety expectancy and anxiety sensitivity. It was repeatedly observed that phobics cannot get rid of their fears even though they realize that the phobic stimuli are actually not dangerous and the fear they experience makes no sense. For example a person may be scared of garden snakes even though he knows that they are harmless. In such a case, because the object is considered

actually not dangerous, the pathological fear is supposed to be sustained by the fear of anxiety associated with the object. As explained, before the fear of anxiety is closely related to anxiety sensitivity. Therefore anxiety sensitivity was suggested to influence the individual differences in the acquisition and maintenance of anxiety disorders. According to this idea, high anxiety sensitive individuals will tend to exhibit an increased fear response to danger because it is associated with anxiety symptoms.

2.1.2.3. Attention Research in Anxiety

2.1.2.3.1 Attentional Bias toward Threat

Due to limited attentional resources a complete processing of all stimuli emerging in the environment as well as those originating from the body is not possible. To cope with this problem the attention selectively focuses on stimuli identified as relevant for the subject.

Suppose an anxious person feels a slight unusual pain in the chest. This pain activates his worries and fears and engages attention, disturbing his daily functioning. The person will attend to every additional symptom that will confirm his worries and negatively interpret all ambiguous remarks made by other people. This example illustrates how anxious people selectively attend to threat cues, negatively interpret various ambiguous events and cannot stop thinking about potential dangers. In fact, a great number of studies demonstrated that fear and anxiety are associated with information processing biases (for review see Mogg & Bradley, 1998). In these studies a high level of anxiety or fear resulted in an increased attention toward threat, a tendency to interpret ambiguous situations or objects as threatening, and a better memory for dangerous events. The relation between anxiety and the selective attention toward threat is especially relevant for the present work and will be now described in detail.

The research on the relation between the selective attention and anxiety was based mainly on two strategies. The first one is to demonstrate how selective attention toward threatening stimuli facilitates the performance in certain tasks. Using this strategy numerous studies revealed that emotionally disturbed individuals have lower auditory and visual thresholds for stimuli associated with their concerns (for review see Williams, Mathews, MacLeod, 1996). The second strategy is to reveal how the attentional bias toward threatening stimuli interferes with successful task performance. One of the most frequently used paradigms in this kind of research is the emotional

Stroop color-naming task. In the classical version of a Stroop task (Stroop, 1935) boards with rows of Xs or names of colors were used as stimulus material. Participants were asked to name the color of ink in which a presented item was printed while trying to ignore its content. Because the meaning of a word automatically captures our attention, the color names were expected to interfere with the task performance. In fact, numerous studies showed delayed response latencies for items presenting a color name that differed from the color of the ink, e.g. BLUE (see MacLeod, 1991). In the emotional Stroop paradigm the participants view single words varying in emotional content and are asked to name the color of ink in which the word is printed. It was supposed that anxious individuals will demonstrate greater color-naming interference for threatening words than for neutral words. In fact, numerous studies shown that the emotional content of presented words interfered with the task performance in participants with high trait-anxiety (Mogg, Mathews, Bird, Macgregor-Morris, 1990; Richards & Millwood 1989; Richards, Richards & McGeeney, 2000) and anxiety disorders (e.g. Generalized Anxiety Disorder in Mathews & MacLeod, 1985; Mogg, Mathews, & Weinman, 1989; see also Williams, Watts, MacLeod, Mathews, 1988 for a review). In these people threatening words required longer reaction times and generated more errors than neutral words.

Despite its successful application in attention research the emotional Stroop paradigm was critically discussed (Mathews, 1990; Fox, 1993a). It was argued that the emotional Stroop task is not an appropriate method to assess the selective attention toward threat. Observed color-naming interference need not be caused by the selective attention toward threatening cues. This paradigm cannot prove whether the color-naming interference proceeds at the level of perceptual analysis or at the level of response (Seymour, 1977 in Fox, 1993a). As noticed by Mathews (1990) "...interference in this paradigm could be produced by the subsequent emotional reactions to words, or by a defensive shift in attention away from them" (p.458).

According to Fox (1993a) these problems can be avoided when displaying the threatening and neutral information at distinct locations. Such a strategy was used in the dot probe task (MacLeod, Mathews and Tata 1986). In this paradigm, a pair of words appears on a computer screen with one word located above and another located below the central screen position. Such a word pair may include one threatening (e.g. cancer) and one neutral (e.g. window) word. Its offset is followed by the onset of a neutral stimulus (a dot probe) being displayed on the same spatial position as one of the two

words. The participants are asked to read aloud the upper word and to indicate the position of a dot probe that appears on the screen after the offset of the word pair. Selective attention toward threat would manifest itself in faster detection of probes presented at the position of threatening words and slowed detection of probes presented at position of neutral words. Using this task high trait-anxiety subjects were observed to exhibit greater selective attention for threat words (Fox, 1993b; MacLeod & Mathews, 1988) and threatening scenes (Mogg, Bradley, McNamara, Powys, Rawlinson, and Seiffer, 2000) than low trait anxious individuals.

The paradigms described above were also used to investigate the selective attention in individuals with high fear of anxiety (for review see McNally, 1999b). The research based on a Stroop paradigm demonstrated an attentional bias for threat in high anxiety sensitive individuals (Stewart, Conrod, Gignac, & Pihl, 1998) as well as in subclinical and clinical panicers (Ehlers, Margraf, Davies, Roth, 1988; Maidenberg, Chen, Craske, Bohn, & Bystritsky, 1996; Hope, Rapee, Heimberg, and Dombeck, 1990; Lundh et al., 1999). These findings were replicated with the dot probe task (Beck et al., 1992; Less, Mogg, Bradley, 2005). Since some of these studies observed that individuals with high fear of anxiety exhibit a general hypervigilance toward threat (Ehlers et al., 1988; Maidenberg et al., 1996; Beck et al., 1992) others demonstrated that this attentional bias is particularly intense in case of panic-relevant stimuli (Hope et al., 1990; Lundh et al., 1999).

In summary, the previous studies showed that anxious individuals exhibit an attentional bias toward threat. This bias of attention was mostly limited to concern-relevant stimuli. Even if subjects with high fear of anxiety were observed to exhibit a general hypervigilance for threat some data show that their attention might be engaged more intensively especially by panic-relevant stimuli.

2.1.2.3.2. Preattentive Bias toward Threat

Using different experimental paradigms the researchers observed that the vigilance for threat affects not only conscious but also unconscious sensory processing (Öhman, 1993; Mathews & Mackintosh, 1998). The studies on preattentive (and thus unconscious) processing of visual stimuli were mostly based on the masking procedure. The words or pictures were presented very briefly (for about 10-30 ms) and immediately obscured by a pattern mask, so that the participants were not aware of their meaning. It was repeatedly shown that masked presentation influences the information

processing. The exposition to subliminally presented stimuli resulted in affective priming effects, such as changes in preference judgments or subsequent decision speeds. For example, subliminally presented pictures of faces with different affective expressions influenced the preference ratings of subsequently displayed novel pictures. Pictures paired with smiling faces were judged as more liked than pictures paired with angry faces (Murphy & Zajonc, 1993).

Using a masking procedure numerous researchers demonstrated preattentive bias toward threat in anxious individuals. There is a lot of evidence for an increased vigilance for subliminally presented threatening words in high trait anxious individuals (Fox, 1996; Mogg, Bradley, Williams, Mathews, 1993a). The selective processing of threat was also observed at preattentive levels in clinical anxiety. Individuals with generalized anxiety disorder demonstrated hypervigilance for threat both in unmasked and masked versions of the emotional Stroop task (Mogg, Kentish, Bradley, 1993b; Bradley, Mogg, Millar, White, 1995) and the dot probe task (Mogg, Bradley, Williams, 1995).

Mogg and Bradley (1998) noticed an interesting principle underlying the data obtained from masked and unmasked presentation. In the masked condition the individuals with generalized anxiety disorder showed a selective attention for threatening contents in general (i.e. anxiety and depression-relevant words) (Mogg et al., 1993a; Bradley et al., 1995; Mogg, Bradley, Williams, 1995). In the unmasked condition this bias was limited only to words associated with predominant concerns (Mathews & MacLeod, 1985; Mogg, & Bradley, 1989, Mogg, Mathews, & Eysenck, 1992). Interpreting these findings Mogg & Bradley (1998) suggested that the unmasked presentation enables a detailed analysis of the word content resulting in the selective attention toward concern-relevant stimuli whereas the masked presentation allows only a relatively superficial level of semantic analysis resulting in the selective attention toward diverse threatening events.

This hypothesis did not stand the test in case of individuals with high fear of anxiety. As revealed by Lundh et al. (1999) these individuals demonstrated indeed a preattentive bias for different threatening words but this bias was even greater in case of panic-relevant words. However, these findings were still not replicated.

2.1.2.4. Summary

In the present chapter factors contributing to the occurrence of fear and anxiety as specified in the expectancy model of Reiss and McNally (1985) were described. Accordingly, the fear of anxiety and the anxiety sensitivity were characterized in greater detail according to their importance for the present study.

Further focus lay on the research on selective attention in anxious individuals and especially in subjects with high fear of anxiety. As demonstrated a great number of data revealed that subclinical and clinical anxiety results in a selective attention toward threat. This effect was observed not only for consciously perceived visual materials but also when threatening stimuli occurred outside awareness. The hypervigilance observed in the masked condition speaks for an automatic and involuntary selective attention toward threat.

Furthermore, the findings indicate that independent of the status of awareness subjects with high fear of anxiety are characterized by a general hypervigilance toward threat. This tendency was observed to be particularly intense in case of panic-relevant visual materials.

2.1.3. Fear and the Selective Attention

2.1.3.1. Fear

As described in chapter 2.1.1., fear occurs as a reaction to an explicit threat. The fear response is activated by the defensive fear system of the mammalian brain (Lang, Davis, Öhman, 2000; Öhman & Mineka, 2001) that developed in the phylogenesis because it proved to be helpful to survive dangerous situations. It leads to facilitated sensory processing of threat cues and initiates a specific pattern of physiological and behavioral responding that helps to cope with the threat. Due to its old evolutionary origin the human fear system operates in a similar way as in other mammals (Marks, 1987). According to the predator imminence model the pattern of a defensive activity depends on the proximity of the threatening or painful stimulus (Fanselow, 1994; Lang, Simons, Balaban, 1997). Suppose an animal left a safe nesting area and entered a context associated with a threatening event. Even in the absence of an explicit threat, the fear system will respond to this situation with an appropriate adaptive activity including the reorganization of behavior and hypervigilance toward potential danger. These assumptions were proved by experiments with rats (Blanchard & Blanchard, 1989; Fanselow, Lester, & Helmstetter, 1988). To have food rats were forced to leave their hiding-place and enter an area associated with danger. The animals developed strategies that reduced the risk. They spent more time at the entrance into the dangerous area making more scanning head movements and started to make less frequent trips in the risky area taking larger meals. Since this pattern of a defensive activity, called the pre-encounter defense mode (Fanselow, 1994), is related to a potential danger it is typically observed in anxiety (see chapter 1.1)¹.

The post-encounter defense mode is activated when the predator already appeared but is still distant. Here, the typical response pattern is characterized by freezing and an increase of vigilance toward the source of danger. Increasing proximity of threat is associated with an increased fear response in order to mobilize the organism for an appropriate action. When the predator reaches a certain location, so that contact is inevitable, the potential prey will escape (if it is possible) or fight. When these options are not available, the organism will completely immobilize.

¹ Since it is important to mention that the anxiety engages a bit different neural structures than the fear (including e.g. the bed nucleus of the stria terminalis, see Davis & Lee, 1998) the present chapter will deal with the neural basis of the fear system.

Recently Löw, Lang, Smith, Bradley (2004) arranged an interesting experiment manipulating the proximity of visual stimuli, representing threat. In a continuous stream of pictures a single picture was occasionally presented repeatedly being loomed as if it was coming closer. The study demonstrated that behavioral, physiological and electrocortical responses to the emotionally relevant visual stimuli were modulated by their proximity.

2.1.3.2. Characteristics of the Fear Module

In the fundamental article Öhman & Mineka (2001) reviewed the findings from fear research and proposed a theoretical framework of the fear module. Due to its important implications for the study of selective attention toward threat the characteristics of the fear module will be described below.

2.1.3.2.1. Selectivity of the Fear Module

As already mentioned the fear module was established during evolution to assure an effective avoidance of danger. Because fear triggered by any accidental stimuli would be very unproductive, the defensive behavior is activated selectively by stimuli associated with threat. The associations are acquired mostly through simple Pavlovian conditioning. The stimuli that coincide with threat and by this way enable to predict danger in the future will be able to activate the fear system by themselves.

There is a wide range of stimuli that can trigger fear. Öhman, Dimberg, & Öst (1985) organized these stimuli according to the categorization of behavior proposed by Mayr (1974) and distinguished three classes of fear. Mayr suggested that every kind of behavior can be directed toward living objects (communicative behavior) and toward nonliving objects (noncommunicative behavior). The living objects can be further divided into the members of our own or other species. Accordingly, fear, as every other kind of behavior, can be directed toward objects or events (noncommunicative), other humans (communicative, the same species) or animals (communicative, other species) (Öhman et al., 1985).

The differentiation made by Öhman and coworkers was incorporated in the classification of phobias made by American Psychiatric Association and included in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV): nature phobias, social phobias and animal phobias. Phobic fear is characterized by a high intensity and irrationality and is accompanied by negative affect, sense of uncontrollability, cognitive

biases for threat, chronic hypervigilance and impaired functioning (see Rosen & Schulkin, 1998). In accordance with the preparedness hypothesis (Seligman, 1970, 1971), fear and phobias are more frequently related to stimuli being important for mammals in the foretime. In fact, it is easier to acquire a fear response to phylogenetically fear-relevant stimuli like spiders, snakes, heights or blood than to phylogenetically fear-irrelevant stimuli, even if they are highly dangerous but appeared very late in our phylogenesis like weapons or electricity outlets. The defensive response to phylogenetically fear-relevant stimuli is not only easy and fast to acquire but also more resistant to extinction.

The above assumptions were supported by experiments on differential conditioning. In this paradigm the participants were exposed to a series of fear-relevant (e.g. spider, snakes, angry faces) and fear-irrelevant (e.g. flowers, mushrooms, happy faces) pictures. During the presentation some specific pictures (CS+) were paired with an electric shock (UCS) whereas other pictures (CS-) were not paired. In order with the principles of the classical conditioning the stimulus associated with an aversive UCS (i.e. CS+) obtains the power to trigger the fear response. It was observed that the aversive response to fear-relevant pictures was acquired even when these pictures were presented subliminally. This effect was not found for fear-irrelevant stimuli (Öhman & Soares, 1998; Esteves, Dimberg, Öhman, 1994).

2.1.3.2.2. Neural Structures Involved in Fear

The confrontation with a stimulus associated with threat initiates a series of changes in a specific neural circuit. The core structure of this circuit is considered the amygdala, a group of nuclei located in the anterior medial temporal lobe. Previous findings demonstrated that lesions of the amygdala blocked unconditioned and conditioned fear responses typically indicated by freezing, increased skin conductance, potentiated startle reflex as well as greater heart rate and blood pressure (Davis, 2000; Fanselow, 1994). On the other hand electrical stimulation of the amygdala provoked fear responses in animals and humans (for review see Davis and Whalen, 2001). Studies using brain imaging methods observed an enhanced activation of the amygdala in phobic subjects viewing phobia-relevant pictures (Carlsson, Petersson, Lundquist, Karlsson, Ingvar, Öhman, 2004; Dilger, Straube, Mentzel, Fitzek, Reichenbach, Hecht et al., 2003; Fredrikson and Furmark, 2003; Schienle, Schäfer, Walter, Stark, & Vaitl,

2005; Sabatinelli, Bradley, Fitzsimmons, & Lang, 2005; Straube, Mentzel, & Miltner, 2006) or conditioned aversive stimuli (Morris, Öhman, Dolan, 1999).

The basolateral nucleus of the amygdala is considered the input region. It receives information from the thalamus, the hippocampus and the cerebral cortex. The information about the occurrence of a threatening stimulus can be transferred to the amygdala via the thalamic or via the cortical projections. The first pathway which omits the cortical structures and involves the direct connections between the thalamus and the amygdala is called the “low road” (LeDoux, 2000, 2002). The second pathway which involves the cortico-amygdalar connections is called the “high road”. These pathways were suggested to perform various functions. The “low road” is engaged in the automatic response to threatening stimuli and enables a fast detection of threat relying on the preliminary analyses of simple stimulus features (Öhman, 1993). The “high road” is involved in more elaborated processing of threatening information.

The input that reaches the basolateral nucleus of the amygdala is redirected to the central and lateral nuclei that in turn project to behavioral, autonomic and endocrine response control systems located in the brainstem nuclei (LeDoux, 2000). Via its backward projections to the cerebral cortex the amygdala also influences the vigilance toward threat (Davis and Whalen, 2001).

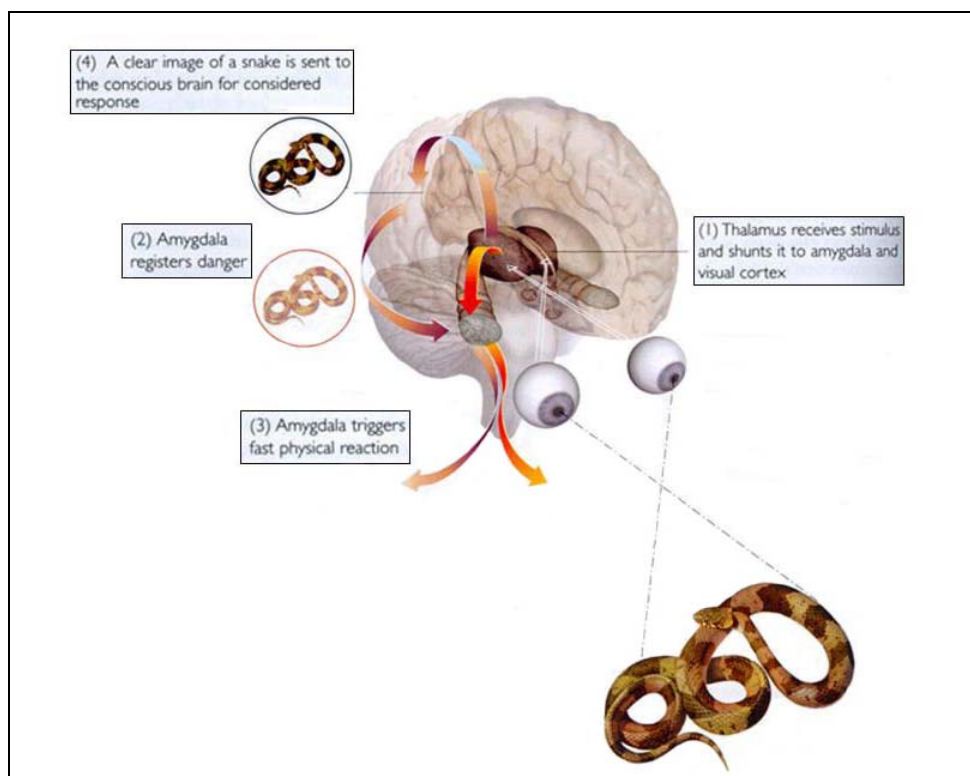


Figure 1. LeDoux's schematic demonstration of information transfer during the processing of fear-relevant stimuli (from Rita C., 1999).

2.1.3.2.3. Automaticity

As already mentioned the fear-relevant stimuli can activate the defensive system automatically, without any voluntary control via the evolutionary older thalamo-amygdalar pathway (“low road”). This property developed in animals having primitive brains which did not allow for a voluntary control of the defensive behavior. The advantage of an automatic and fast reaction to threat was also proved to be useful in humans because any elaborative processing of occurring stimuli would often waste time and diminish the chance for survival.

The automaticity manifests itself in a facilitated preattentive processing of threatening cues. It was repeatedly observed that even unrealized threatening stimuli can trigger an enhanced physiological activity. Accordingly, the occurrence of a spider in a visual field will activate the fear response of a spider phobic before he realizes the danger or even if he is not able to notice it.

Numerous experiments demonstrated that the physiological response can be triggered by aversive stimuli even without any knowledge about the stimulus meaning. Accordingly, Hamm, Weike, Schupp, Treig, Dressel, Kessler, (2003) observed physiological fear responses to an aversive visual stimulus in a cortically blind patient, who was not able to become aware of a stimulus content. Further evidences for an automatic activation of the fear system come from experiments using the masking procedure. In these studies the participants showed an increased activation of the fear system when exposed to masked aversive stimuli. Öhman and Soares (1994) observed that relative to neutral pictures (mushrooms and flowers) phobia-relevant stimuli (snakes or spiders) elicited higher skin conductance response in phobics both in masked and unmasked condition. Such differentiation was absent in non-fearful participants. These results were supported in the brain imaging study performed by Carlsson et al. (2004). In this study masked phobia-relevant pictures presented to phobic participants elicited increased activation of neural structures involved in the fear system.

The above-presented data revealed that a threatening stimulus can automatically trigger a physiological response. Other evidences for the automaticity come from studies investigating selective attention. This research is based mainly on visual search experiments that measure automatic *orienting* toward threat and on ERP studies that enable to observe the time course of sensory processing. The findings from these studies will be described later on.

2.1.3.2.4. Encapsulation

Once activated, the fear module will proceed to prepare the organism for a defense. It manifests itself in the maintained physiological activity and elaborated sensory processing that cannot be easily terminated by a voluntary control. For example, a spider phobic is most likely unable to influence the activation of a fear module that was just induced by a spider.

2.1.3.3. Selective Attention in Fear

Compared to the research on the selective attention in anxiety (see chapter 1.2.3) the characteristics of the sensory processing in individuals with high levels of fear appear to be investigated more carefully. The following chapter presents this high quality data as well as the theoretical considerations regarding the selective attention in fear.

Numerous studies demonstrated that phobia-relevant stimuli trigger increased physiological and behavioral responses (Öhman and Soares, 1994; Hamm, Cuthbert, Globisch, Vaitl, 1997; Globisch, Hamm, Esteves, Öhman, 1999). However, the effective defense cannot rely only on improved responding but also needs a mechanism that enables a fast selection of relevant stimuli from the whole range of events occurring in the perceptual field. Indeed, it was suggested that the perceptual field would be preattentively scanned and analyzed for relevant stimuli (Mathews & Mackintosh, 1998; Öhman, 1993; Öhman & Mineka, 2001b). Such a stimulus would activate an automatic *orienting* and facilitate further postattentive processing including the stimulus identification and evaluation. Accordingly, a spider located at the ceiling would automatically capture the attention of a spider phobic and initiate elaborated sensory processing.

The mechanism of selective attention toward relevant stimuli was specified in the *information processing model* proposed by Öhman (1993). According to this model the incoming information is first processed by the *feature detection system*. Some relevant stimuli (i.e. phylogenetically prepared or very intense) include elementary features (such as e.g. a specific shape) that make them easy to be identified by the feature detection system. These stimuli activate autonomic arousal without further processing. The output from the feature detection system is passed on to the nonconscious “*significance evaluation system*”. When the stimulus is assessed as relevant the “*significance evaluation system*” makes the decision to call for further processing resources and sends the information to the “*conscious perception system*” for

a conscious evaluation of stimulus meaning. The stimuli labelled as dangerous during the conscious evaluation result in an increased autonomic arousal. Because an increased arousal and a danger expectancy prime the “significance evaluation system” for the detection of threat, a threatening stimulus is more easy to be detected in a context associated with danger. Accordingly, since a spider phobic entering a cellar anticipates a spider, he is more likely to detect one.

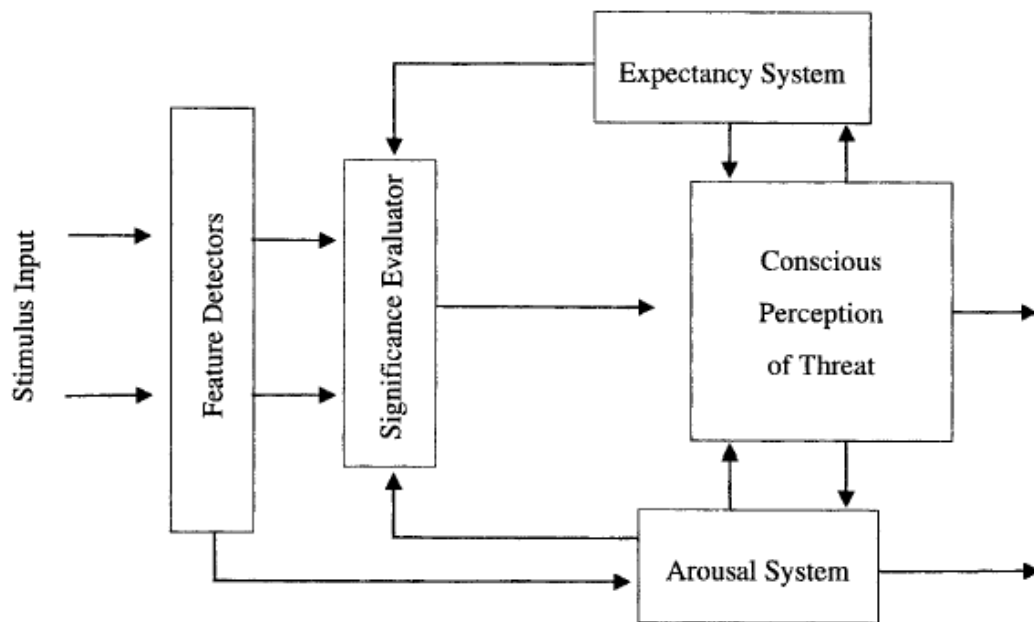


Figure 2. Schematic diagram of the information-processing model (Öhman, 1993).

The model proposed by Öhman was verified experimentally. Many experiments provided evidence for prioritized sensory processing of fear-relevant stimuli. In a Stroop task spider phobics (Thorpe, Salkovskis, 1997) showed delayed color recognition of phobia-relevant words, probably caused by the allocation of attention to the phobic content of the word. Due to the previously described deficiencies of the Stroop task further reports will rather focus on the experiments using the visual search task, which was proved to be a better tool for elaborated research on the selective attention. In this paradigm participants are required to detect a target picture embedded in an array of various pictorial materials. Such a design gives a possibility to investigate the characteristics of the visual attention in phobics (Allport, 1989; LaBerge, 1995; Fox, Russo, & Bowles, & Dutton, 2001). The fear-relevant stimulus can serve as a target presented against a neutral background. Measuring the reaction time required to detect the fear-relevant target in these trials we are exploring the *orienting* toward threat. On the other hand the fear-relevant stimulus can be presented as a distractor since the

neutral picture serves as a target. In this case the reaction time required to detect the neutral target indicates how far a threatening distractor *maintains* subjects attention. An automatic *orienting* is an indication for facilitated preattentive processing whereas prolonged *maintenance* of attention is considered an elaborated stimulus evaluation.

In a series of visual search experiments Öhman, Flynkt, Exteves (2001a) measured the reaction time required for the detection of fear-relevant (spider or snakes) or neutral (mushroom or flower) stimuli in phobic participants and non-fearful controls. The target stimulus was always embedded in a contrasting context (fear-relevant picture in a neutral context, etc.). Additional manipulations were related to the matrix size (2x2 or 3x3) and the position of the target picture in the matrix. The results revealed that fear-relevant target pictures presented against the background of fear-irrelevant stimuli were detected faster than fear-irrelevant targets presented against the background of fear-relevant stimuli. This effect was observed both in controls and phobic subjects. However, the fear-relevant targets were detected faster in phobic participants than controls. This finding indicates that fear facilitates *orienting* toward fear-relevant stimuli. Moreover, though the reaction time to trials including fear-relevant distractors was not affected by group, phobic participants made more errors in these trials than controls. According to Öhman et al. (2001a) this effect may indicate that fear-relevant distractors maintained the attention of phobics to a greater extent than the attention of non-fearful controls. The matrix size and the target location did not affect the detection of the fear-relevant target picture in both experimental groups. This effect was discussed as evidence that fear-relevant stimuli include some elementary features and pop-out from the background that makes them easy for preattentive search. On the other hand the position of the target picture and the size of the matrix influenced the detection time for neutral stimuli. This effect was recently replicated by Brosch, Naumann, Hagemann, Seifert, & Bartussek (2005a).

Taken together, the above-described findings indicate that an intensive fear influences the visual processing of fear-relevant stimuli. However, while phobic participants exhibited a facilitated orienting toward fear-relevant stimuli, they did not clearly show maintained attention toward those stimuli. Moreover, supporting the preparedness hypothesis, the study revealed that phylogenetically relevant pictures modulated the sensory processing also in non-fearful subjects. However, due to some methodological problems the experimental design used by Öhman et al. (2001a) did not

allow to draw definitive conclusions about the specific nature of the attentional bias observed in these participants.

It was suggested that the data based on reaction time may not provide reliable evidence for selective attention toward threat (Miltner, Krieschel, Hecht, Trippe, & Weiss, 2004, Mogg & Bradley, 1998). A manual response may be generated at later stages of stimulus processing and does not necessarily reflect a faster orienting. Considering all critical arguments subsequent visual search studies used more elaborated designs including the eye tracker as an additional measuring method which enabled a more detailed analysis of the fear-related modulation of attention. (Rinck, Reinecke, Ellwart, Heuer, & Becker, 2005; Miltner et al., 2004; Springmann, Gerdes, Alpers, Pauli, 2006). Not all findings from these studies stay in agreement with those from the study performed by Öhman.

These studies clearly demonstrated an effect of maintained attention toward fear-relevant stimuli in phobics. In the study by Rinck et al. (2005) spider phobics required more time for the detection of a neutral target than non-fearful controls when the whole distracting background was composed of spiders. Miltner et al. (2004) and Springmann et al. (2006) revealed that even a single spider distractor slowed down the detection time of a neutral target stimulus to a greater extent in spider phobics than in nonfearful controls. No group differences were observed for other distractors.

These studies, however, did not consistently replicated Öhman's evidence (2001a) of speeded orienting toward the fear-relevant stimuli in phobics. In a series of experiments performed by Miltner et al. (2004) phobics showed faster reaction times to a fear-relevant target presented against the background of 15 flowers than nonfearful controls. However, they did not demonstrate speeded eye movements toward fear-relevant targets. These data do not correspond to the results of Rinck et al. (2005) that observed a speeded detection of fear-relevant stimuli in phobics for both measures - eye movements and reaction time. However, in this study this effect was observed only when the task required to find a spider hidden among other contents but was not demonstrated when the task required to detect a specific spider presented against the background of other spiders. According to the authors it was the analytic search strategy used in the latter condition that most probably cancelled a speeded detection of threat in spider phobics.

In accordance with the preparedness hypothesis the study by Öhman et al. (2001a) demonstrated a facilitated sensory processing of phylogenetically fear-relevant

targets in nonfearful subjects. In their study spiders and snakes presented against a neutral background were detected faster by nonfearful subjects than neutral targets presented against the background of spiders or snakes. These results were not replicated by Miltner et al. (2004). Here the nonfearful subjects did not demonstrate neither a faster orienting nor a maintained attention toward phylogenetically fear-relevant stimuli. However, Öhman et al. (2001a) presented a target stimulus against a background including only fear-relevant pictures whereas Miltner et al. (2004) presented only one single fear-relevant distractor. It is possible that the amount of threatening distractors in the study of Öhman et al. (2001a) exceeded some critical value required to distract the attention of nonfearful controls. Because Miltner et al. (2004) investigated the influence of discretely presented distractors the spider distractor might have not engaged more attention of nonfearful subjects.

2.1.3.4. Summary

The present chapter introduced the standard of knowledge about fear and coping with threatening events. It was demonstrated that the processing of fear-relevant stimuli and the arrangement of an appropriate defensive response is controlled by the neural defensive system that developed over a long evolutionary history. This system can be activated very fast even without the awareness of danger. Once turned on the defensive activity continues and cannot be easily terminated.

Although numerous studies demonstrated that the fear intensity modulates defensive responses to threat (Hamm et al., 1997, Globisch et al., 1999), less is known about its influence on the early and late sensory processing. While the information processing model of Öhman (1993) suggests that the fear modulates early and late processing stages, the experimental evidence only partially supports this assumption. The findings from visual search experiments demonstrated that fear results in a maintained attention to fear-relevant stimuli which suggests that the fear modulates later stages of sensory processing associated with an elaborated stimulus evaluation. These studies did not provide a definite evidence for faster orienting toward fear-relevant stimuli in phobics and thus did not warrant any conclusion about influence of fear on the early sensory processing of fear-relevant stimuli. Moreover, supporting the preparedness hypothesis (Seligman, 1970, 1971; Öhman et al., 2001b) also nonfearful subjects showed a facilitated sensory processing of fear-relevant stimuli during later processing stages.

2.2. Event Related Potentials and the Study on Selective Attention

2.2.1. Electrocortical Activity and Event Related Brain Potentials

Measuring event related brain potentials (ERPs) allowed to observe the timing of the sensory processing and its modulation by implicit or explicit focus of attention. Event related brain potentials (ERPs) are low frequency changes in electrocortical activity that occur in response to discrete stimuli. The ERPs measured on the head surface result from a synchronous activity of the nerve cells located with a perpendicular orientation toward it (Lutzenberger, Elbert, Rockstroh, 1987; Nunez & Srinivasan, 2006; Speckmann & Elger, 1982)

The raw electrocortical activity recorded from the subjects head contains not only the activity related to the appearance of the experimental stimuli but also artefacts and EEG activity of high frequency and high amplitude ($\pm 100\mu\text{V}$) which are unrelated to the stimulus. For this reason the data have to be submitted to a specific processing procedure. This procedure allows to clear out the artefacts, to average out the EEG activity and to isolate the ERP waveforms linked to the specific type of stimuli. The averaging procedure is illustrated in Figure 3. The left panel displays the EEG segments linked to the time point of the stimulus onset and the right panel shows the ERP waveform obtained after the averaging of these EEG segments. As highlighted in the right panel of Figure 3 the ERP waveforms are characterized by a sequence of positive and negative voltage fluctuations called *components*. The shape of the ERP waveforms depends on the type of an engaged sensory modality, the experimental task, the stimulus features and the personal characteristics of the subject. Accordingly, there is a great number of components with different spatial and temporal characteristics which reflect various operations of the sensory processing. The amplitude and the latency of these components provide information about the strength and the time course of underlying operations. In the following the ERP components evoked by visual stimuli in experiments that engage implicit or explicit attention will be described.

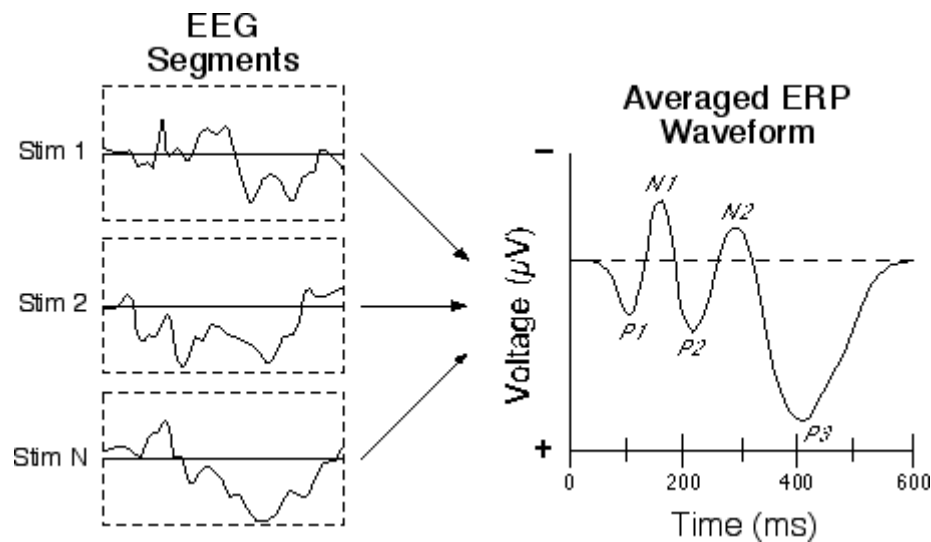


Figure 3. The left panel illustrates the EEG segments linked to the time point of the stimulus onset. The averaging of the EEG segments results in the ERP waveform (see right panel) characterized by several negative and positive components (from Luck, Woodman, & Vogel, 2000).

2.2.2. Mechanism of Selective Attention

The mechanism of selective attention can operate reflexively or undergo a voluntary control. In the first case the attention is attracted automatically as a result of specific stimulus features like brightness, color, a sudden onset, etc. This kind of mechanism is initiated e.g. when we suddenly hear a honk while crossing the road. Also some stimuli having a relevant personal meaning like our name or the name of a favoured football team can reflexively capture our attention. Because this perceptual mechanism does not undergo a voluntary control it is called reflexive, or implicit, selective attention and is said to be “bottom-up driven”. In the second case the subject willingly labels the stimulus as relevant and voluntarily attends to it e.g. while looking for a friend in a crowd. Because the sensory processing is facilitated by an explicit and voluntary amplification of the stimulus relevance this kind of mechanism is called explicit selective attention and is said to be “top-down driven”.

Both implicit and explicit selective attention can be investigated in an experimental situation. Asking participants to attend to some kind of stimuli, like in an Oddball task or to a special feature of a stimulus like in a Stroop task as well as to attend to stimuli occurring in a defined location, like in a Posner paradigm, will engage explicit selective attention. Whereas such experimental designs that do not explicitly define the stimuli that have to be attended, like passive picture viewing paradigm, will activate implicit selective attention.

2.2.3. Explicit Attention and Event Related Potentials

ERP studies revealed that manipulating the explicit attention modulates very early stages of the sensory processing. In these studies subjects are mostly asked to attend to objects occurring at a defined location (visuo-spatial attention) or to select objects with predefined features from the whole range of presented stimuli (nonspatial attention).

In a typical visuo-spatial attention task stimuli occurring at the attended position elicited more pronounced P1 and N1 (the time window 80-130 ms and 120-200 ms respectively) observed over occipital areas than stimuli occurring at the unattended position (Hillyard & Anllo-Vento, 1998; Mangun, Hillyard, & Luck, 1993). Hillyard, Vogel, Luck (1998b) suggested separate mechanisms underlying these components. In case of P1 the effect of visuo-spatial attention (attended vs. unattended locations) is probably caused by an attentional suppression of unattended stimulus whereas in case of N1 by an attentional facilitation of attended stimulus (Luck, Hillyard, Mouloua, Woldorff, Clark, Hawkins, 1994; Luck & Hillyard, 1995; Mangun & Hillyard, 1991). The extrastriate visual cortex is suggested as a neural generator of these components (Clark, Hillyard, 1996; Hillyard et al., 1998b; Martinez, Anllo-Vento, Sereno, Frank, Buxton, Dubowitz, Wong, Hinrichs, Heinze, Hillyard, 1999).

The earliest and the most prominent ERP component modulated by an explicit attention toward nonspatial stimulus features is the selection negativity observed over the occipital areas in the time interval between 140-250 ms (Harter & Aine 1984; Mangun, Hillyard, & Luck, 1993). The selection negativity is thought to reflect an elementary feature analysis. The selection negativity is enhanced during the presentation of task relevant stimuli with a predefined color, orientation, shape, direction of motion, etc. (Harter and Previc, 1978; Hillyard & Anllo-Vento, 1998). Some experiments demonstrated a modulation of the selection negativity when the identification of the task relevant and the task irrelevant stimuli based on the semantic denotation ("Does the picture present an animal?") (Fabre-Thorpe, Delorme, Marlot, & Thorpe, 2001; Rousselet, Fabre-Thorpe, & Thorpe, 2002 ; Delorme, Rousselet, Mace, & Fabre-Thorpe, 2004). A recent study revealed that the effects of an explicit attention observed in the selection negativity are probably generated in the temporo-occipital brain areas (Codispoti, Ferrari, Junghöfer, & Schupp, 2006).

There are several ERP components which appear later than the selection negativity and belong to the group of the N200s (identified between 200-300 ms). The N200s were observed during nonspatial attention tasks that engaged different sensory modalities. The N200s are considered to reflect later stages of the sensory processing and are associated with detection and identification of the relevant stimuli. Several N200s were observed to be modulated by an explicit attention toward visual stimuli. One of them, the N2pc, was observed over posterior areas and was enhanced for target stimuli during the visual search task (Luck & Hillyard 1995; Eimer 1996; Patel & Azzam 2005). Another component of the N200s, called also N2b, was observed over central or frontal brain regions for rare stimuli and stimuli that mismatched mentally-stored expectations (Sams, Alho, Näätänen, 1983; see review Fabiani, Gratton, & Coles, 2000). The N2b was found for deviations in both visual and auditory modality (Sams et al., 1983; Gehring, Gratton, Coles, Donchin, 1992) as well as by orthographic, phonologic and semantic alterations (Sanquist, Rohrbaugh, Syndulko, & Lindsley, 1980).

The P300 is the next component which was demonstrated to be more pronounced in the encoding of target stimuli when compared to nontarget stimuli. It is modulated by a great number of factors and appears independently of the stimulus modality in various experimental paradigms such as visual search task, oddball paradigm or counting task (Johnson, 1988; Kok, 2000; Schupp, Junghöfer, Weike, & Hamm, 2003a). The P300 is mostly observed over the centro-parietal areas in the time window between 300 and 700 ms although its location and latency varied extensively across different experimental designs. Some studies demonstrated that the latency of P300 varied with a time required for stimulus evaluation (Brookhuis, Mulder, Mulder, Gloerig, 1983; Donchin & Coles, 1988). The amplitude of P300 is sensitive to manipulations of attention, stimulus value, task complexity, stimulus complexity as well as stimulus probability (Johnson, 1988). Because the P300 is sensitive to a great number of different factors and originates from different neural generators it is supposed to reflect more complex sensory processing involving the working memory and stimulus evaluation.

2.2.4. Motivation and Event Related Potentials

2.2.4.1. Implicit Attention and Event Related Potentials

Numerous studies demonstrated that sensory processing can be modulated by specific physical characteristics or motivational relevance of the stimuli even without voluntary attention. One of the ERP components involuntarily modulated by physical characteristics of the visual stimuli is the novelty P3. It was observed over frontal brain areas and was marked out by a shorter latency than the centro-parietal P3. The novelty P3 was more pronounced during the processing of infrequent stimuli (Katayama & Polich 1998; Patel & Azzam 2005).

Some stimuli can automatically capture the attention because of their motivational relevance. As a consequence of this “attentional bias” the ERP waveforms elicited by emotionally relevant stimuli will differ from the ERP waveforms evoked by emotionally irrelevant stimuli. In the following, after a short introduction to the topic of motivated attention, the evidences for the affective modulation of the ERP waveforms will be described.

2.2.4.2. Motivational Organization of Emotion

The theory of motivated attention was developed by Lang and associates on the basis of previous findings on motivation and emotion performed by Konorski (1967) as well as Dickson and Dearing (1979). This research is fundamental for the study of the sensory processing in fear and anxiety and will be shortly described. Konorski (1967) identified two functionally different unconditioned responses in animals - *protective* and *appetitive*. Numerous researchers postulated that these different responses are controlled by appetitive and aversive motivational systems (Dickinson & Dearing, 1979; see Lang, Bradley, Cuthbert, 1990, 1992). The activation or inhibition of these motivational systems can be generated by a broad range of different stimuli. When activated these systems trigger a behavior characterized by specific *direction* and *intensity* (see Lang 1995). The activation of the aversive motivational system induces protective reflexes (e.g. startle reflex) and results in the withdrawal behavior (e.g. escape) whereas the activation of the appetitive motivational system potentiates appetitive reflexes (e.g. salivation) and leads to an approach behavior. The intensity of behavior will depend on the level of motivational activation as well as on the metabolic and somatic potential of the organism.

Lang and associates (1994) transferred these findings to the field of human emotions. Emotion can be described as a set of subevents which are elicited by a specific situation, person or object (Russell & Feldman-Barrett, 1999) and results in specific peripherphysiological responses, overt expressions (facial expression, gestures, running away, freezing, etc.) and subjective feelings. Emotions are considered as an output of a specific motivation activated by external or internal stimuli. The representatives of the evolutionary perspective emphasize the role of emotion in the preparation of behavior and thus in the adaptation to the environmental requirements (Frijda, 1986; Lang et al., 1997). According to Lang and associates (Lang et al., 1997; Lang, Bradley, & Cuthbert 1998; Bradley, 2000; Davis & Lang, 2003) all emotional states can be described on two dimensions - valence (or direction) and arousal (or intensity). The activation of the aversive system will evoke emotions of negative valence whereas the activation of the appetitive system will result in positive emotions. The intensity of emotion depends on the strength of motivational activation. Under certain conditions the emotions of negative valence will result in withdrawal behavior and the emotions of positive valence will lead to approach behavior.

Numerous studies revealed that the motivational activation modulates peripherphysiological and behavioral responses. And so, the emotional relevance of a stimulus influenced the reaction time in different experimental paradigms such as the emotional Stroop task (Mogg & Bradley, 1999) or visual search task (Öhman, Hamm, & Hugdahl, 2000). The influence of the motivational activation on other physiological parameters such as facial and peripherphysiological activity was extensively investigated with picture viewing paradigm. In this paradigm participants are asked to passively view a sequence of different pictures. Two standardized picture sets most commonly used in these studies will be shortly introduced here. The International Affective Picture Set (IAPS) includes pictures of different contents that cover the whole range of valence denotations and arousal intensities ((CSEA-NIMH), Bradley & Lang, 2000). Figure 4 illustrates the affective space of IAPS pictures obtained with valence and arousal ratings performed by a great number of subjects with the Self Assessment Manikin (Bradley & Lang, 1994). According to valence ratings the whole set can be divided into neutral, pleasant and unpleasant pictures. As expected, pleasant and unpleasant pictures were rated as more arousing than neutral pictures. These data indicate that pleasant and unpleasant IAPS pictures activate opposite motivational systems whereas neutral IAPS pictures fail to show any motivational significance. A

similar two-dimensional organization was found for the Karolinska Directed Emotional Faces (KDEF, Lundquist, Flykt, & Öhman, 1998). This set contains pictures of faces reflecting different emotions that can be categorized as unpleasant, pleasant and neutral. Relative to the IAPS pictures face images included in the KDEF are characterized by higher homogeneity in terms of physical features.

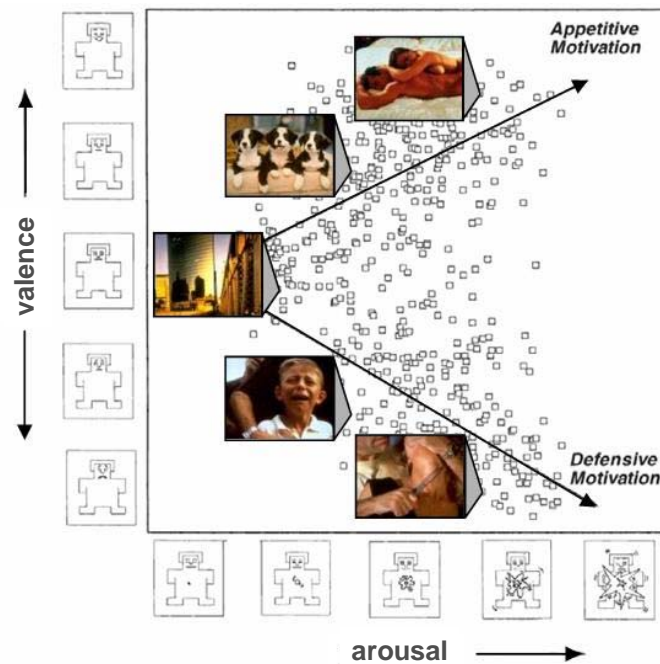


Figure 4. The two dimensional affective space of IAPS pictures composed of horizontal axis containing the arousal scale and vertical axis representing the measurements of valence. Each axis is labelled with an appropriate notation and corresponding iconographic SAM rating scales. Each picture is plotted as a square located in the affective space according to the mean valence and arousal values originating from SAM ratings performed by a great number of subjects. The C-shaped vectors indicate that the evaluation of pictures activated distinct motivational systems.

Pictures from IAPS and KDEF were used in several studies to verify the model of motivational organization proposed by Lang (for review see Bradley, 2000). These studies revealed that the activity of facial muscles, measured by the response of zygomaticus and corrugator, was related to the dimension of valence. The response of the corrugator muscle was inversely correlated with valence i.e. there was a smaller corrugator response for pleasant than for unpleasant pictures. In the case of the zygomaticus the response was largest for pleasant pictures, smallest for neutral pictures and again slightly greater for unpleasant pictures (Lang, Greenwald, Bradley, & Hamm, 1993). Moreover, the magnitude of the startle reflex was enhanced for unpleasant pictures and attenuated for pleasant pictures (Vrana, Spence, & Lang, 1988; Cuthbert, Bradley, Lang, 1996). The skin conductance level was positively correlated with arousal

ratings whereas the heart rate was positively correlated with valence ratings (Lang et al., 1993). These findings demonstrated that the motivational relevance of the stimulus modulates the behavioral and physiological output channels. These studies positively verified the two-dimensional model of emotion proposed by Lang and associates.

2.2.4.3. Emotion and Event Related Brain Potentials

A successful adaptation to the environment depends not only on the appropriate responding but also on the effective sensory processing of critical events occurring in the environment (Lang et al., 1997; Öhman et al., 2000). As previously demonstrated sensory processing can be successfully investigated with the Event Related Potentials. This method allowed to prove that the motivational relevance of the stimulus can modulate the perceptual and evaluative processing.

There are two most commonly investigated ERP components established in the experiments with picture viewing paradigm. The first one is called the relative early posterior negativity (EPN) and holds similar spatial and temporal characteristics as the previously described selection negativity. Accordingly, the EPN was observed over temporo-occipital areas at about 180-320 ms after picture onset. Several studies revealed that the EPN increases with greater emotional relevance of the visual stimulus (Junghöfer, Bradley, Elbert, & Lang, 2001; Schupp Junghöfer, Weike, & Hamm, 2003a, Schupp, Junghöfer, Weike, & Hamm, 2004b, Schupp, Stockburger, Codispoti, Junghöfer, Weike, & Hamm, 2006a). The current source density (Junghöfer et al., 2001) and minimum norm analyses (Schupp et al., 2006a) revealed that the emotional differentiation of the EPN was generated in temporo-occipito-parietal brain regions. Most studies demonstrating the affective EPN differentiation utilized IAPS pictures. However, several studies revealed that this component might be modulated not only by the emotional relevance but also by various physical characteristics of IAPS pictures. A recent study by Löw et al. (2005) revealed that the EPN was modulated not only by the emotional relevance of the picture but also by its content (objects vs. people) and perceptual type (figure-ground vs. complex scenes). Similar results were recently obtained in the study performed by Bradley, Hamby, Löw, & Lang (2007). Accordingly, a study on affective ERP modulation performed with IAPS pictures required an appropriate control of these picture characteristics (Schupp et al., 2004c). However, while the emotional EPN modulation was replicated with Karolinska Directed Emotional Faces characterized by higher physical homogeneity (Schupp, Öhman,

Junghöfer, Weike, Stockburger, Hamm, 2004c) it is reasonable to claim that the physical characteristics of IAPS pictures cannot entirely explain the obtained effects.

The second extensively studied ERP component is the late positive potential (LPP) usually evoked over centro-parietal areas in the time interval between 300 and 700 ms. Several studies observed a more pronounced LPP in the processing of emotionally relevant pictures than neutral pictures (Schupp et al., 2000, 2003a, 2004a; Cuthbert, Schupp, Bradley, Birbaumer, & Lang, 2000). The affective modulation of LPP is supposed to originate in the visual cortex. In a recent study Sabatinelli, Bradley, Fitzsimmons, & Lang (2005) found a correlation between an enhanced LPP to emotionally relevant pictures and increased blood oxygen level in the visual cortex.

Although the data indicate that both components are modulated in a similar way by the emotional relevance of the stimulus, they are hypothesized to reflect different stages of sensory processing. The EPN is supposed to reflect the perceptual categorization up to the level of semantic meaning (e.g. Fabre-Thorpe, Delorme, Marlot, & Thorpe, 2001). The LPP belongs to the category of P300s and is thus associated with the process of stimulus identification (Kok, 1997) and working memory (Donchin and Coles, 1988). The differential functional meaning of these both components was demonstrated in a great number of experiments. The study by Schupp et al. (2006b) revealed that the components were differentially modulated by the explicit attention toward task relevant picture category. In this study subjects had to count one of three picture categories (pleasant, unpleasant, and neutral) viewed in a rapid continuous stream. Each picture category served as a target in three separate runs. As expected task relevant images elicited more pronounced EPN and LPP. However, while the explicit attention did not influence the affective EPN modulation it changed the pattern of affective modulation reflected by the LPP. Since the EPN amplitude increased similarly with attention directed toward pleasant, unpleasant and neutral pictures, the LPP amplitude was more pronounced with attention directed toward pleasant and unpleasant pictures than toward neutral materials. Summarizing their findings Schupp et al. (2006b) noticed that the resources available at the early processing stage (reflected by the EPN) allow for the preliminary analysis of all important aspects of the incoming information (i.e. the emotional significance and the task relevance). At this stage the perceptual system decides whether the stimulus needs further sensory processing. In case of the stimuli detected as significant the perceptual system will initiate further processing including working memory consolidation and conscious recognition

(reflected by the LPP). This level of analysis dispose of limited resources so that, among all to-be-attended pictures, the perceptual system allocates more processing resources toward emotionally-significant pictures at the expense of a less intense processing of neutral pictures.

2.2.4.4. ERPs in High Anxiety Sensitivity Individuals and Phobic Participants

Previous research revealed that an enhanced defensive activation triggered in highly anxious subjects confronted with concern-relevant cues affected the level of sensory analysis (see chapters 2.1.2.3 and 2.1.3.3). To investigate this effect several researchers utilized Event Related Potentials which proved to be useful to study the interaction between emotion and attention. Previous ERP findings regarding the sensory processing of concern-relevant stimuli in high anxiety sensitive individuals and in phobic participants will be presented below.

There are only few ERP studies that investigated the sensory processing in individuals with increased anxiety sensitivity. In her ERP study Amrhein (2003) observed a facilitated sensory processing of panic-relevant pictures (medical emergency pictures) in high anxiety sensitive subjects and in panic patients. However, this effect was observed only for later ERP components. In her study anxiety sensitivity did not modulate early processing stages – there was no difference in the early ERP components when high anxiety sensitive individuals and controls were compared. Similar results were found with panic-relevant words in two ERP studies performed by Pauli, Dengler, Wiedemann, Montoya, Flor, Birbaumer, & Buchkremer (1997) and Pauli, Amrhein, Mühlberger, Dengler, & Wiedemann (2005). In their studies Pauli et al. (1997, 2005) also observed that the level of anxiety sensitivity affected later stages of sensory processing for panic-relevant words and did not influence the early sensory processing. However, these findings must be interpreted with caution due to the fact that the lexical material generates other cognitive processes than pictures. Since none of these ERP studies used any other emotionally relevant contents, they did not allow to verify whether the hypervigilance observed in high anxiety sensitive subjects is triggered also by other emotionally unpleasant materials.

There are only a few studies that measured Event Related Potentials in phobics during encoding of phobia-relevant pictures. And so, in the ERP study performed by Miltner, Trippe, Krieschel, Gutberlet, Hecht, Weiss (2005) small animal phobics and nonfearful controls exposed to a series of randomly presented picture set including

neutral and pleasant pictures from IAPS as well as feared visual materials. Furthermore, measuring Event Related Potentials Kolassa, Musial, Mohr, Trippe, & Miltner (2005) presented red- or blue-colored pictures of spiders, birds or flowers to spider phobics and nonfearful controls. In this study participants were additionally required to identify the object (identification task) or to name its color (emotional Stroop task) by pressing different buttons. At last, Kopp & Altman (2005) measured Event Related Potentials evoked by phobia-related pictures and pictures of household objects in participants from two phobia-relevant groups (spider phobics and snake phobics) performing a contingency assessment task. In this paradigm subjects were exposed to pairs of pictures (a combination of two consecutively presented pictures) that were followed by one of two outcomes (electric shock or pictorial presentation of coin). After each pair participants had to predict the upcoming outcome (contingency assessment task).

2.2.5. Summary

Previous sections introduced basic information about the mechanism of the selective attention and demonstrated the utility of the Event Related Potentials for the attention research. This research revealed that the effects of an explicit attention operate at the early (P100, N100) and later processing stages (P300). Moreover, the ERP studies provided strong evidence that the sensory processing can be modulated without a voluntary control by the physical characteristics and motivational relevance of the stimuli. To assure a theoretical framework for the research on motivated attention the model of motivational organization of emotion proposed by Lang (1994) was introduced. This model illustrates how the emotional meaning tagged on the stimulus affects the motivational activation and in a consequence modulates the physiological responses and the sensory processing.

The results of the ERP studies demonstrated that the motivational relevance of a stimulus modulates the sensory processing already at a very early perceptual level (EPN) engaged in a preliminary analysis of stimulus significance. The effects of motivated attention are also observed at the later processing stages associated with a conscious stimulus evaluation. The later periods of sensory analysis were also observed to be modulated by the fear intensity.

3. HYPOTHESES

3.1. Sensory Processing and the Emotional Relevance of Visual Stimuli

According to the information processing model (Öhman, 1993), emotionally relevant stimuli are preattentively identified by the “significance evaluation system” and as a consequence capture automatic selective attention (see chapter 2.1.3.3). According to this model, an increased preattentive processing of emotionally relevant stimuli initiates a more intense processing in the “conscious perception system” responsible for stimulus identification and evaluation.

Numerous studies supported the model presented by Öhman (1993) demonstrating that visual stimuli with high emotional relevance undergo a facilitated sensory processing. A great part of the evidence supporting Öhman’s model was obtained using Event Related Potentials which is a very reliable method to observe the time course of sensory processing and in consequence allows to investigate the properties of early and late processing stages. Applying this method, many researchers revealed that the emotional relevance of visual stimuli modulates both early and later stages of sensory analysis. More precisely, it was demonstrated that visual materials with high emotional relevance elicited an enhanced Early Posterior Negativity observed over temporo-occipital brain areas between 180 and 320 ms after stimulus onset and an increased Late Positive Potentials observed over centro-parietal scalp regions between 300 and 600 ms after stimulus onset.

Using pictures of different arousal intensities and valence connotations from the International Affective Picture System the present study aimed at finding a similar pattern of an early and late affective modulation. Accordingly, standard pleasant and unpleasant IAPS pictures were expected to elicit an enhanced Early Posterior Negativity and greater Late Positive Potentials than neutral pictures.

Building upon this replication, the primary goal of the present study was to investigate the influence of fear and anxiety on the selective attention. To achieve this goal, two different groups of highly anxious individuals (high anxiety sensitive subjects and spider phobics) and a control group were assigned to this experiment and the picture set was completed by concern-relevant stimuli (pictures of spiders and pictures of medical emergency scenes).

The knowledge about the pathology as well as the extensive research on the sensory processing in highly anxious individuals allow to hypothesize that anxiety and

fearfulness differentially affect the selective attention. And so, as previously discussed (see chapter 2.1.1), fear is a reaction triggered by very specific stimuli occurring in the perceptual field whereas anxiety is characterized by a permanent expectation of danger and as a consequence by an attentional bias toward diverse potentially threatening stimuli. Accordingly, previous studies demonstrated that spider phobics exhibit an attentional bias toward spider pictures (see chapter 2.1.3.3) whereas high anxiety sensitive subjects exhibit an attentional bias toward a wide range of potentially relevant cues (see chapter 2.1.2.3).

3.2. Perceived Arousal and Valence of Pictorial Materials

It was expected that subjective arousal and valence assigned to the pictorial material will be modulated by fear and anxiety. Because for spider phobics spider pictures are emotionally relevant, they are expected to rate these pictures as more unpleasant and more arousing than controls. High anxiety sensitive subjects are expected to assign greater unpleasantness and greater arousal intensity to panic-relevant pictures (i.e. medical emergency pictures) as well as to standard unpleasant contents than control participants. Corresponding support for these assumptions was found in numerous studies investigating high anxiety sensitive individuals (Amrhein, 2003) and phobic subjects (Miltner et al., 2005; Carlsson et al., 2004; Kolassa et al., 2005; Kopp & Altmann, 2005).

3.3. Sensory Processing in High Anxiety Sensitive Subjects

As demonstrated in chapter 2.1.2.3, anxiety is characterized by a general hypervigilance toward potential threat. This assumption was supported by numerous studies applying emotional Stroop task or dot probe task (see chapter 2.1.2.3). In these studies individuals with nonclinical and clinical anxiety showed an increased selective attention toward threatening stimuli. The effects of selective attention toward threat were also found for individuals with high level of anxiety sensitivity. However, these findings did not clearly show whether these effects are related toward threat in general or rather toward panic-relevant contents. Some studies demonstrated that high fear of anxiety results in the selective attention toward diverse unpleasant contents such as physical threat, social threat or separation (Ehlers et al., 1988; Stewart et al., 1998; McNally et al., 1994; Maidenberg et al., 1996). However, due to the fact that the

concerns of high anxiety sensitive subjects are limited mainly to the symptoms of physiological arousal it would be legitimate to expect a greater vigilance toward physical threat than toward other threatening materials. In fact, some studies revealed that panic-relevant material triggered a greater attentional bias in high anxiety sensitive subjects than other threatening contents (Lundh et al., 1999 and Hope et al., 1990).

Beyond the assumption that anxious people selectively attend to threatening stimuli (threat-relatedness hypothesis) some researchers postulated that anxiety might modulate the sensory processing of all emotional contents independent of their valence connotations (emotionality hypothesis) (Williams et al., 1988). In fact using an emotional Stroop task some studies demonstrated that nonclinical and clinical anxiety is associated with Stroop interference for both pleasant and unpleasant words - i.e. anxious participants took longer to name positive words than neutral words (Dalglish, 1995; Mogg & Marden, 1990; Richard, French, Johnson, Naparstek, & Williams, 1992; Riemann & McNally, 1995; Martin, Williams, & Clark, 1991). However, other studies did not find any Stroop interference from positive stimuli in anxious individuals (Mogg, Bradley, Hallowell, 1994; Mogg, Kentish, & Bradley, 1993; Richard & French, 1990; Richard & Millwood, 1989; Bryant & Harvey, 1995; see also Ruiz-Caballero & Bermudez, 1997 for a review).

Little is known about the timing of attentional bias in high anxiety sensitive individuals. Studies applying emotional Stroop task and dot probe task revealed that these people exhibit an attentional bias toward threat both for subliminally and supraliminally presented stimuli, which might indicate that the level of anxiety sensitivity modulate early and late sensory processing for emotionally arousing unpleasant materials. As to the proposed attentional bias toward pleasant contents these studies do not allow to make any assumptions about its timing. Furthermore, as already discussed, the findings originating from emotional Stroop task and dot probe task do not necessarily prove the modulation of sensory processing. This goal might be more reliably reached by measuring Event Related Potentials. As discussed in chapter 2.2.4.4, several ERP studies revealed that the level of anxiety sensitivity modulated later stages of sensory processing for panic-relevant pictures and words but did not affect the early sensory processing of these stimuli. Since none of these ERP studies used any other emotionally relevant contents, they did not allow to verify whether the hypervigilance observed in high anxiety sensitive subjects is triggered also by other emotionally unpleasant or pleasant materials.

In summary, numerous findings (see chapter 2.1.2.3) indicated that high anxiety sensitive individuals exhibit a general hypervigilance toward emotionally arousing unpleasant materials. Some of them suggest that this effect might be stronger for panic-relevant stimuli than for other unpleasant contents (Lundh et al., 1999; Hope et al., 1990). Moreover, according to the emotionality hypothesis (Williams et al., 1988) anxiety is proposed to modulate the encoding of all emotionally arousing stimuli independent on their valence connotations. However, among several studies that positively verified this assumption, only one (Beck, Stanley, Averill, Baldwin, Deagle, 1992) investigated individuals with high anxiety sensitivity. Anyway, the theoretical assumptions and experimental evidence presented above allowed to specify hypotheses to be tested in the present study. First, high anxiety sensitive individuals were expected to show a facilitated sensory processing of panic-relevant contents (medical emergency pictures) and high arousing unpleasant materials (mutilation pictures). Second, the present study aimed at clarifying whether this effect is stronger for panic-relevant contents than for high arousing unpleasant materials. Third, in order to test the emotionality hypothesis ERPs of high anxiety sensitive individuals and controls elicited during the encoding of high arousing pleasant materials (pictures of erotic couples) will be additionally compared. Finally, since the use of Event Related Potentials allow to investigate the time course of sensory processing all effects will be proved for early and late stages of sensory analysis.

3.4. Sensory processing in Spider Phobics

As observed in the emotional Stroop task and the visual search task phobic participants show an effect of selective attention toward their feared stimuli (see chapter 2.1.3.3). According to the model of Öhman (1993), this effect would appear both at early and late processing stages - a phobia-relevant stimulus should be more intensively analysed during the early processing periods and engage more attentional resources for conscious evaluation. However, previous studies do not consistently support the model formulated by Öhman. Since they leave no doubt that phobics exhibit a selective attention toward phobia-relevant stimuli it was still not definitely demonstrated whether this effect can be observed both during early and late periods of sensory analysis.

For the late processing stages, there is a quite homogenous evidence that the fear of spiders triggers more elaborated processing of phobia-relevant stimuli. Accordingly, despite apparent methodological differences previous ERP studies (see chapter 2.2.4.4)

clearly demonstrated that phobia-relevant pictures elicit enhanced LPPs in phobic individuals when compared to controls. The assumption that later stages of sensory analysis for phobia-relevant materials are modulated by the fear intensity was additionally supported in visual search studies (Miltner et al., 2004; Rinck et al., 2005). Showing that animal phobics have increased difficulties to detect a neutral target among spider distractors these studies suggested that the main problem of phobic participants is to disengage their attention from threatening stimuli which might be related to an elaborated analysis.

On the contrary, the evidence for an increased automatic attention toward fear-relevant stimuli in phobics is less clear. While Kopp and Altmann also found increased selection negativity over the occipital cortex for these stimuli in phobic volunteers, no such early selective processing for phobia-relevant pictures was found in the study performed by Miltner et al. (2005) and Kolassa et al. (2005). Also visual search studies provided ambiguous findings with regard to the automatic attention toward phobia-relevant pictures in phobics (see chapter 2.1.3.3).

In summary, the goal of the present study was to analyse the time course of attentional bias toward phobia-relevant pictures in spider phobics. And so, based on the previous ERP studies spider phobia was expected to affect later stages of sensory analysis for phobia-relevant materials. Moreover, the present study aimed at testing whether a facilitated processing of phobia-relevant pictures would be observed in spider phobics also at early stages of sensory analysis.

3.5. Selective Attention during Anticipation of Threat

Another question put in the present study is whether the anticipation of a fear-relevant event affects the sensory processing in high anxiety sensitive individuals and spider phobics.

Numerous data showed that the anticipation of a threatening event triggers an increased activity of the autonomic nervous system and amplifies protective reflexes. For example, the anticipation of threat induced by announcing an electric shock resulted in a potentiation of startle reflex (e.g. Grillon, Ameli, Woods, Merikangas, & Davis, 1991) and produced heart rate changes (Somsen, van der Molen, & Orlebeke, 1983). Moreover, as demonstrated in neuroimaging studies, neural structures involved in the processing of emotionally relevant information were activated in individuals

anticipating exposure to aversive pictures (Nitschke, Sarinopoulos, Mackiewicz, Schaefer, & Davidson, 2006) or to an electric shock (Chua, Krams, Toni, Passingham, Dolan, 1999).

The anticipation effects described above were modulated by the anxiety level. During the anticipation of threat trait anxiety mediated the increase of startle magnitude (Grillon, Ameli, Foot, & Davis, 1993) and heart rate (Thayer, Friedman, Borkovec, Johnson, & Molina, 2000) and modulated the electrocortical activity (Davidson, Marshall, Tomarken, & Henriques, 2000). Similar effects were demonstrated in phobics and in high anxiety sensitive individuals expecting a fear-relevant event. Accordingly, participants with a high level of anxiety sensitivity demonstrated increased startle reflex and heart rate when anticipating a hyperventilation task (Melzig, Weike, Hamm, 2005) and an increased activation of the neuronal fear system during the anticipation of CCK-4-induced panic attacks (Janvanmard et al., 1999). Similarly, the anticipation of snake videos increased the activation of the neuronal fear system in snake phobics (Kerr et al., 2006).

According to the information processing model (Öhman, 1993) increased autonomic arousal and danger expectancy prime our sensory processing system for the detection of threat. Since the anticipation of a threatening event has been shown to triggered an increased autonomic arousal (see above), it is also expected to modulate the sensory processing. Accordingly, the electrocortical activity measured during the picture presentation in high anxiety sensitive participants and spider phobics was expected to differ as a function of condition (standard condition vs. anticipation of threat condition). To generate a certain level of autonomic arousal each group was required to anticipate an event related to its concerns. Accordingly, the anticipation of hyperventilation was supposed to modulate the selective attention toward threatening stimuli in high anxiety sensitive individuals whereas the anticipation of a spider was hypothesized to modulate the selective attention toward spiders in spider phobics. Since the anticipation of challenge is not expected to trigger an increased vigilance in nonfearful controls, ERPs evoked in these participants would not differ as a function of condition.

3.6. Is the Selective Attention in Fear and Anxiety Concern-Specific?

While previous studies show clear evidence for an increased selective attention toward concern-relevant stimuli relative to neutral materials in individuals with high levels of anxiety and fear, it is unclear whether these selective attention effects are indeed threat specific because no other arousing unpleasant and pleasant materials were included in these studies as was the case in studies demonstrating fear specific defensive response mobilization (Globisch et al., 1999; Hamm et al., 1997). If such specificity would already occurred during stimulus encoding and not only during defensive response mobilization such findings would have important implications for the understanding of the psychopathology of anxiety disorders. Indeed, some authors claim that the selective attention to threat might play an important role in the etiology and maintainance of anxiety disorders (Williams, Watts, MacLeod, & Mathews, 1997). To test the hypothesis that threat specific effects appear not only at the response level but can be observed also for attentional mechanisms the present study not only compared concern-relevant stimuli (which are unpleasant and highly arousing in one group but not in other groups) with neutral materials (which are non-arousing for all groups) but also included other unpleasant (arousing) and also pleasant (arousing) stimuli, as in the studies showing phobia specific startle potentiation.

4. METHODS

4.1. Participants

A total of 336 students from various departments at the University of Greifswald were screened for participation in the present study. They completed a German version of the 31-item spider fear questionnaire SPQ (Klorman, Weerts, Hastings, Melamed, Lang, 1974; Hamm, 2006) as well as a German version of the 16-item Anxiety Sensitivity Index (Reiss et al., 1986). The criteria for inclusion in the study were based on the scores of normative samples as assessed with the ASI (Reiss et al., 1986) and the SPQ (Hamm, 2006). For inclusion in the spider phobia group subjects had to score above the 85th percentile of the distribution of the relevant gender group in the Spider Phobia Questionnaire (SPQ scores ≥ 16 or ≥ 13 for females and males, respectively: $M=19.9$, $SD=2.9$; $M=17.8$, $SD=5.0$ for females and males, respectively) and below the 85th percentile of the distribution in the Anxiety Sensitivity Inventory (ASI scores ≤ 29 : $M=17.9$; $SD=7.0$). For inclusion in the high anxiety sensitivity (AS) group subjects had to score above the 85th percentile of the distribution in the Anxiety Sensitivity Inventory (ASI scores ≥ 11 : $M=33.6$; $SD=5.8$) and below the 85th percentile of the distribution of the relevant gender group in the Spider Phobia Questionnaire (SPQ scores ≤ 16 or ≤ 13 for females and males, respectively: $M=8.5$, $SD=4.7$; $M=5.0$, $SD=2.8$ for females and males respectively). For inclusion in the control group subjects had to report low levels of spider fear (SPQ scores ≤ 16 or ≤ 13 for females and males, respectively: $M=3.4$, $SD=3.3$; $M=3.7$, $SD=2.6$ for females and males, respectively) and low levels of anxiety sensitivity (ASI scores ≤ 11 : $M=9.0$; $SD=3.7$). According to the criteria 115 students were asked to take part in the experiment and 73 agreed to participate. Thus 22 subjects (17 females) were recruited for the spider phobia group, 25 subjects were recruited for the high AS group (17 females) and 26 subjects were included in the control group (17 females). To further characterize the sample all participants completed additional questionnaires: State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970), Agoraphobic Cognitions Questionnaire (ACQ; Chambless, Caputo, Bright, & Gallagher, 1984), Body Sensations Questionnaire (BSQ; Chambless et al., 1984), Fear Questionnaire (FQ; Marks & Matthews, 1979) and Mutilation Questionnaire (MQ; Klorman et al., 1974).

Table 1 shows the mean questionnaire scores and age range for three experimental groups. Students received either course credits toward their research requirements or were paid 8 Euros for their participation in the study.

Table 1. Age Range and Mean Questionnaire Scores for High Anxiety Sensitivity Subjects, Spider Phobics and Nonfearful Controls.

Group	Age range	ASI [0-64]	BSQ [17-90]	ACQ [14-75]	FQ [0-160]	STAI [20-80]	SPQ [0-31]	MQ [0-30]
Controls	20-30	9	1,7	1,3	15,6	32	3,5	9,4
High AS	19-35	33,6	2,3	1,8	28,8	41	7,4	14,9
Spider phobics	18-30	17,9	2,2	1,7	27,9	41	19,4	9,5

Note: Possible range of scores are displayed below the questionnaire abbreviations in brackets.

4.2. Stimulus Materials

Participants viewed 180 color pictures from five categories: 36 pleasant (18 high arousing (e.g., erotic couples), 18 low arousing (e.g., cute animals, babies and family scenes)), 36 neutral (e.g. landscapes, buildings and neutral people), 36 unpleasant (18 high arousing (e.g., mutilation), 18 moderate arousing (e.g. human and animal attack)), 36 phobia-relevant spider pictures, as well as 36 panic-relevant pictures of medical emergency situations (e.g. faint, car accident, air hunger, people undergoing surgery). Pleasant, neutral and unpleasant pictures were selected from the International Affective Picture System (IAPS; Lang, Bradley & Cuthbert, 1999). Spider pictures originated partly from IAPS and partly from our own laboratory. Medical emergency slides were prepared by the author.

Pictures of neutral, unpleasant and pleasant categories were selected from the IAPS according to the normative ratings of valence and arousal obtained with the Self Assessment Manikin (SAM) (Bradley & Lang, 1994). All three picture categories differed from each other in IAPS normative valence ratings. Moreover, pleasant and unpleasant pictures were significantly more arousing than neutral pictures. The set of medical emergency slides was chosen from an original set of 60 medical emergency pictures obtained from the internet. For the purpose of selection medical emergency slides were presented together with 16 IAPS pictures of neutral, unpleasant and pleasant

contents in a random order to 70 introductory psychology students from the University of Greifswald. Students completed the Anxiety Sensitivity Inventory and rated all pictures for valence and arousal. Ratings ranged from 1 – very unpleasant to 9-very pleasant for valence and from 1-low arousing to 9-high arousing for arousal. 36 pictures rated ≥ 4 for arousal and ≤ 5 for valence by subjects with high anxiety sensitivity ($ASI \geq 29$) were included in the experimental set.








CATEGORY	pleasant		neutral (n=36)	unpleasant		spiders (n=36)	medical emergency (n=36)
	erotic couples (n=18)	family & babies (n=18)		mutilation (n=18)	attack (n=18)		
EXAMPLES							

Figure 5. Exemplary pictures for categories included in the study.

For EEG recordings pictures were displayed on a 20” computer monitor located 1.5 m from participants’ eyes ($\approx 11^\circ$ of visual angle). Every picture was presented centrally on a black background with a size of 1024 x 768 dpi.

4.3. Procedure and Experimental Design

At the beginning of the experiment subjects were informed about the experimental procedure and signed an agreement for their participation in the experiment. Then the 129- channel Geodesic Sensor Net (Electrical Geodesics, Inc; Eugene, USA) was attached to the participant’s head. Participants were seated in a recliner in a dimly lit, sound-attenuated and electromagnetically shielded room in front of the computer monitor. Prior to the first part of the experiment participants rated their current level of stress as well as experienced anxiety on a Lickert scale ranging from 1 to 10. Than participants were informed that a series of pictures will be shown and were asked to avoid movements and attend to the pictures. To familiarize participants with the experimental procedure a series of five additional neutral pictures was presented as a practice run.

4.3.1. Slow Picture Presentation

In the first part of the experiment participants viewed a total of 360 pictures displayed in a randomized order (each of 180 pictures included in the set was displayed twice). Three different picture orders were constructed and counterbalanced across participants. Picture orders were created with the restriction of non consecutive presentation of two pictures from the same category. Figure 6 shows a scheme of the experimental design. Each picture was displayed for 1500 ms, preceded by a fixation cross (500ms) and followed by a variable Inter-Trial-Interval (ITI) of 750, 1000 or 1250 ms (in a random order).

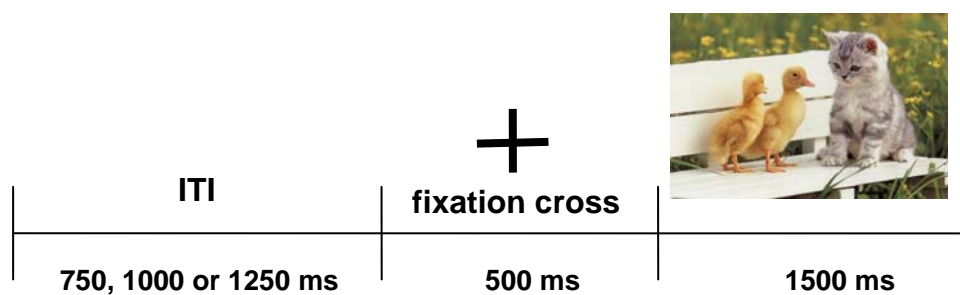


Figure 6. Scheme of the experimental design. Each picture was presented for 1500 ms preceded by a fixation cross (500 ms) and an Inter-Trial-Interval (randomized between 750, 1000, 1250 ms) .

4.3.2. Rapid Serial Visual Presentation (RSVP)

In the second part of the experiment a rapid serial visual presentation (RSVP) paradigm was applied (Potter, 1999). In this paradigm pictures are presented in a continuous stream for about 333 ms each (see Figure 7). As for the slow picture presentation, three different picture orders were constructed and counterbalanced across participants. Each order included a total of 360 pictures (each picture from the set of 180 pictures was presented twice). Again, consecutive presentation of two pictures from the same category was avoided.

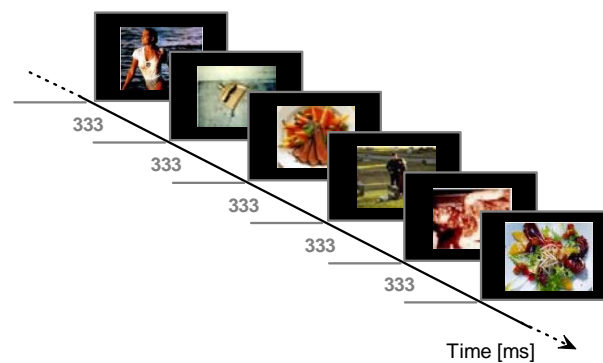


Figure 7. Scheme of the experimental design. Pictures were presented in a continuous stream for 333 ms each.

Each participant viewed the same stream of pictures twice². For the first presentation standard instructions were given. Prior to the second presentation participants were informed that a specific challenge would follow the picture viewing. This instruction differed between the experimental groups. High AS subjects and controls were asked to perform a 3-minutes hyperventilation test subsequently to the picture presentation. Participants were familiar with this procedure from another experiment they had taken part previously to the present study. Spider phobics were asked to have a look at a spider enclosed in a glass case that would be brought into the experimental room immediately after the picture presentation. Based on results from previous studies (Grillon Ameli, Foot, & Davis 1993; Melzig, Weike, & Hamm, 2005) these verbal instructions were expected to induce anticipatory anxiety in the participants. In fact the participants were not confronted with the challenge and after the presentation finished they were informed that the instruction was a part of an experimental manipulation and would not be completed.

4.3.3. Valence and Arousal Ratings

For assessment of valence and arousal participants were asked to view each picture once more, after the EEG net was removed. They were instructed to watch the pictures as long as desired and to terminate its presentation by pressing a button. After the picture offset participants evaluated their subjective experience of valence and arousal on the computerized version of the Self-Assessment Manikin.

²In the RSVP participants were exposed to another picture order as in the slow picture presentation.

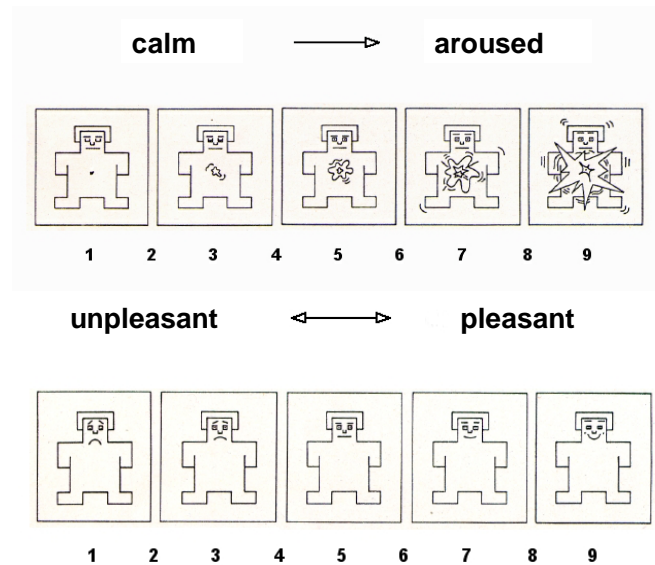


Figure 8. Pictorial materials used for the assessment of valence and arousal.

At the end, subjects filled out an end-of-session questionnaire targeted at assessing physical symptoms and panic attack as well as the set of previously described questionnaires (see chapter 4.1.).

For a subsample the level of stress and anxiety experienced after the anticipation instruction was tested (Lickert scale 1-10).

4.4. Apparatus, Data Collection and Data Transformation

EEG data were collected from the scalp using 129-channel system (Electrical Geodesics, Inc, Eugene, OR). Scalp impedance was kept below 30 k Ω and for the reference sensor below 10 k Ω , as recommended by the EGI-system guidelines. Electrophysiological activity was continuously recorded in the 0.1–100 Hz frequency range with a sampling rate of 250 Hz. The vertex sensor served as a reference electrode. The data acquisition was performed with a software package (Net Station, version 9.00) installed on a Macintosh computer. Continuous EEG data were low pass filtered at 40 Hz using digital filtering before stimulus synchronized epochs were extracted for further data analysis. For data analysis of the slow picture presentation stimulus synchronized epochs were extracted from 120 ms before to 1000 ms after picture onset. For data analysis of the RSVPs extracted epochs ranged from 332 ms before to 680 ms after picture onset. The raw EEG epochs were passed through a computerized artifact detection algorithm (Junghöfer et al., 2000). Artifact rejection was based upon boundary

values of three parameters: the maximal absolute value over time, standard deviation over time and the maximal temporal gradient over time. In the first step the data with common reference were used to detect contaminated sensors and sensor epochs. On the basis of the artifact-free data the averaged reference was calculated. The data transformed to averaged reference were used to detect global artifacts and reject contaminated trials. For the remaining trials the signal of all previously rejected channels was estimated by a spherical spline interpolation on the basis of all remaining sensors on a trial-by-trial base. Accepted trials completed by interpolated sensors were finally averaged for each participant using a software package generated by Junghöfer & Peyk (2004).

4.5. Definition of Time Intervals and Sensor Clusters

4.5.1. Slow Picture Presentation

In the first part of the experiment EEG recordings of 8 subjects were excluded due to an excessive artifact contamination (over 35% contaminated trials). In the remaining sample on average 30 percent of contaminated trials were excluded.

The results contain EEG data from 20 (15 females) spider phobic subjects, 22 subjects with high ASI scores (16 females) and 23 controls (15 females). Table 2. shows mean scores in the SPQ and the ASI for these participants.

Table 2. Mean Scores in the Spider Phobia Questionnaire (in Parentheses Females and Males Respectively) and in the Anxiety Sensitivity Inventory for the High Anxiety Sensitivity Subjects, Spider Phobics and Nonfearful Controls Included in the Analysis of the Slow Picture Presentation.

GROUP	N (♀/♂)	Spider Phobia Questionnaire Mean (♀/♂)	Anxiety Sensitivity Index Mean
Spider phobics	20 (15/5)	19,6 (20,3/17,8)	18,4
Controls	23 (15/8)	3,1 (2,9/3,5)	9,0
High AS	22 (16/6)	7,4 (8,4/4,5)	34,1

Note: The range of possible scores extended from 0 to 31 in the Spider Phobia Questionnaire and from 0 to 64 in the Anxiety Sensitivity Inventory

In order to frame regions of interest and time intervals of EPN and LPP for further analyses the temporal and spatial characteristics of early and late affective ERP modulation to standard affective categories (family and babies, erotic couples, mutilated bodies, human and animal attack, neutral) were identified. As in previous research (Schupp et al., 2004), this step was carried out using individual waveform analyses and conventional ANOVAs. The analyses of individual waveforms found an evidence for early and late selective processing of affective pictures that showed spatial and temporal characteristics comparable with Early Posterior Negativity and Late Positive Potentials identified in previous studies (Schupp et al., 2003, 2004, 2006; Junghöfer et al., 2001). To verify these findings repeated measures ANOVAs with the factor Picture Category (family and babies, erotic couples, mutilated bodies, human and animal attack, neutral) were calculated for each time point and each individual sensor using a criterion of $p < .001$. To avoid false positives and to assure a stronger statistical support, a significant effect was considered meaningful only when observed for at least eight continuous data points (32ms) and two neighbouring sensors. Repeated measures ANOVAs supported the findings from individual waveform analyses.

Early Posterior Negativity. The Early Posterior Negativity was analyzed for two occipito-temporal clusters including the following sensors: 59,60,64,65,66,67,69, 70,71,72,74,75 in the left hemisphere and 77,78,83,84,85,86,89,90,91,92,95,96 in the right hemisphere (see Figure 9). The greatest affective modulation for these sensor clusters was observed in the time window of 176–256 ms after picture onset with a peak around 220 ms. The average potential values for each participant and each picture category in the specified sensor clusters and the time window were calculated and included in the repeated measures ANOVA.

Late Positive Potentials. Two centro-parietal sensor clusters showing the greatest affective modulation of the ERP waveforms were chosen for the analysis of the LPP: 7,13,31,32,37,38,43,53,54,61 in the left hemisphere and 79,80,81,87,88,94, 105,106,107,113 in the right hemisphere (see Figure 10). The late selective processing appeared to be most pronounced in the time window of 400–560 ms after picture onset. In specified channel clusters and the time window the average potential values for each participant and each picture category were calculated and included in the repeated measures ANOVA.

Following these preliminary tests between group comparisons were carried out for spider pictures by calculating two sample t-tests between spider phobics and

controls as well as for medical emergency pictures, erotic pictures and mutilation pictures by calculating two sample t-tests between high AS participants and controls. In the first step, these tests were calculated for each time point and each individual sensor. To avoid false positives and to assure a stronger statistical support, a significant group effect ($p < .05$) was only considered meaningful when observed for at least eight continuous data points (32ms) and two neighbouring sensors. These analyses did not reveal any significant differences between spider phobics and controls in the early processing of spider pictures. Significant group effects, however, occurred for later processing periods and were most pronounced in the time window of 432 – 600 ms after picture onset over two centro-parietal sensor clusters: 7,13,31,32,38,43,53,54 in the left hemisphere and 80,81,87,88,94,106,107,113 in the right hemisphere. In specified sensor clusters and the time window average potential values for every participant from the spider phobia group and the control group and for every picture category were calculated. These averages were applied in the two samples t-tests. As to the comparisons between high AS participants and controls, no significant differences in the early and late processing of mutilation pictures and erotic pictures were found. However, there was a significant difference between high AS subjects and controls in the early processing of medical emergency pictures. This difference was most pronounced in the time window of 188 – 232 ms after picture onset over two temporo-occipital sensor clusters: 83,84,85,90,91,92 in the right hemisphere and 65,66,70,71,74,75 in the left hemisphere. Again, in specified sensor clusters and the time window average potential values for every participant from the high AS group and the control group and for every picture category were calculated. These averages were applied in the two samples t-tests.

4.5.2. Rapid Serial Visual Presentation

In the second part of the experiment EEG recordings of 9 subjects were excluded due to excessive artifact contamination (over 35% contaminated trials). In the remaining sample on average 26 percent of contaminated trials were excluded from further analyses.

All analyses are based on the EEG data from 20 (15 females) spider phobic subjects, 21 subjects with high ASI scores (15 females) and 23 controls (15 females). Table 3. shows mean scores in the SPQ and the ASI for high AS participants, spider phobics and nonfearful controls included in this analysis.

Table 3. Mean Scores in the Spider Phobia Questionnaire (in Parentheses Females and Males Respectively) and in the Anxiety Sensitivity Index for the group of High Anxiety Sensitivity Subjects, Spider Phobics and Nonfearful Controls Included in the Analysis of the Rapid Serial Visual Presentation.

GROUP	N (♀/♂)	Spider Phobia Questionnaire	Anxiety Sensitivity Index
		Mean (♀/♂)	Mean
Spider phobics	20 (15/5)	19,3 (19,9/17,8)	18,2
Controls	23 (15/8)	3,1 (2,9/3,5)	9,0
High AS	21 (15/6)	7,4 (8,3/5,3)	34,4

Note: The range of possible scores extended from 0 to 31 in the Spider Phobia Questionnaire and from 0 to 64 in the Anxiety Sensitivity Inventory

As for the slow picture presentation, the first step was to identify the temporal and spatial characteristics of the early and late ERP modulation in order to frame regions of interest and time windows of the EPN and the LPP for further statistical analysis³. To aim this goal individual waveform analyses and conventional ANOVAs were applied (see above).

Early Posterior Negativity. Following occipito-temporal sensor clusters were chosen for further analysis of the Early Posterior Negativity: 58,59,60,63,64, 65,66,67,69,70,71,72,74,75 in the left hemisphere and 77,78,83,84,85,86,89,90, 91,92,95,96,97,100 in the right hemisphere. The greatest affective modulation for these sensor clusters was observed in the time window of 220-280 ms after picture onset with a peak around 236 ms. In specified sensor clusters and the time window the average potential values for each participant and each picture category were calculated and included in the repeated measures ANOVA.

Late Positive Potentials. Two centro-parietal sensor clusters showing the greatest affective modulation of the ERP waveforms were chosen for the analysis of the LPP: 7,13,30,31,32,37,38,43,53,54,61 in the left hemisphere and 79,80,81,87,88, 94,105,106,107,112,113 in the right hemisphere. The late selective processing appeared to be most pronounced in the time window of 380-520 ms after picture onset. For the purpose of statistical analyses the average potential values for each participant and each picture category in specified channel clusters and the time window were calculated.

³To define regions of interest and time windows of the early and late affective ERP modulation generated during the RSVP the waveforms elicited during the first and during the second run were pooled together.

As for the slow picture presentation, these preliminary tests were followed by between group comparisons carried out for medical emergency pictures, pictures of erotic couples and mutilation pictures by calculating two sample t-tests between high AS participants and controls for all time points and all individual sensors (see above). These comparisons did not reveal any meaningful differences in the early and late processing of medical emergency pictures, mutilation pictures and erotic pictures between high AS subjects and controls.

4.6. Statistical Analyses

In each picture presentation block statistical analyses were computed separately for the Early Posterior Negativity and the Late Positive Potentials. All statistical tests used $p < .05$ as significance level. In repeated measures ANOVAs including factors with two or more levels the Greenhouse-Geisser adjustment of significance level was used. Results are reported with uncorrected F-values, as well as corrected p- and ϵ -values.

4.6.1. Slow Picture Presentation

The first step was to replicate the results from previous studies that demonstrated affective modulation of the ERP waveforms elicited by the standard pictorial materials. Multivariate analysis of variance involved Picture Category (mutilation, erotic couples, attack, family and babies, neutral) and Laterality (right, left) as within-subjects factors as well as Group (spider phobics, high AS, controls) as between-subjects factor. Significant effects were followed up by multiple tests.

The second step was carried out for concern-relevant pictorial materials by calculating $2 \times 2 \times 2$ ANOVAs including the between-subjects factor Group (spider phobics vs. controls or high AS subjects vs. controls respectively) as well as the within factors Picture Category (concern-relevant vs. neutral) and Laterality (right vs. left). Concern-relevant pictures were further compared to standard affective picture categories by calculating $2 \times 2 \times 5$ ANOVAs including one between-group factor (spider phobics vs. controls or high AS subjects vs. control respectively) as well as Laterality (right vs. left) and Picture Category (concern-relevant, mutilation, erotic couples, attack, family and babies) as within-subjects factors. Significant effects found during the analyses of variance were followed up by multiple tests. In the next step, direct group comparisons were carried out for spider pictures by calculating two sample

t-tests between controls and spider phobics as well as for medical emergency pictures by calculating two sample t-tests between controls and high AS subjects (see above).

As for concern-relevant materials, similar tests were carried out for pictures of erotic couples and mutilation pictures by calculating $2 \times 2 \times 2$ ANOVAs including the between-subjects factor Group (high AS subjects vs. control) as well as the within factors Picture Category (erotic couples vs. neutral or mutilation vs. neutral respectively) and Laterality (right vs. left). Again, mutilation pictures and pictures of erotic couples were further compared to other affective picture categories by calculating $2 \times 2 \times 4$ ANOVA including one between-group factor (high AS subjects vs. control) as well as Laterality (right vs. left) and Picture Category (mutilation, erotic couples, attack, family and babies) as within-subjects factors. Significant effects found during the analyses of variance were followed up by multiple tests.

4.6.2. Rapid Serial Visual Presentation

Further analyses aimed at testing whether the affective modulation of the ERP waveforms can be replicated for rapid serial visual presentation and whether the anticipatory anxiety influenced the sensory processing.

Primary analyses concentrated on the processing of standard pictorial materials in high AS subjects and controls. The overall ANOVA design included the within-subjects factors Picture Category (mutilation, erotic couples, attack, family and babies, neutral), Laterality (right vs. left) and Condition (anticipation condition vs. standard condition) as well as the between-subjects factor Group (high AS vs. controls). Significant effects were followed-up by additional analyses of variance or t-tests. For precise exploration of formulated hypotheses between factor Group was included in each follow-up analysis.

In the next step the selective processing of medical emergency pictures in high AS subjects and controls was analyzed. These analyses were carried out by calculating the repeated measures ANOVAs including the within-subjects factors Picture Category (medical emergency vs. neutral), Laterality (right vs. left) and Condition (anticipation condition vs. standard condition) as well as the between-subjects factor Group (high AS vs. controls). Significant effects were followed-up by multiple tests.

Following the analyses performed for high AS subjects and controls, it was tested whether the pattern of early and late affective ERP modulation would be

replicated in spider phobics exposed to the rapid serial visual presentation and whether the introduction of the anticipation instruction provoked changes in the sensory processing in these participants. Primary analyses of variance were carried out for standard Picture Categories (mutilation, erotic couples, attack, family and babies, neutral), Laterality (left vs. right) and Condition (anticipation condition vs. standard condition) as within-subjects variables. Again, significant effects were followed up by additional tests.

Further tests were carried out for the phobia-relevant material by calculating repeated measures ANOVA including following within-subjects factors: Picture Category (spider pictures vs. neutral), Laterality (left vs. right) and Condition (anticipation condition vs. standard condition). If necessary these analyses were completed by multiple tests.

4.6.3. Valence and Arousal Ratings

Subjective valence and arousal ratings were analyzed separately with multivariate analysis of variance. Within-subjects comparisons were carried out for all Picture Categories whereas between-group variables included spider phobics, high AS group and controls. The results were completed by independent sample t-tests.

5. RESULTS

5.1. Slow Picture Presentation

5.1.1. Affective ERP Modulation in Standard Picture Categories

5.1.1.1. Early Posterior Negativity

Figure 9a illustrates the ERP waveforms elicited by standard picture categories over representative right and left temporo-occipital sensors. The results confirmed previous findings regarding early affective modulation (Junghöfer et al., 2001; Schupp et al., 2003, 2004). Affective pictures evoked more negative ERP waveforms in the time window von 176 bis 256 ms than neutral slides ($F(4,248)=107.24$; $p<.001$; $\epsilon=0.702$) (see difference waves in Figure 9b). As shown in the Table 4 this relative negative shift was observed in the encoding of each standard affective picture category (all $F_s>60$; $p_s<.001$). As expected, pictures of erotic couples elicited significantly more negative waveforms than pictures of family and babies ($F(1,64)=54.79$; $p<.001$). Mutilation pictures elicited more negative ERP waveforms than pictures of attack ($F(1,64)=30.0$; $p<.001$). Relative to pictures of erotic couples mutilation pictures elicited a less pronounced negative shift ($F(1,64)=72.86$; $p<.001$) that was comparable to the ERP waveforms elicited by pictures of family and babies ($F(1,64)=1.06$; $p=.308$). Pictures of attack elicited significantly less negative ERP waveforms than pictures from any other affective category ($F_s(1,64)>33$; $p_s<.001$). As expected, no group differences in the affective modulation for standard picture categories were found ($F(8,248)=0.292$; $p=.931$). As illustrated in Figure 9b the relative EPN was more pronounced over right than left sensor areas ($F(4,248)=3.472$; $p<.05$; $\epsilon=0.681$). However additional analyses revealed that the affective modulation occurred over both left and right sensor areas ($F_s(4,248)>85$; $p_s<.001$). As expected, these patterns of results were equally pronounced in all groups ($F_s<1$; ns).

Table 4. Mean Amplitudes and Results from Statistical Analyses of the Contrasts between Neutral Pictures and Standard Affective Contents Calculated for the Temporo-Occipital Cluster in the Time Window 176-256 ms.

CONTRAST	EPN AMPLITUDE M (\pm SE) in μ V	ANOVA RESULT F (1,64)
Erotic couples vs. Neutral	-5.15 (\pm 0.36)	209.24; $p<.001$
Mutilation vs. Neutral	-2.87 (\pm 0.23)	153.22; $p<.001$
Family&babies vs Neutral	-3.07 (\pm 0.21)	217.11; $p<.001$
Attack vs. Neutral	-1.60 (\pm 0.20)	63.44; $p<.001$

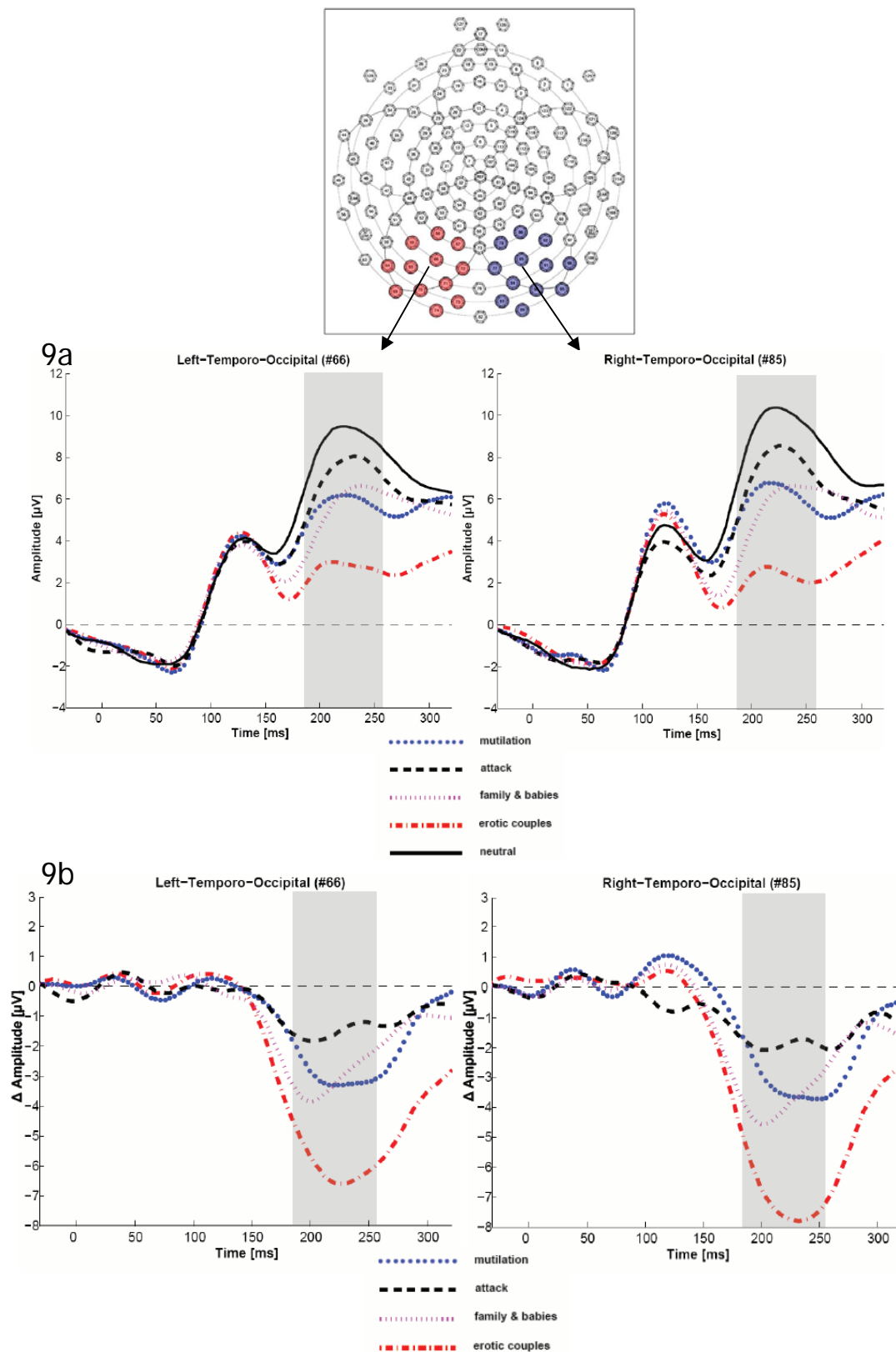


Figure 9. The top graph illustrates an outline of the 129-Geodesic sensor net with colored right and left temporo-occipital sensor clusters used in the data analysis of the Early Posterior Negativity (EPN). The mid graphs (1a) show grand-averaged ERP waveforms elicited over representative left and right temporo-occipital sensors by each standard picture category. The bottom graphs (1b) display the relative EPN elicited by standard affective materials over representative right and left temporo-occipital sensors. Shaded areas mark the time interval of 176-256 ms selected for the analysis of the relative EPN.

5.1.1.2. Late Positive Potentials

Figure 10a illustrates the grand-averaged ERP waveforms over representative right and left centro-parietal sensors. In accordance with previous findings (Schuppp et al., 2000, 2003, 2004) the results indicated that affective pictures elicited greater LPPs than neutral slides ($F(4,248)=179.07$; $p<.001$; $\epsilon=0.635$) (see also Figure 10b). Follow-up tests revealed that each affective picture category elicited a larger LPP than neutral contents (all $F_s>100$; $p_s<.001$) (see Table 5). Due to a higher arousal pictures of erotic couples and mutilation pictures evoked a more pronounced LPP than pictures of family and babies and pictures of attack ($F_s(1,64)=140$; $p_s<.001$). The amplitude of the LPP evoked by pictures of family and babies was comparable to the amplitude of the LPP elicited by pictures of attack ($F(1,64)=1.152$; $p=.287$). Again, erotic pictures lead to a stronger ERP modulation than mutilation pictures ($F(1,64)=9.01$; $p<.01$). The ERP waveforms elicited by standard affective picture categories did not significantly differ as a function of group ($F(8,248)=1.863$; $p=.103$; $\epsilon=0.635$). As illustrated in Figure 10b there was a greater left than right affective modulation ($F(4,248)=3.275$; $p=.021$; $\epsilon=0.787$). However, additional tests revealed that the affective modulation was observed over both left and right sensor clusters ($F_s>100$; $p_s>.001$). These effects did not differ as a function of group ($F_s<2.3$; ns).

Table 5. Mean Amplitudes and Results from Statistical Analyses of the Contrasts between Neutral Pictures and Standard Affective Materials Calculated for the Centro-Parietal Cluster in the Time Window 400-560 ms.

CONTRAST	LPP AMPLITUDE M (\pm SE) in μ V	ANOVA RESULT F (1,64)
Erotic couples vs. Neutral	5.30 (\pm 0.32)	274.45; $p<.001$
Mutilation vs. Neutral	4.64 (\pm 0.26)	317.08; $p<.001$
Family&babies vs Neutral	1.92 (\pm 0.17)	126.02; $p<.001$
Attack vs. Neutral	1.75 (\pm 0.16)	112.74; $p<.001$

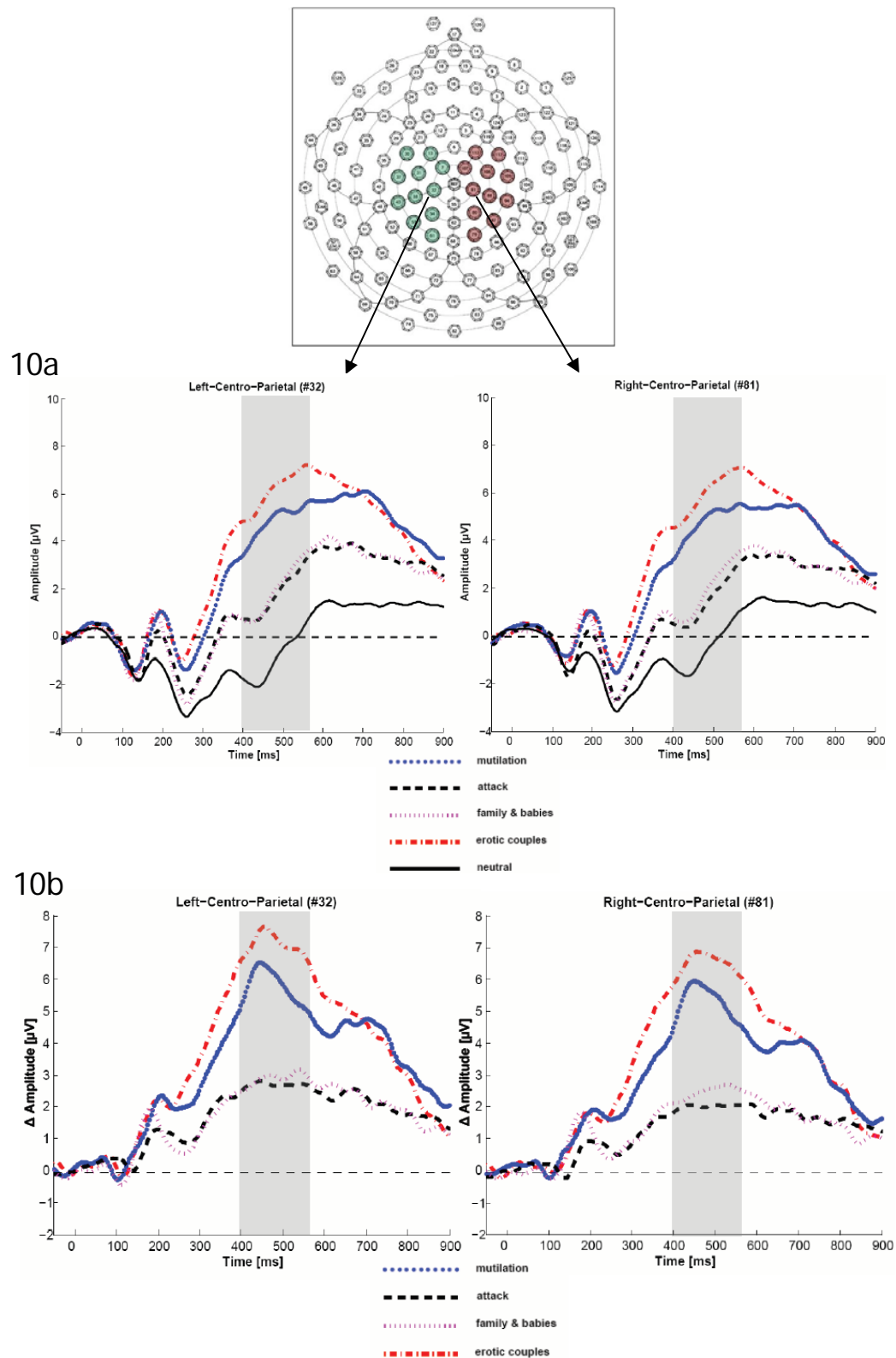


Figure 10. The top graph outlines the 129-Geodesic sensor net with colored right and left centro-parietal sensor clusters selected for the analysis of the Late Positive Potentials. The middle panel (2a) shows grand-averaged ERP waveforms elicited over representative left and right centro-parietal sensors by each standard picture category. The bottom graphs (2b) display the difference waveforms obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by standard affective picture categories. The time interval of 400-560 ms selected for the analysis of the LPP is shaded in gray.

5.1.2. Sensory Processing of Medical Emergency Pictures in High Anxiety Sensitive Subjects and Controls

5.1.2.1. Early Posterior Negativity

Figure 11 illustrates the difference ERP waveforms of the high AS participants and controls over a representative temporo-occipital sensor obtained by subtracting the waveforms elicited by neutral slides from the waveforms elicited by medical emergency slides. As expected, viewing of medical emergency pictures resulted in a significant relative negative shift in the ERP waveforms ($F(1,43)=24.474$; $p<.001$). While the EPN for medical emergency pictures was observed in both experimental groups ($F_s>6$; $p_s<.05$) it was more pronounced in the group of high AS subjects than in controls ($F(1,43)=4.297$; $p<.05$). This pattern of results did not differ as a function of Laterality (Laterality \times Picture Category $F(1,43)=1.761$; $p=.192$; Laterality \times Picture Category \times Group $F(1,43)=0.082$; $p=.776$).

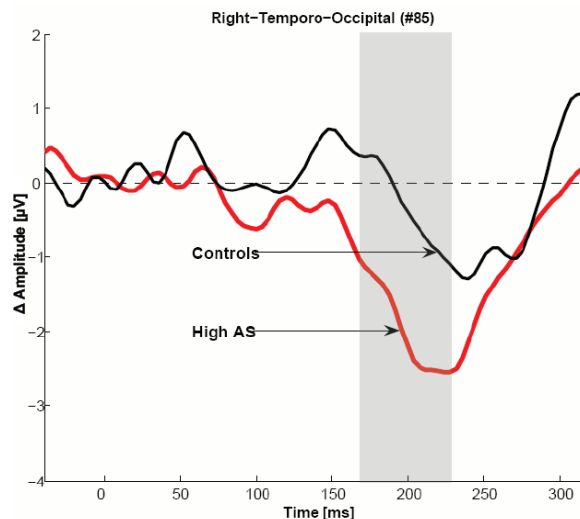


Figure 11. Difference waveforms over a representative temporo-occipital sensor (# 85) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by pictures of medical emergency plotted for high AS subjects and controls. Shaded area marks the time interval of 176-256 ms selected for the analysis of the Early Posterior Negativity.

To assess the strength of the EPN shift pictures of medical emergency were additionally compared to each standard affective picture category. The ERP waveforms differed as a function of Picture Category ($F(4,172)=61.456$; $p<.001$; $\epsilon=.782$). Follow up tests revealed that each standard affective picture category elicited significantly more negative ERP waveforms than medical emergency pictures ($F_s>8$; $p_s<.01$) (see Figure 12). This pattern of results did not differ as a function of group ($F(4,172)=0.384$; $p=.774$; $\epsilon=.782$) (see Table 6) and laterality ($F(4,172)=2.05$; $p=.11$; $\epsilon=.741$).

Table 6. Mean Amplitudes of Grand-averaged Event Related Potential (ERP) Waveforms Elicited by Standard Pictorial Materials and Medical Emergency Pictures over the Temporo-Occipital Area in the Time Window 176-256 ms in High Anxiety Sensitive Subjects and Controls.

PICTURE CATEGORY	Mean EPN amplitude in HIGH AS GROUP (μV)	Mean EPN amplitude in CONTROLS (μV)
Erotic couples	-0,11	0,84
Attack	3,76	4,20
Family and babys	2,19	2,98
Medical emergency	4,14	5,18
Mutilation	2,43	2,97
Neutral	5,36	5,68

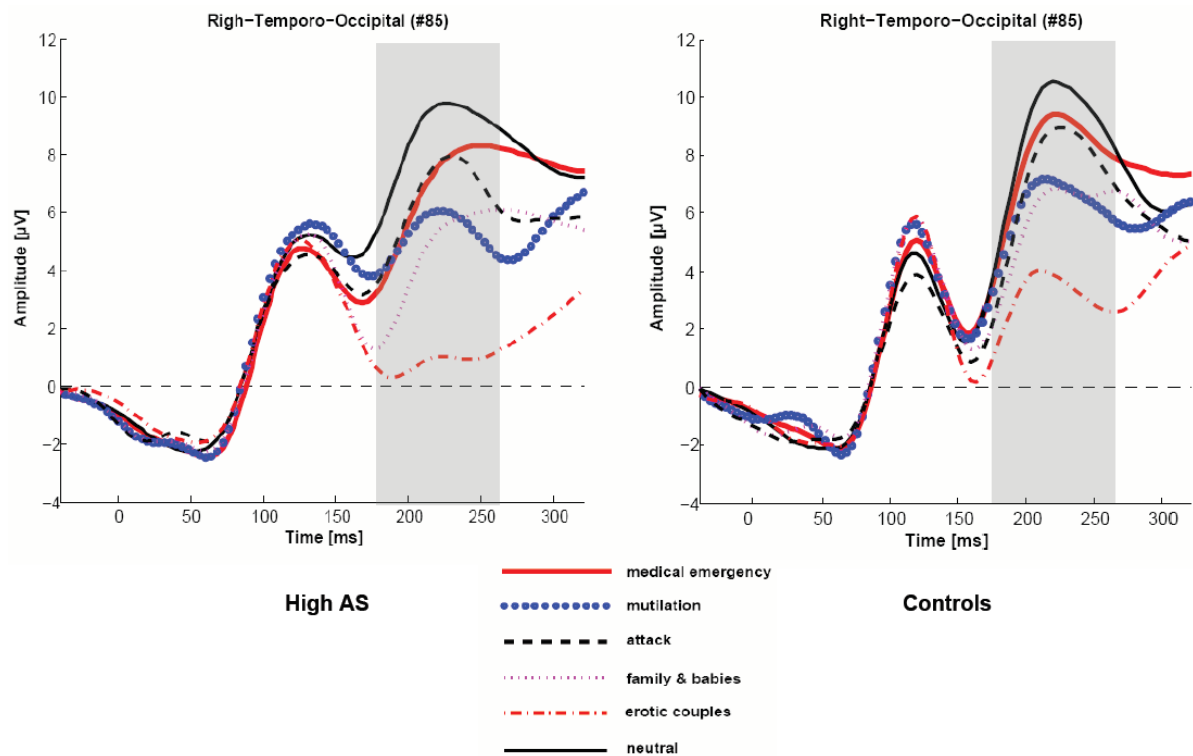


Figure 12. Grand-averaged of event related potential (ERP) waveforms over a representative temporo-occipital sensor evoked during the processing of each standard picture category and medical emergency slides in high Anxiety Sensitive subjects and controls. Shaded areas mark the time intervall of 176-256 ms, selected for the analysis of the Early Posterior Negativity.

Direct Group Comparison Between High AS Subjects and Controls for the EPN Evoked During the Encoding of Medical Emergency Pictures.

Figure 13 illustrates the grand-averaged ERP waveforms evoked over representative left and right temporo-occipital sensors during the encoding of medical emergency pictures in high AS subjects and controls. Medical emergency pictures elicited significantly more negative ERP waveforms over the right temporo-occipital sensor cluster in the high AS subjects when compared to nonfearful controls ($t(43)=2.05$; $p<.05$). This effect was not observed over the left temporo-occipital sensor cluster ($t(43)=1.39$; $p=.17$). As expected, the ERP waveforms elicited over the temporo-occipital regions during the encoding of standard picture categories did not differ as a function of group ($t(43)<1.4$; ns).

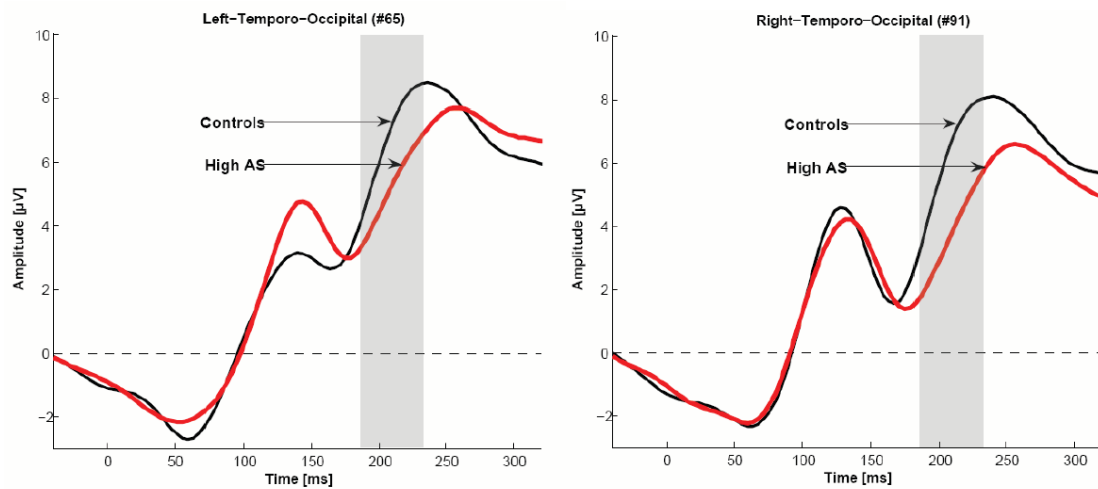


Figure 13. Grand-averaged ERP waveforms elicited over representative left (#65) and right (#91) temporo-occipital sensors during the encoding of medical emergency pictures in high AS subjects and controls. Shaded areas mark the time window of 188-232 ms selected for the direct group comparison

The Estimation of Neural Sources Responsible for the Group Differences in the Scalp Potential Observed During the Encoding of Medical Emergency Pictures in the Time Interval of 188-232.

The L2-Minimum-Norm-Estimations were performed to assess the brain sources involved in the differential processing of medical emergency pictures observed between high AS participants and controls in the time interval of 188-232 ms. The applied method does not require to predefine the localization and the number of possible brain sources but assumes that the ERPs originate from multiple sources that can be

calculated on the basis of the current density distribution measured on the head surface. However, because a specific pattern of scalp potential can be generated by a variety of dipoles arrangements the present method introduced additional criteria limiting possible solutions. The brain source estimation was based on a spherical four-shell head model with 3 (radial, azimuthal, and polar direction) x 197 evenly and spherically distributed dipoles. As a compromise between depth sensitivity and spatial resolution a source shell radius of 4 cm was chosen.

As illustrated in the top panel of Figure 14 the differential processing of medical emergency pictures was generated by sources over temporo-occipital regions. This effect was more pronounced over right than left temporo-occipital areas. For comparison, the calculation of the L2-Minimum-Norm did not reveal any meaningful group differences in the early encoding of standard pictorial materials (the bottom panel of Figure 14).

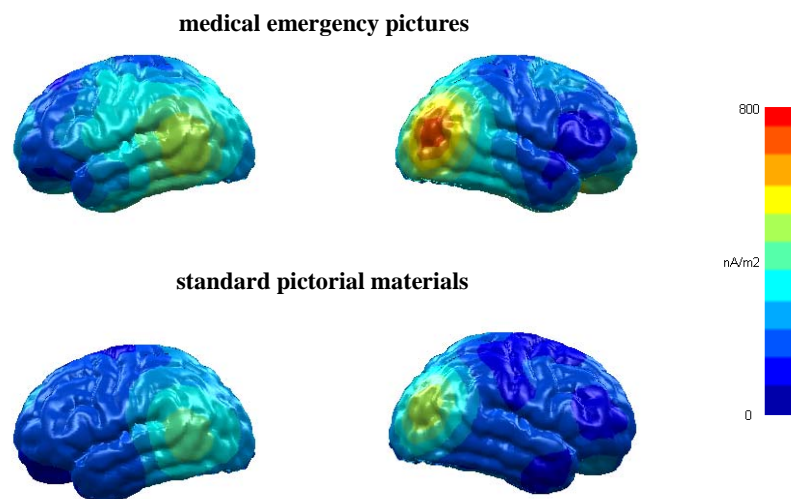


Figure 14. The neural sources for the fear-related differences in the ERP waveforms elicited in the time interval of 188-232 ms plotted for medical emergency pictures and standard pictorial materials.

5.1.2.2. Late Positive Potentials

As highlighted in Figure 15 the amplitude of the LPP was significantly larger during the processing of medical emergency pictures than during encoding of neutral materials ($F(1,43)=55.533$; $p<.001$). This contrast did not differ as a function of group ($F(1,43)=0.635$; $p=.430$). However the differentiation between medical emergency and neutral pictures was more pronounced over left than right centro-parietal areas ($F(1,43)=4.471$; $p<.05$). This effect was comparable in both experimental groups ($F(1,43)=2.782$; $p=.103$).

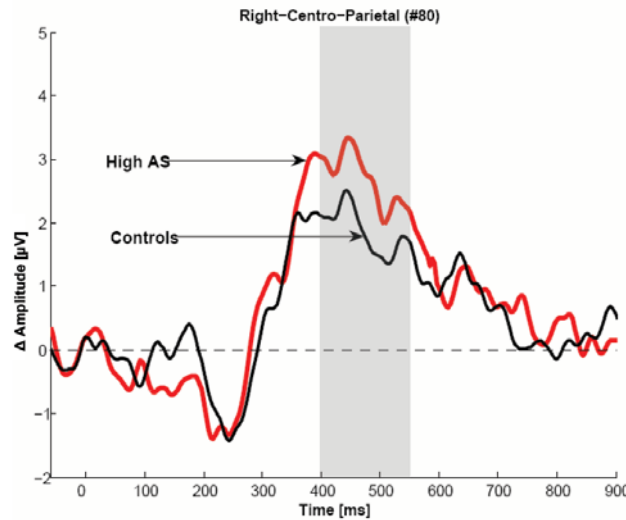


Figure 15. Difference waveforms over a representative centro-parietal sensor (# 80) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by pictures of medical emergency plotted for high AS subjects and controls. The time interval of 400-560 ms selected for the analysis of the Late Positive Potentials is shaded grey.

Next, LPPs elicited by medical emergency pictures and standard affective picture categories were compared. Figure 16 illustrates that the LPP elicited by standard affective materials was larger than the LPP evoked in the encoding of medical emergency pictures ($F(4,172)=123.06$; $p<.001$; $\epsilon=0.623$). Follow up tests revealed that relative to medical emergency pictures the late positivity was more pronounced for pictures of erotic couples and mutilation pictures ($F_s>160$; $p_s<.001$) as well as for pictures of attack and pictures of family and babies ($F_s>8.603$; $p_s<.01$). This pattern of results was similar for both experimental groups ($F(4,172)=0.92$; $p=.419$; $\epsilon=0.623$) and did not differ as a function of laterality ($F(4,172)=2.066$; $p=.106$; $\epsilon=0.775$).

Table 7. Mean Amplitudes of Grand-averaged Event Related Potential (ERP) Waveforms Elicited by Standard Pictorial Materials and Medical Emergency Pictures over the Centro-Parietal Area in the Time Window 400-560 ms in High Anxiety Sensitive Subjects and Controls.

PICTURE CATEGORY	Mean LPP amplitude in HIGH AS GROUP (μV)	Mean LPP amplitude in CONTROLS (μV)
Erotic couples	5,75	5,42
Attack	1,75	1,61
Family and babys	1,84	1,56
Medical emergency	1,47	0,97
Mutilation	5,19	4,16
Neutral	-0,03	-0,19

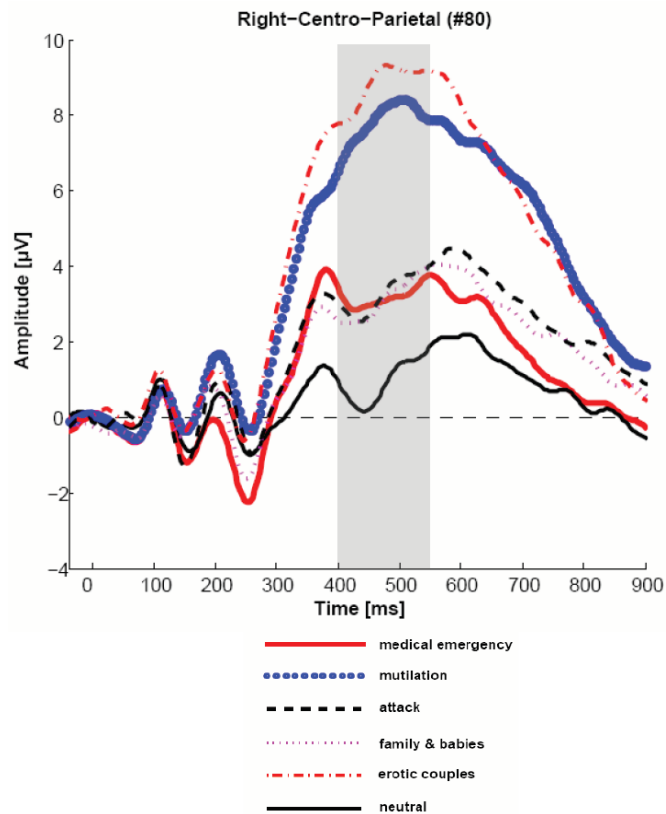


Figure 16. Grand-averaged of event related potential (ERP) waveforms over a representative centro-parietal sensor (#80) evoked during the processing of each standard picture category and medical emergency pictures. Due to the lack of group differences the figure shows data pooled from high Anxiety Sensitive subjects and controls. Shaded area marks the time interval of 400-560 ms, selected for the analysis of the Late Positive Potentials.

5.1.3. Sensory Processing of Pictures of Erotic Couples in High Anxiety Sensitive Subjects and Controls

5.1.3.1. Early Posterior Negativity

Figure 17 shows the difference waveforms over a representative temporo-occipital sensor resulting from subtraction of the waveforms elicited by neutral pictures from the waveforms evoked by pictures of erotic couples plotted for high AS participants and controls. As expected, pictures of erotic couples elicited significantly more negative ERP waveforms than neutral slides ($F(1,43)=157.824$; $p<.001$). This effect was observed to be similar in both experimental groups ($F(1,43)=0.605$; $p=.441$) and both sensor clusters ($F(1,43)>131$; $p<.001$).

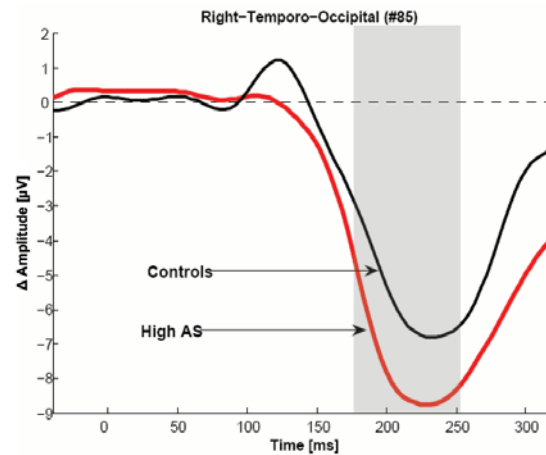


Figure 17. Difference waveforms over a representative temporo-occipital sensor (# 85) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by pictures of erotic couples plotted for high AS subjects and controls. Shaded area marks the time interval of 176-256 ms selected to analyse the EPN.

In the next step the EPNs elicited by pictures of erotic couples and other standard affective picture categories were compared (see Figure 18). This analysis revealed that pictures of erotic couples evoked more negative shift over temporo-occipital scalp regions than other standard affective contents ($F(3,129)=51.269$; $p<.001$; $\epsilon=0.907$); single contrasts ($F_s(1,43)>56$; $ps<.001$). This pattern of results was similar for both experimental groups ($F(3,129)=.316$; $p=.795$; $\epsilon=0.907$) and did not differ as a function of Laterality ($F(3,129)=1.856$; $p=.152$; $\epsilon=0.823$).

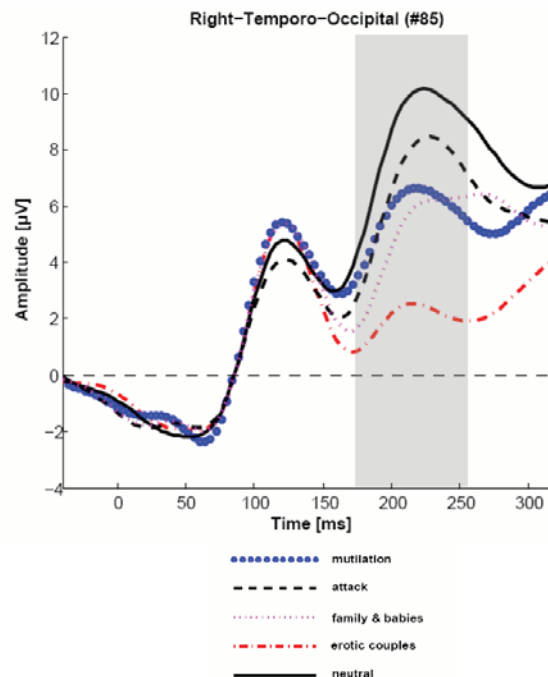


Figure 18. Grand-averaged ERP waveforms over a representative temporo-occipital sensor (#85) evoked during the encoding of standard pictorial materials. The data was pooled from high AS subjects and controls. The time window of 176-256 ms selected for the analysis of the EPN is colored gray.

5.1.3.2. Late Positive Potentials

As highlighted in Figure 19 pictures of erotic couples elicited larger LPP amplitudes than neutral pictures ($F(1,43)=218.374$; $p<.001$). This contrast did not differ as a function of Group ($F(1,43)=0.019$; $p=.89$) and Laterality ($F(1,43)=2.601$; $p=.114$).

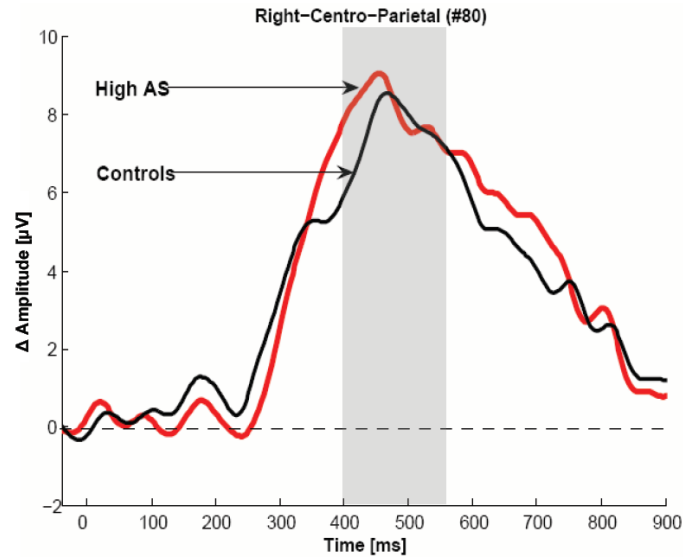


Figure 19. Difference waveforms over a representative centro-parietal sensor (# 80) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by pictures of erotic couples plotted for high AS subjects and controls. The time interval of 400-560 ms selected for the analysis of the Late Positive Potentials is shaded grey.

LPPs evoked by pictures of erotic couples were further compared with those elicited by standard affective picture categories. And so, pictures of erotic couples elicited larger LPPs than other affective pictures ($F(3,129)=116.153$; $p<.001$; $\epsilon=.822$); single contrasts ($F_s(1,43)>13$; $p_s<.001$) (see Figure 20). These effects did not differ as a function of Group ($F(3,129)=1.134$; $p=.333$; $\epsilon=.822$) and Laterality ($F(3,129)=2.384$; $p=.083$; $\epsilon=.853$).

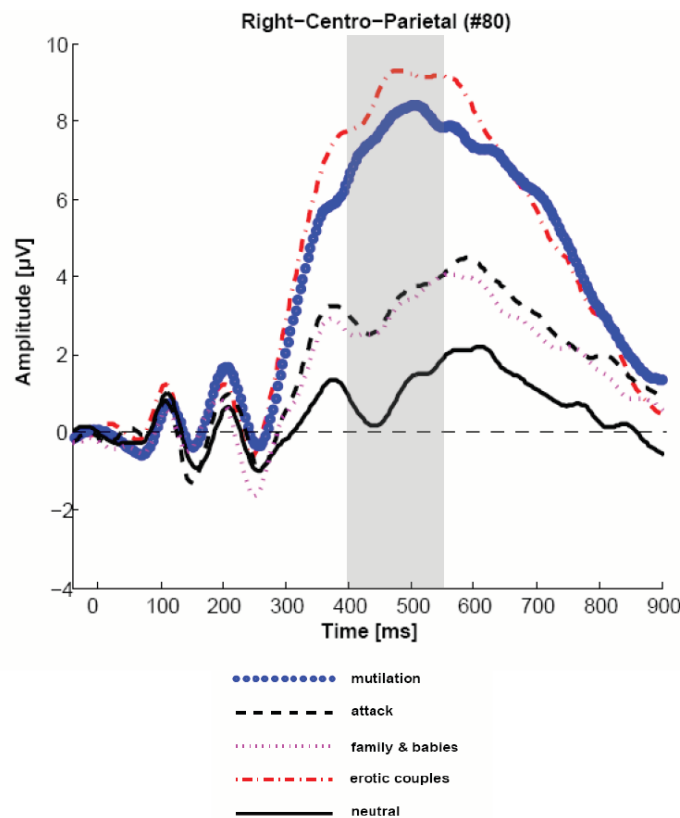


Figure 20. Grand-averaged event related potential (ERP) waveforms over a representative centro-parietal sensor (#80) evoked during the processing of each standard picture category. The data was pooled from high Anxiety Sensitive subjects and controls. Shaded areas mark the time interval of 400-560 ms selected for the analysis of the Late Positive Potential.

5.1.4. Sensory Processing of Mutilation Pictures in High Anxiety Sensitive Subjects and Controls

5.1.4.1. Early Posterior Negativity

Figure 21 illustrates the difference ERP waveforms of the high AS participants and controls over a representative temporo-occipital sensor obtained by subtracting the waveforms elicited by neutral slides from the waveforms elicited by mutilation slides. As expected, mutilation pictures resulted in a significant relative negative shift in the ERP waveforms ($F(1,43)=87.41$; $p<.001$). This effect did not differ as a function of group ($F(1,43)=.133$; $p<.717$) and laterality ($F(1,43)=1.24$; $p<.272$).

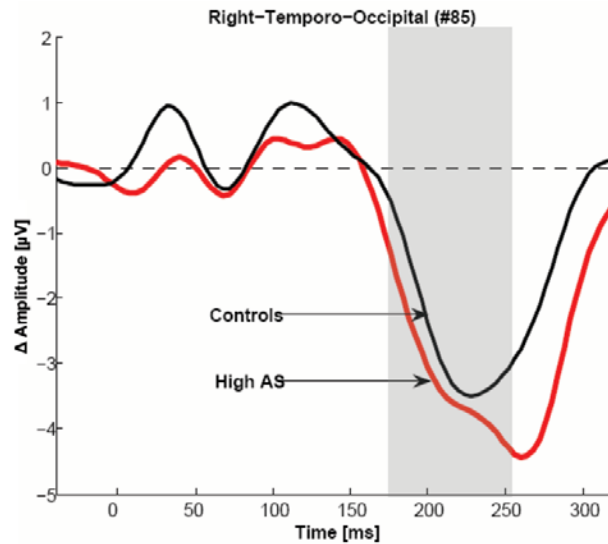


Figure 21. Difference waveforms over a representative temporo-occipital sensor (# 85) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by mutilation pictures plotted for high AS subjects and controls. Shaded area marks the time interval of 176-256 ms selected for the analysis of the Early Posterior Negativity.

In the next step the EPNs elicited by mutilation pictures and other standard affective picture categories were compared. As expected, this analysis demonstrated a significant effect of Picture Category ($F(3,129)=51.269$; $p<.001$; $\epsilon=0.907$). Follow-up tests revealed that the EPN elicited by mutilation pictures was similar to those evoked by pictures of family and babies ($F(1,43)=.225$; ns) but were more negative when compared to pictures of attack and less negative when compared to pictures of erotic couples ($F(1,43)>22$; $ps<.001$) (see Figure 18). This pattern of results was similar for both experimental groups ($F(3,129)=.316$; $p=.795$; $\epsilon=0.907$) and did not differ as a function of Laterality ($F(3,129)=1.856$; $p=.152$; $\epsilon=0.823$).

5.1.4.2. Late Positive Potentials

As highlighted in Figure 22 the amplitude of the LPP was significantly larger during the processing of mutilation pictures than during the encoding of neutral materials ($F(1,43)=229.195$; $p<.001$). This contrast did not differ as a function of Group ($F(1,43)=1.667$; $p=.204$) and Laterality ($F(1,43)=0.037$; $p=.849$).

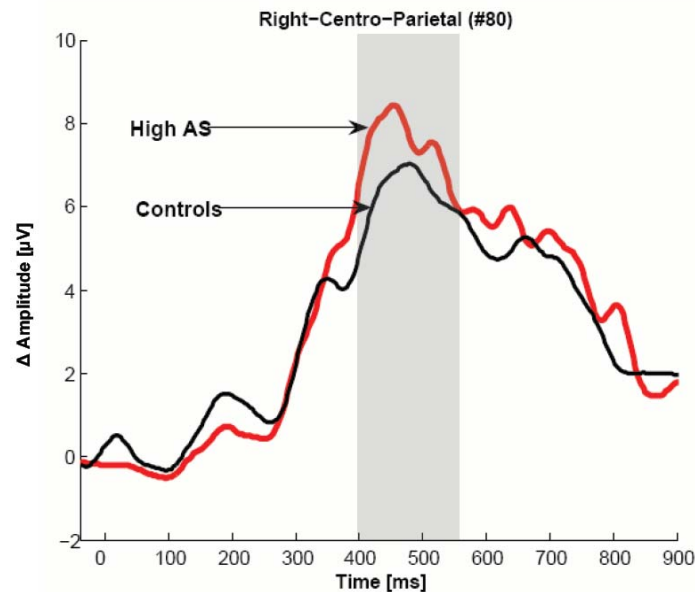


Figure 22. Difference waveforms over a representative centro-parietal sensor (#80) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by mutilation pictures plotted for high AS subjects and controls. The time interval of 400-560 ms selected for the analysis of the Late Positive Potentials is shaded grey.

LPPs evoked by mutilation pictures were further compared with those elicited by standard affective picture categories. In accordance with the expectations, this analysis disclosed a significant effect of Picture Category ($F(3,129)=158.987$; $p<.001$; $\epsilon=0.719$) (see Figure 20). Follow-up tests revealed that mutilation pictures elicited less pronounced LPPs than pictures of erotic couples and greater LPPs than pictures of attack and pictures of family and babies ($F_s(1,43)>13$; $p_s<.001$). Although, this pattern of results differed as a function of Laterality ($F(3,129)=29.11$; $p=.044$) it was observed over right and left sensor clusters ($F_s(3,129)>88$; $p_s<.001$). These effects did not differ as a function of Group ($F(3,129)=0.836$; $p=.444$; $\epsilon=0.719$).

5.1.5. The Evoked Potentials Elicited by High Arousing Unpleasant Material in High Anxiety Sensitive Subjects and Controls During Later Processing Periods

Explorative analyses performed for categorically splited pictorial materials indicated that the LPP elicited by mutilation pictures was slightly more pronounced in the high AS group than in controls. However, this effect was not statistically significant (see chapter 5.1.4.2). For further exploration, unpleasant pictures were splited according to their arousal intensity as assessed with SAM by high AS participants and controls (see chapter 5.3). Further analyses were performed for 12 high arousing unpleasant pictures and 24 low arousing unpleasant pictures.

Figure 23 illustrates the difference waveforms over a representative centro-parietal sensor resulting from subtraction of the waveforms elicited by neutral pictures from the waveforms evoked by high arousing unpleasant pictures plotted for high AS subjects and controls. These difference waveforms were larger in high AS participants than in controls. To identify the temporal and spatial characteristics of this effect individual waveform analyses and conventional ANOVAs including the factor Picture Category (high arousing unpleasant and neutral) and Group (high AS subjects and controls) were calculated for each time point and each individual sensor (see chapter 4.5.1.). According to these tests the above-described effect was most pronounced in the time window of 400-480 ms over two centro-parietal sensor clusters: 7,13,30,31,32,37,38,54,53,61 in the left hemisphere and 79,80,81,87,88,105,106,107,112,113 in the right hemisphere. Further statistical analyses were carried out for LPPs averaged in above-specified sensor clusters and the time window. These analyses revealed that high arousing unpleasant pictures elicited larger LPPs than neutral slides ($F(1,43)=234.74$; $p<.001$). While the selective processing of these pictures was observed for both experimental groups ($F_s>100$; $p<.001$) it was more pronounced in high AS subjects than in controls ($F(1,43)=4.42$; $p<.05$)⁴. This pattern of results did not differ as a function of laterality ($F_s<1.5$; ns).

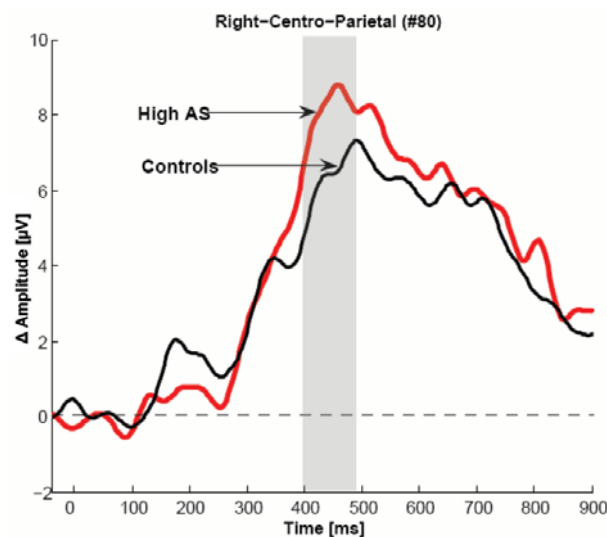


Figure 23. Difference waveforms over a representative centro-parietal sensor (# 80) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by high arousing unpleasant pictures in high AS subjects and controls. The time interval of 400-480 ms selected for the analysis of the Late Positive Potentials is shaded grey.

⁴Additional tests revealed that this effect was not related to an augmented fear of mutilated bodies observed in high AS subjects. Scores of Mutilation Questionnaire did not correlate with ERP difference scores (high arousing unpleasant vs. neutral slides) ($r=.236$; $p=.123$).

Figure 24 illustrates ERP waveforms over a representative centro-parietal sensor elicited in high AS subjects (left panel) and controls (right panel) by following picture categories: high arousing unpleasant, high arousing pleasant⁵, low arousing unpleasant, low arousing pleasant. High arousing unpleasant pictures elicited lower LPPs than pictures of high arousing pleasant pictures and larger LPP amplitudes relative low arousing contents ($F(3,129)=83.04$; $p<.001$; $\epsilon=.732$); single contrasts ($F_s(1,43)>27$; $p_s<.001$). This pattern did not differ as a function of group ($F(3,129)=1.979$; $p=.14$; $\epsilon=.732$) (see Table 8) and laterality ($F(3,129)=1.379$; $p=.379$; $\epsilon=.768$).

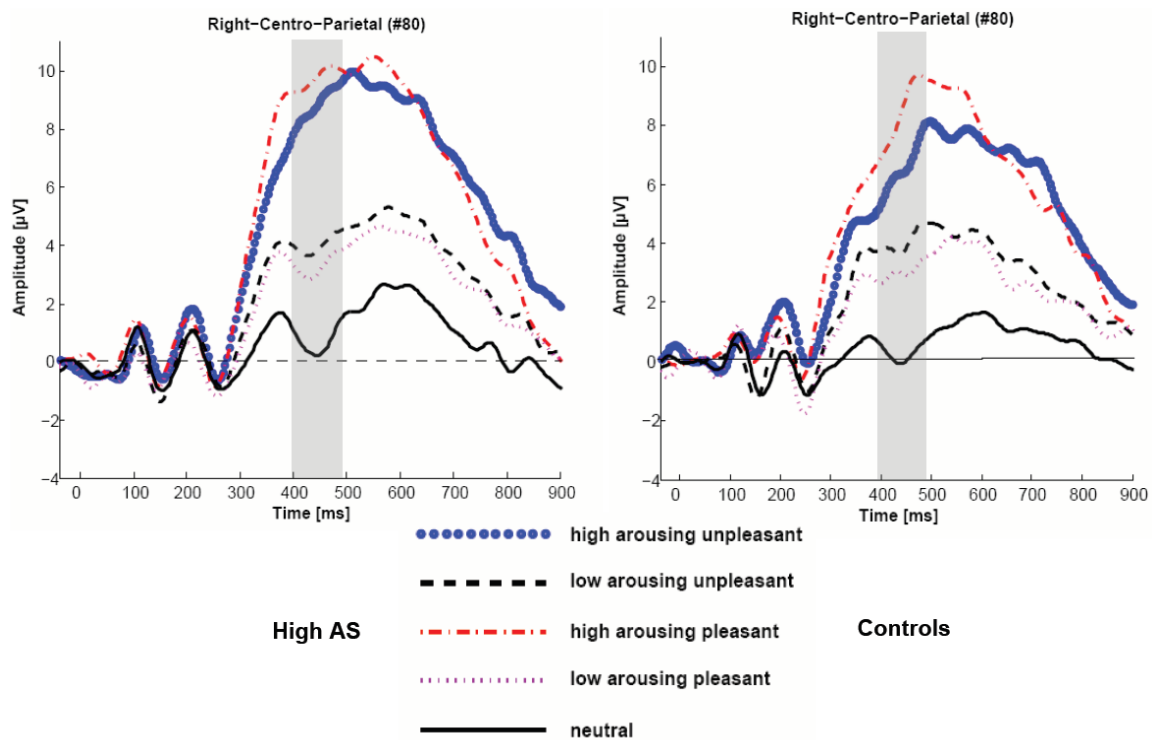


Figure 24. Grand-averaged event related potential (ERP) waveforms over a representative centro-parietal sensor (#80) evoked during the processing of standard pictorial materials split by arousal in high AS subjects (left panel) and controls (right panel). Shaded areas mark the time interval of 400-480 ms selected for the analysis of the Late Positive Potentials.

⁵As for unpleasant materials, similar arousal split was performed for pleasant pictures. The analyses of individual waveforms did not reveal any group differences in the affective differentiation between neutral pictures and high arousing pleasant pictures. These observations were supported by statistical analyses performed for the LPP averaged in the time window from 400 to 480 ms over two centro-parietal sensor clusters: 7,13,30,31,32,37,38, 54,53,61 in the left hemisphere and 79,80,81,87,88,105,106,107,112,113 in the right hemisphere (Picture Category $F(1,43)=247.474$; $p<.001$; Picture Category \times Group $F(1,43)=0.462$; ns).

Table 8. Mean Amplitudes of Grand-averaged Event Related Potential (ERP) Waveforms Elicited by Standard Pictorial Materials splited by arousal over the Centro-Parietal Area in the Time Window 400-480 ms in High Anxiety Sensitive Subjects and Controls.

PICTURE CATEGORY	Mean LPP amplitude in HIGH AS GROUP (μ V)	Mean LPP amplitude in CONTROLS (μ V)
High arousing unpleasant	4,51	3,16
High arousing pleasant	5,63	5,04
Low arousing unpleasant	1,78	1,75
Low arousing pleasant	1,49	1,22
Neutral	-0,80	-0,86

Direct Group Comparison Between High AS Subjects and Controls for the Evoked Potentials Elicited by High Arousing Unpleasant Pictures During Later Processing Periods.

Between group comparisons were first carried out for high arousing unpleasant pictures by calculating two sample t-tests between high AS participants and controls in all time points and all individual sensors (see also chapter 4.4.1). This kind of analysis revealed a significant difference between high AS subjects and controls during later stages of sensory processing for high arousing unpleasant material. This effect was most pronounced in the time window of 416 – 472 ms after picture onset over two centro-parietal sensor clusters: 32,38,43,48,52,53,54,61 in the left hemisphere and 79,80,81, 87,88,93,94,99 in the right hemisphere. In above-specified sensor clusters and the time window average potential values for every participant from the high AS group and the control group and for every picture category were calculated. Using these averages further statistical analyses were carried out showing that high arousing unpleasant materials elicited significantly more pronounced LPPs in high AS subjects than in controls ($t(43)=2.03$; $p<.05$) (see Figure 25). This effect did not differ as a function of Laterality (Laterality x Group: $F(1,43)=.107$; ns).

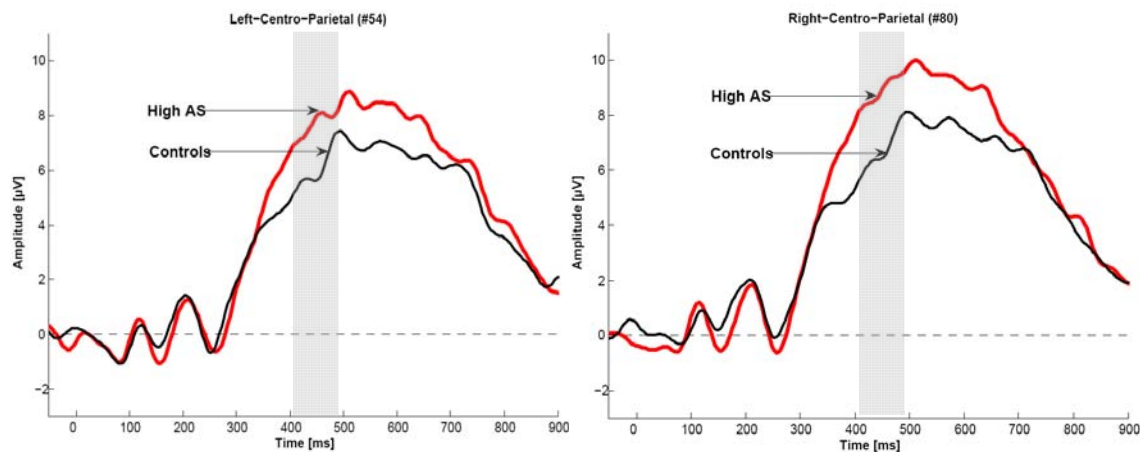


Figure 25. Grand-averaged ERP waveforms elicited over representative left (#54) and right (#80) centro-parietal sensors during the processing of high arousing unpleasant pictures in high AS participants and controls. Shaded areas mark the time interval of 416-472 ms selected for the analysis of the Late Positive Potential.

The Estimation of Neural Sources Responsible for the Differential Processing of High Arousing Unpleasant Materials Observed Between High AS Subjects and Controls in the Time Interval of 416-472 ms.

Further analysis concerned the estimation of brain sources (see above) responsible for the differential processing of high arousing unpleasant materials between high AS subjects and controls in the time interval of 416-472 ms. As illustrated in the upper panel of Figure 26 the differential processing of high arousing unpleasant material observed between high AS subjects and controls in the defined time interval was generated by sources over right parietal and fronto-temporal brain regions. An additional calculation of the L2-Minimum-Norm did not reveal any group differences in scalp potentials elicited by standard pictorial materials in the defined time window (the bottom panel of Figure 26).

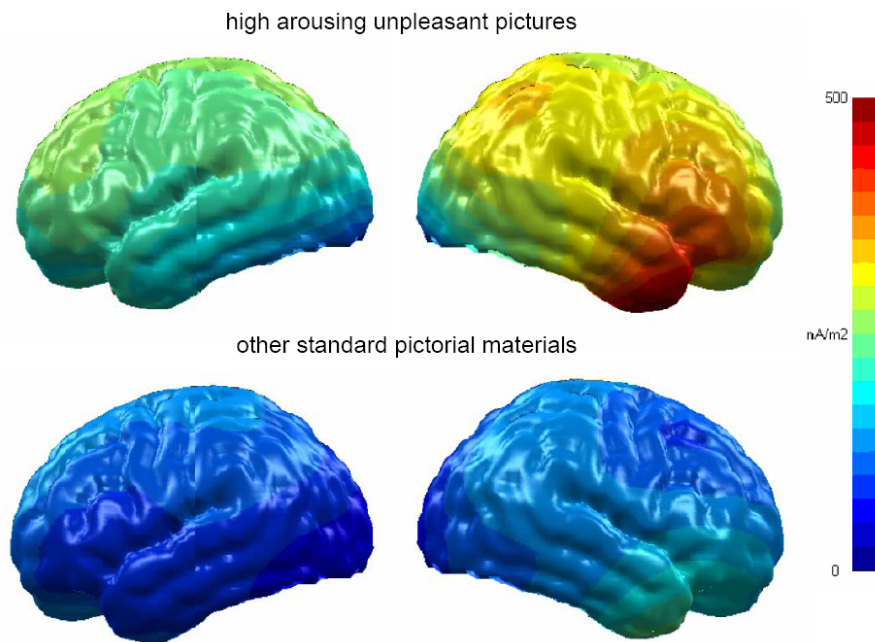


Figure 26. The neural sources for the fear-related differences in the ERP waveforms elicited in the time interval of 416-472 ms plotted for high arousing unpleasant pictures and standard pictorial materials.

5.1.6. Sensory Processing of Spider Pictures in Spider Phobia Participants and Controls

5.1.6.1. Early Posterior Negativity

Figure 27 shows the difference waveforms over a representative temporo-occipital sensor resulting from subtraction of the waveforms elicited by neutral pictures from the waveforms evoked by spider pictures plotted for spider phobics and controls. Spider pictures elicited significantly more negative ERP waveforms than neutral slides ($F(1,41)=82.689$; $p<.001$). This effect was not affected by Group ($F_s>30$; $p_s<.001$) and Laterality ($F<1.6$; ns).

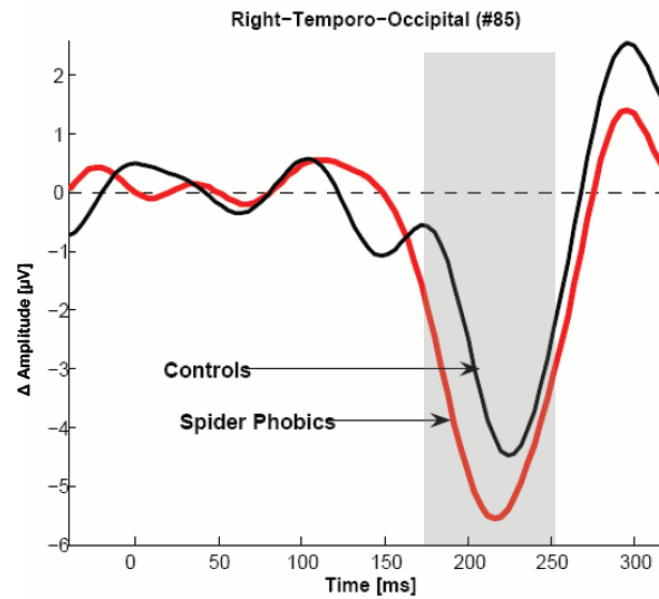


Figure 27. Difference waveforms over a representative temporo-occipital sensor (# 85) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by spider pictures in spider phobics and controls. Shaded area marks the time interval of 176-256 ms selected for the analysis of the relative Early Posterior Negativity.

The ERP waveforms evoked by spider pictures were further compared to the ERP waveforms elicited by standard affective materials (see Figure 28). The overall analysis revealed differences during the processing of spider pictures compared to standard affective picture categories ($F(4,164)=29.166$; $p<.001$; $\epsilon=0.842$). Spider pictures elicited a more negative shift than pictures of attack ($F(1,42)=17.207$; $p<.001$) and less negative shift than pictures of erotic couples ($F(1,42)=40.069$; $p<.001$). The ERP waveforms evoked by spider pictures were similarly pronounced as those elicited by pictures of mutilated bodies and pictures of family and babies ($F_s>1$). These effects did not differ as a function of group ($F(4,164)=0.850$; $p=.480$; $\epsilon=0.842$) and laterality ($F(4,164)=1.097$; $p=.355$; $\epsilon=0.791$) (see Table 9).

Table 9. Mean Amplitudes of Grand-Averaged Event Related Potential (ERP) Waveforms Elicited by Standard Pictorial Materials and Spider Pictures over the Temporo-Occipital Area in the Time Window 176-256 ms in Spider Phobics and Controls.

PICTURE CATEGORY	Mean EPN amplitude in SPIDER PHOBICS (μV)	Mean EPN amplitude in CONTROLS (μV)
Erotic couples	0,83	0,84
Attack	4,23	4,20
Family and babys	2,57	2,98
Spiders	2,31	3,23
Mutilation	2,99	2,97
Neutral	5,96	5,68

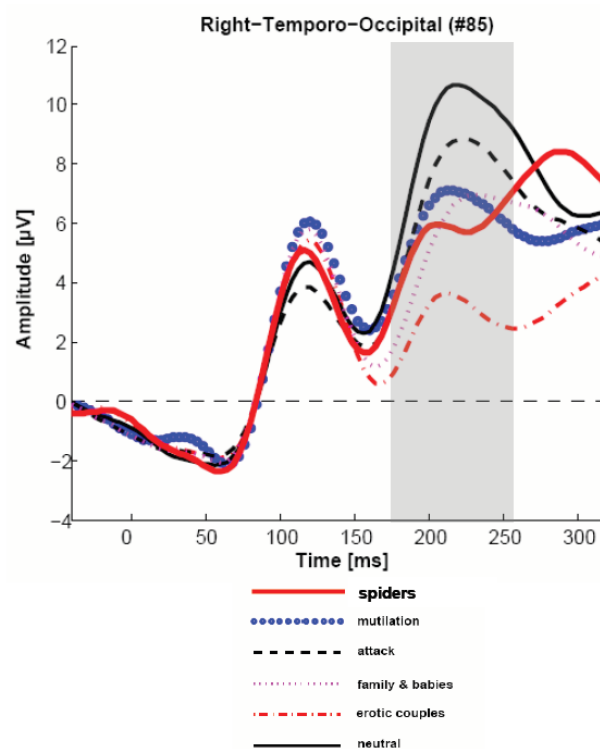


Figure 28. Grand-averaged event related potential (ERP) waveforms over a representative temporo-occipital sensor (#85) evoked during the processing of each standard picture category and spider pictures in spider phobics and controls. Shaded areas mark the time interval of 176-256 ms selected for the analysis of the relative Early Posterior Negativity.

5.1.6.2. Late Positive Potentials

The processing of spider pictures was further analyzed in the time interval specified for the LPP. As illustrated in Figure 29 spider pictures evoked a significantly greater LPP than neutral slides ($F(1,41)=111.963$; $p<.001$). This effect was observed for both spider phobics and controls ($F_s>38$) and was more pronounced in spider

phobics than controls ($F(1,41)=6.638$; $p<.05$). The fear-related differentiation was greater over left than right sensor areas ($F(1,41)=5.185$; $p<.05$). The group differences in the selective processing of spider pictures were independent of laterality ($F(1,41)=0.045$; $p=.833$).

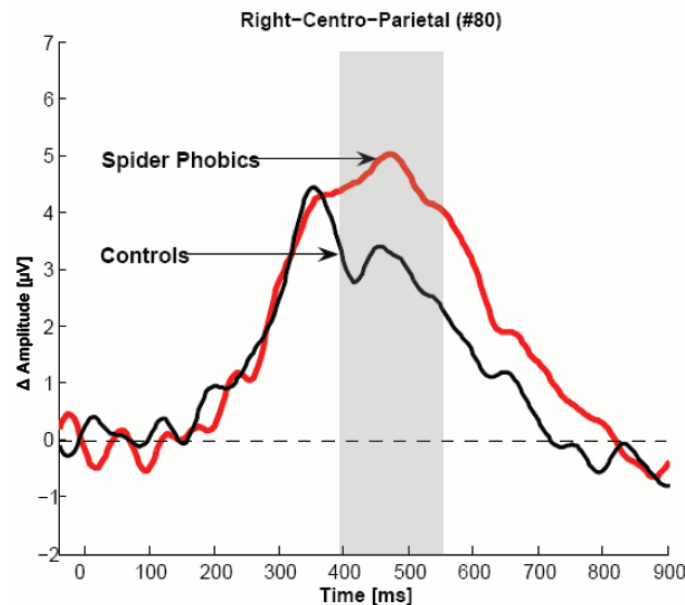


Figure 29. Difference waveforms over a representative centro-parietal sensor (#80) obtained by subtracting the waveforms elicited by neutral slides from the waveforms evoked by spider pictures in spider phobics and controls. Shaded area mark the time interval of 400-560 ms selected for the analysis of the Late Positive Potential.

The LPP evoked during the processing of spider pictures was further compared to the LPP for standard affective picture categories (see Figure 30). The overall analysis revealed differences between waveforms elicited by spider pictures and waveforms evoked by standard affective materials ($F(4,164)=50.278$; $p<.001$; $\epsilon=.757$). The LPP elicited by spider pictures was smaller than the LPP evoked by pictures of erotic couples and pictures of mutilated bodies ($F_s(1,41)>28$; $p_s<.001$) but more pronounced than the LPP for pictures of attack and the LPP for pictures of family and babies ($F_s(1,41)>8$; $p_s<.01$). Interestingly, these effects differed as a function of group ($F(4,164)=4.77$; $p<.01$; $\epsilon=.757$) (see Table 10). While in the control group pictures of erotic couples and mutilation pictures elicited significantly larger LPPs than pictures of spiders ($F(2,44)=35.04$; $p<.001$; $\epsilon=.777$) and LPPs to spider pictures were comparable to those evoked by pictures of attack and pictures of family and babies ($F<1$; ns), individuals with spider phobia showed significantly increased LPPs to spider pictures relative to pictures of attack and pictures of family and babies ($F(2,38)=11.16$; $p<.01$;

$\varepsilon = .712$). Importantly, the LPPs to spider pictures, however, did not significantly differ from those evoked by high arousing pleasant and unpleasant pictures ($F < 1.5$; ns). These patterns of results were not affected by laterality ($F_s(4,164) < 1.3$; ns).

Table 10. Mean Amplitudes of Grand-averaged Event Related Potential (ERP) Waveforms Elicited by Standard Pictorial Materials and Spider Pictures over the Centro-Parietal Area in the Time Window 400-560 ms in Spider Phobics and Controls.

PICTURE CATEGORY	Mean LPP amplitude in SPIDER PHOBICS (μV)	Mean LPP amplitude in CONTROLS (μV)
Erotic couples	4,00	5,42
Attack	1,23	1,61
Family and babys	1,73	1,56
Spiders	2,97	1,91
Mutilation	3,92	4,16
Neutral	-0,49	-0,19

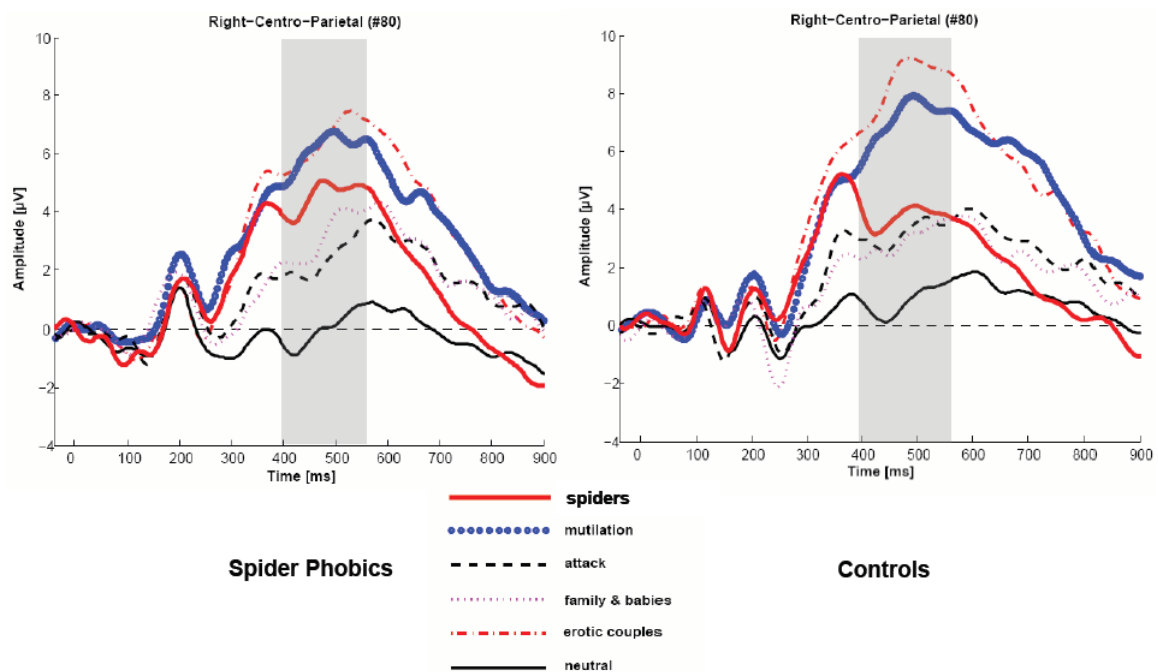


Figure 30. Grand-averaged event related potential (ERP) waveforms over a representative centro-parietal sensor (#80) evoked during the processing of each standard picture category and spider pictures in spider phobics and controls. Shaded areas mark the time interval of 400-560 ms selected for the analysis of the Late Positive Potential.

Direct Group Comparison Between Spider Phobia Participants and Controls for the LPP Evoked by Spider Pictures.

Figure 31 illustrates the grand-averaged ERP waveforms elicited over a representative centro-parietal sensor during the encoding of spider pictures in spider phobics and controls. Replicating previous findings direct group comparison revealed that spider pictures elicited a significantly greater LPP in spider phobics than controls ($t(41)=2.05$; $p<.05$). As expected, the LPP elicited during the encoding of standard picture categories did not differ as a function of group ($t(41)<1.9$; ns).

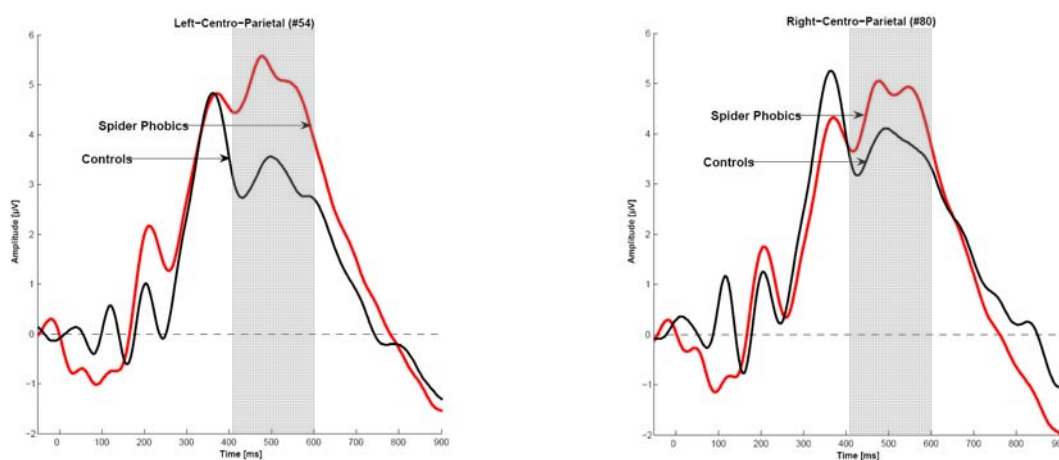


Figure 31. Grand-averaged ERP waveforms elicited over representative left (#54) and right (#80) centro-parietal sensors during the processing of spider pictures in spider phobics and controls. Shaded areas mark the time interval of 432-600 ms selected for the analysis of the Late Positive Potential.

The Estimation of Neural Sources Responsible for the Differential Processing of Spider Pictures Observed Between Spider Phobia Participants and Controls in the Time Interval of 432-600 ms.

Further analysis concerned the estimation of brain sources (see above) responsible for the differential processing of spider pictures between spider phobics and controls in the time interval of 432-600 ms. As illustrated in the upper panel of Figure 32 the differential processing of spider pictures observed between spider phobics and controls in the defined time interval was generated by sources over centro-parietal regions. An additional calculation of the L2-Minimum-Norm did not reveal any group differences in scalp potentials elicited by standard pictorial materials in the defined time window (the bottom panel of Figure 32).

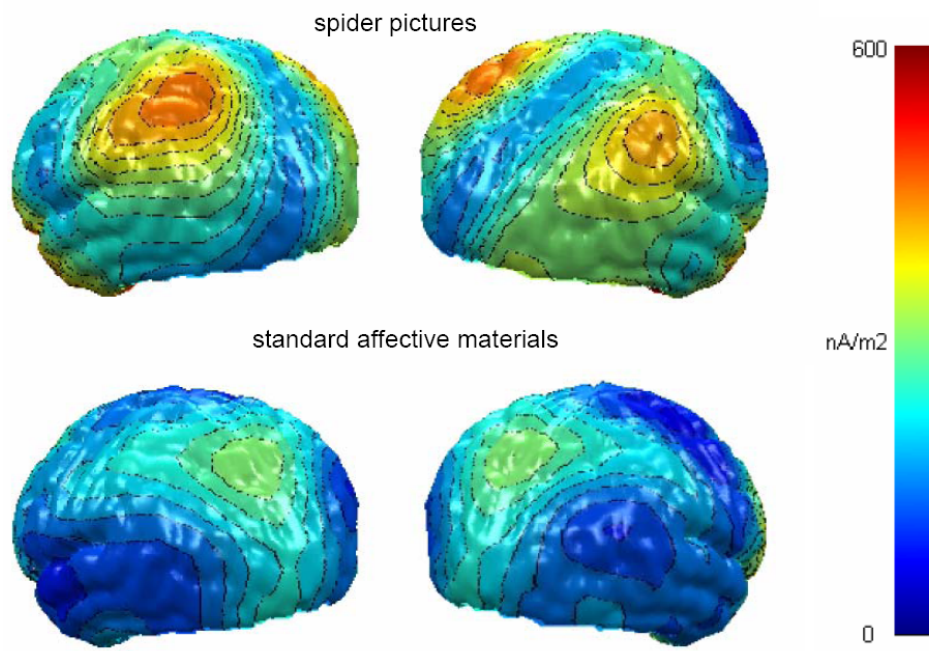


Figure 32. The neural sources for the fear-related differences in the ERP waveforms elicited in the time interval of 432-600 ms plotted for spider pictures and standard pictorial materials.

5.2. Rapid Serial Visual Presentation (RSVP)

5.2.1. Anticipation of Hyperventilation and the Sensory Processing in High Anxiety Sensitive Subjects and Controls

Figure 33 illustrates grand-averaged ERP waveforms elicited over a representative temporo-occipital sensor by briefly presented standard pictorial material in the standard condition (left panel) and the anticipation condition (right panel). The data were obtained from high AS participants and controls. In accordance with previous results standard affective materials elicited a more negative shift in the ERP waveforms than neutral slides ($F(4,168)=61.32$; $p<.001$; $\epsilon=.712$; single contrasts $F_s(1,42)>50$, $p<.001$). Replicating previous findings (Schupp et al., 2004) further analyses revealed that pictures of erotic couples elicited more pronounced negative shift than other standard affective contents ($F_s(1,42)>71$; $p<.001$). The negative shift in the ERP waveforms elicited by mutilation pictures were more pronounced only when compared to pictures of family and babies ($F(1,42)=4.24$; $p>.05$) but did not differ from pictures of attack ($F(1,42)=1.51$; $p=.227$). Pictures of attack and pictures of family and babies elicited similar ERPs ($F(1,42)=1.61$; $p=.221$). The affective EPN modulation (affective pictures vs. neutral contents) was more pronounced over right than left sensor areas ($F(4,168)=4.438$; $p<.01$; $\epsilon=.794$). but additional analyses revealed that it was observed over both hemispheres ($F_s(4,168)>50$; $p<.001$). The affective modulation did not differ as a function of group ($F(4,168)=4.75$; $p=.691$; $\epsilon=.712$) and condition ($F(4,168)=1.01$; $p=.401$; $\epsilon=.902$). However, all picture contents elicited a more pronounced negativity during the anticipation condition than during the standard condition ($F(1,42)=17.07$; $p<.001$).

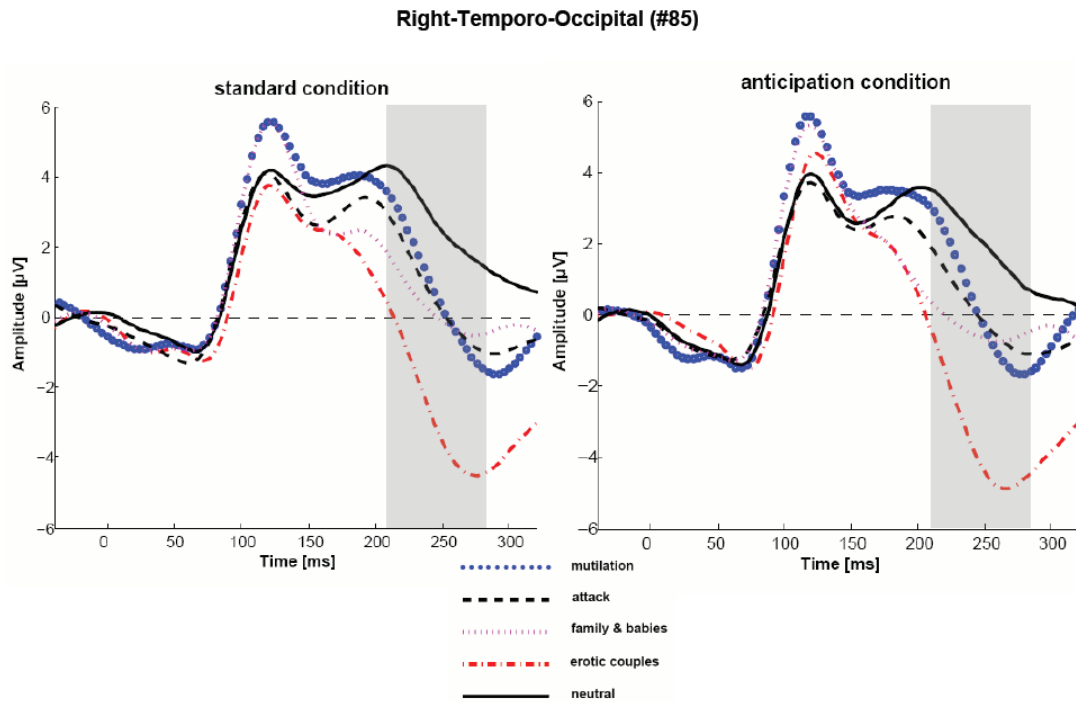


Figure 33. The grand-averaged ERP waveforms elicited over a representative temporo-occipital sensor (#85) by standard pictorial materials during the rapid serial visual presentation in standard condition (left panel) and anticipation condition (right panel). The data incorporate both high AS participants and controls. Shaded areas mark the time interval of 220-280 ms, selected for the analysis of the Early Posterior Negativity.

Figure 34 illustrates the difference waveforms for a representative temporo-occipital sensor (#85) obtained by subtracting the waveforms elicited by neutral materials from the waveforms evoked by medical emergency pictures during the rapid serial visual presentation in the anticipation condition (left panel) and in the standard condition (right panel). The difference waveforms are plotted separately for the high AS subjects and controls. Other than expected, the ERP waveforms elicited by medical emergency pictures did not differ from those evoked by neutral pictures ($F(1,42)=1.74$; $p=.195$). This effect was observed in both experimental groups ($F(1,42)=.023$; $p=.879$) and did not significantly differ as a function of laterality ($F(1,42)=3.36$; $p=.074$). The effect of condition revealed for standard picture categories was not observed in the present analysis ($F(1,42)=2.16$; $p=.149$; single contrasts $F(1,42)<3$; ns).

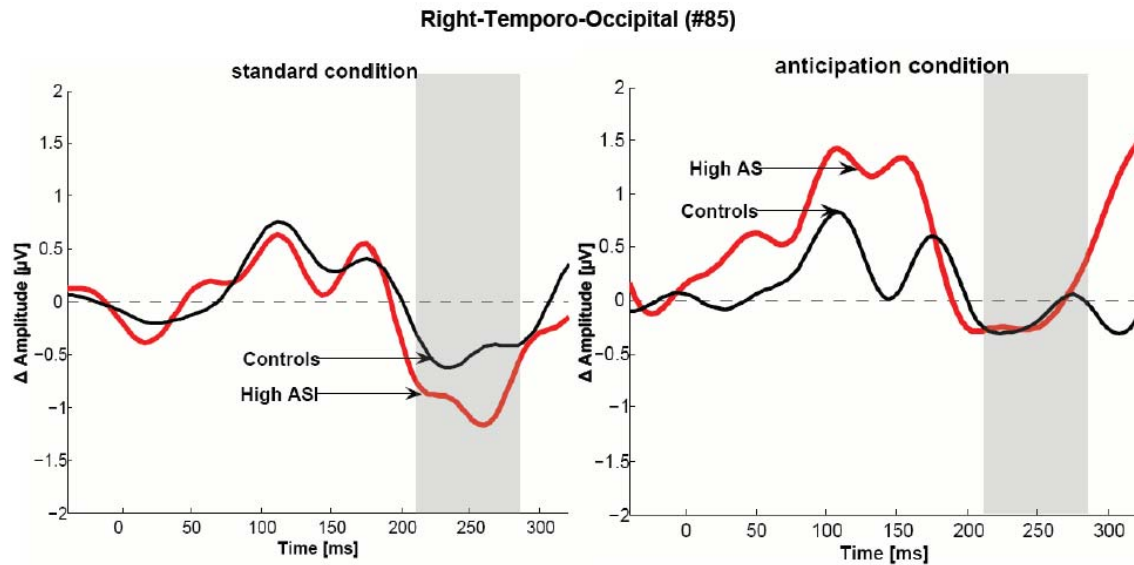


Figure 34. Difference waveforms over a representative temporo-occipital sensor (#85) obtained by subtracting the waveforms elicited by neutral materials from the waveforms evoked by medical emergency pictures during the rapid serial visual presentation plotted for the standard condition (right panel) and the anticipation condition (left panel). The difference waveforms are presented separately for high AS participants and controls. Shaded areas mark the time interval of 220-280 ms, selected for the analysis of the Early Posterior Negativity.

Figure 35 illustrates grand-averaged ERP waveforms pooled from high AS subjects and controls elicited over a representative centro-parietal sensor by standard pictorial materials briefly presented in the standard condition (left panel) and in the anticipation condition (right panel). Replicating previous findings the over-all analysis confirmed that the LPP was modulated by affective relevance of the pictorial material ($F(4,168)=52.502$; $p<.001$; $\epsilon=.855$). Follow-up analyses revealed that mutilation pictures, pictures of attack and pictures of erotic couples elicited greater LPPs than neutral pictures ($F(1,42)>22$; $p<.001$) whereas the LPP elicited by pictures of family and babies was similarly pronounced when compared to neutral pictures ($F(1,42)=2.086$; $p=.156$). Due to the higher arousal values mutilation pictures and pictures of erotic couples elicited greater LPP amplitudes than pictures from low arousing affective categories ($F(1,42)>26$; $ps>.001$). At the same time pictures of erotic couples elicited greater late positive potentials than mutilation pictures ($F(1,42)=8.265$; $p<.01$). The demonstrated affective LPP modulation did not interact with condition, laterality and group ($F(4,168)<1.2$; ns). All picture contents elicited similar LPPs in both experimental conditions ($F(1,42)=.665$; $p=.419$).

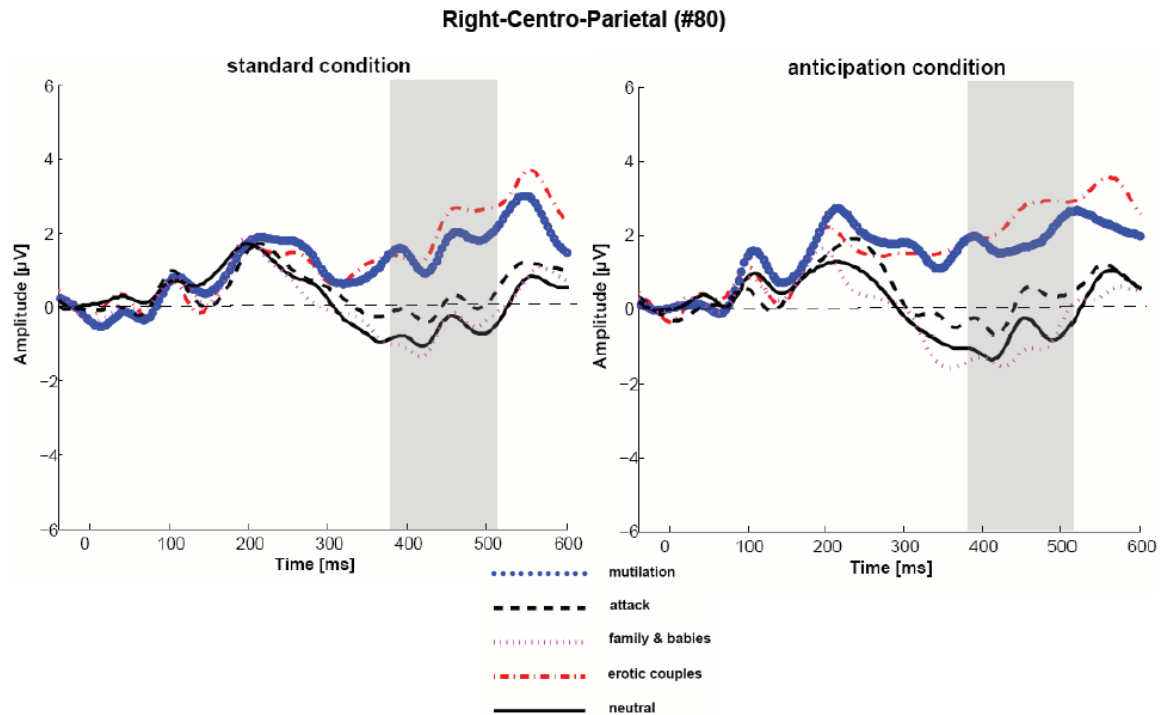


Figure 35. The grand-averaged ERP waveforms elicited over a representative centro-parietal sensor (#80) by standard pictorial materials during their rapid presentation in the standard condition (left panel) and in the anticipation condition (right panel). The data was pooled from both high AS participants and controls. Shaded areas mark the time intervall of 380-520 ms, selected for the analysis of the Early Posterior Negativity.

Further analyses concerned the differences between LPPs elicited by rapidly presented medical emergency pictures and those evoked by rapidly presented neutral contents. Figure 36 illustrates the difference ERP waveforms for a representative centro-parietal sensor (#80) obtained by subtracting the ERP waveforms elicited by neutral materials from those evoked by medical emergency pictures. It can be observed that medical emergency pictures elicited more pronounced LPPs than neutral slides both in the anticipation condition (right panel) and standard condition (left panel) ($F(1,42)=14.086$; $p>.001$). This effect was not affected by group, laterality and condition ($F(1,42)=1.2$; ns). There was no main effect of condition ($F(1,42)=.115$; $p=.736$).

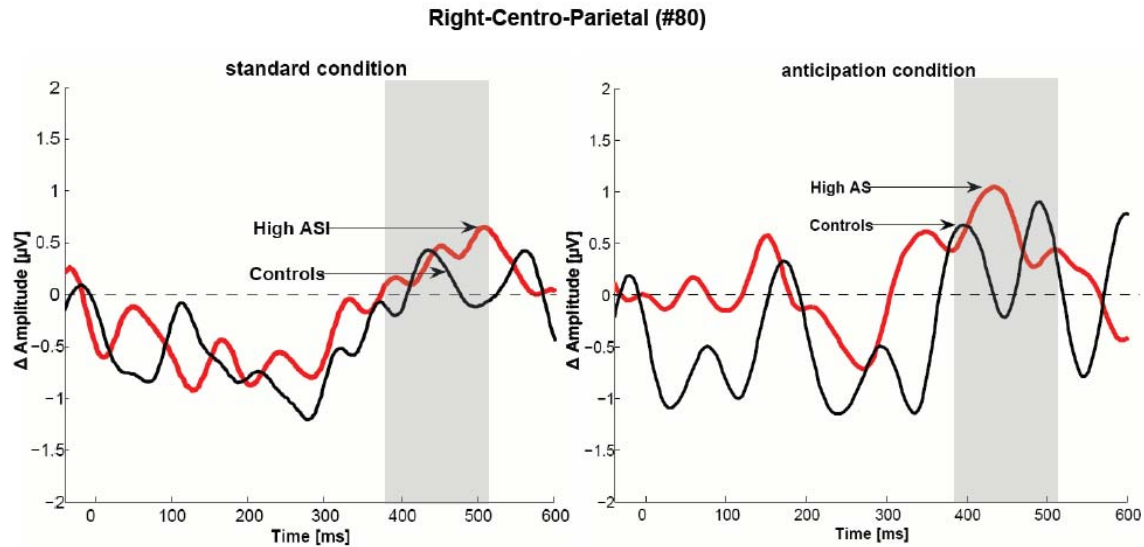


Figure 36. Difference waveforms over a representative centro-parietal sensor (#80) obtained by subtracting the waveforms elicited by neutral materials from the waveforms evoked by medical emergency pictures rapidly presented in the standard condition (right panel) and in the anticipation condition (left panel). The difference waveforms are plotted separately for high AS participants and controls. Shaded areas mark the time interval of 380-520 ms, selected for the analysis of the LPP.

The Estimation of Neural Sources Responsible for the Condition-Related Scalp Potential Difference (Anticipation Condition versus Standard Condition) Observed During the Early Processing (220-280 ms) of Standard Pictorial Materials in High AS Participants and Controls.

An additional analysis concerned the estimation of brain sources (see Chapter 5.1.2 for a detailed characteristic of the method) involved in the condition-related differences in the scalp potential observed during the processing of standard pictorial materials in the time window of 220-280 ms. For these calculations the data from high AS participants and controls were pooled together. As demonstrated in Figure 37 the effect of condition (standard condition vs anticipation condition) observed during the early processing of rapidly presented standard pictorial materials was generated by the occipito-temporal brain regions. This effect was more pronounced over right than left temporo-occipital areas.

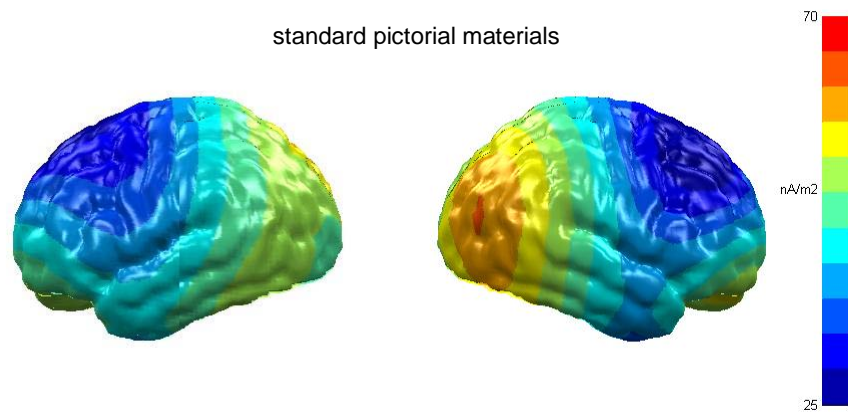


Figure 37. The neural sources responsible for the scalp potential difference observed between standard condition and anticipation condition during the processing of standard pictorial materials in the time interval of 220-280 ms.

5.2.2. Anticipation of Threat and the Sensory Processing in Spider Phobics

Figure 38 illustrates the grand-averaged ERP waveforms elicited over a representative temporo-occipital sensor by standard picture categories during the rapid serial visual presentation viewed by spider phobics under the standard condition (left panel) and the anticipation condition (right panel). As expected, affective picture categories elicited more negative shift than neutral pictures ($F(4,76)=25.027$; $p<.001$); single contrasts ($F_s(1,19)>15$; $ps<.001$). Moreover, high arousing contents (pictures of erotic couples and mutilation pictures) elicited larger temporo-occipital negativity than low arousing materials (pictures of family and babies and pictures of attack) ($F_s(1,19)>10$; $ps<.01$). As for the slow picture presentation, pictures of erotic couples produced larger negative shift than mutilation pictures ($F(1,19)>8$; $p<.01$). Pictures of attack and pictures of family and babies elicited comparable waveforms ($F(1,19)=.033$; $p=.857$). The emotional modulation did not differ as a function of laterality and condition ($F_s(4,76)<.7$; ns). Again, presented in the anticipation condition all picture contents elicited slightly (but not significantly) greater temporo-occipital negativity than during presentation in the standard condition ($F(1,19)=3.348$; $p=.083$).

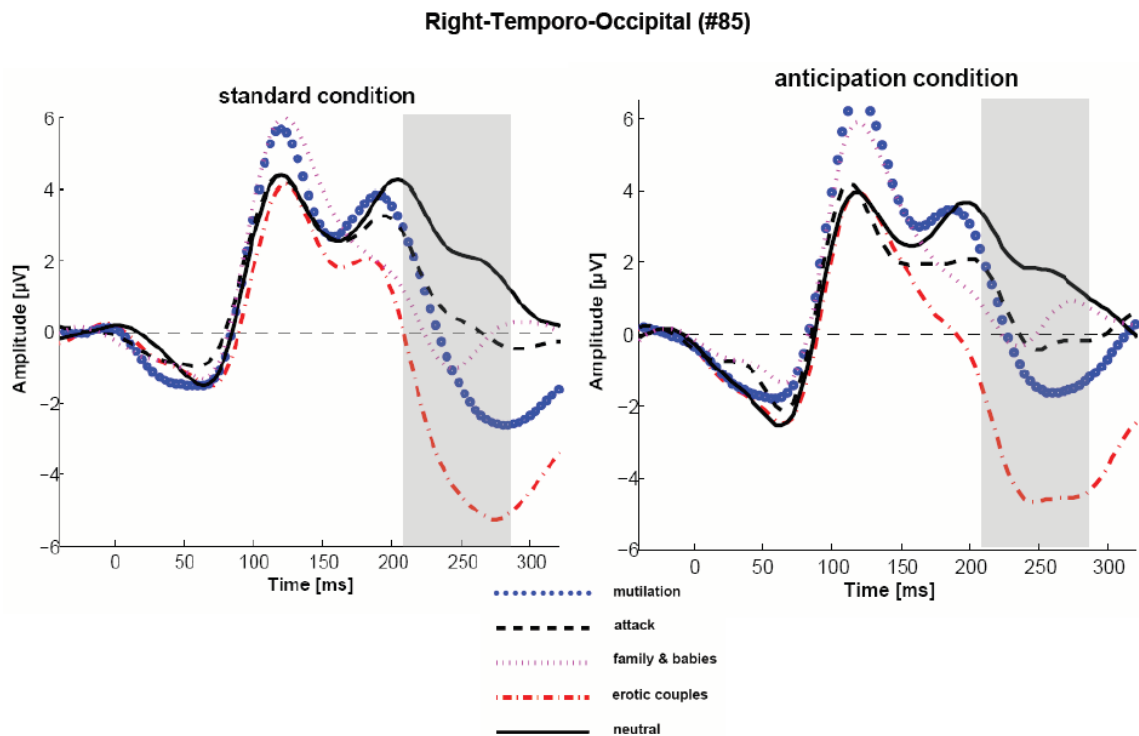


Figure 38. The grand-averaged ERP waveforms elicited over a representative temporo-occipital sensor (#85) by standard pictorial materials presented rapidly to spider phobics in the standard condition (left panel) and the in anticipation condition (right panel). Shaded areas mark the time intervall of 220-280 ms, selected for the analysis of the Early Posterior Negativity.

Figure 39 illustrates the grand-averaged ERP waveforms elicited by spider pictures and neutral materials rapidly presented to spider phobics under the standard condition (left panel) and the anticipation condition (right panel). The statistical analysis revealed that spider pictures elicited more pronounced temporo-occipital negativity than neutral pictures ($F(1,19)=22.127$; $p<.001$). This difference was similar in both experimental conditions ($F(1,19)=.569$; $p=.460$). Although this effect was more pronounced over right than left sensor clusters ($F(1,19)=5.215$; $p=.034$), it was observed both over right ($F(1,19)=28.775$; $p<.001$) and left ($F(1,19)=14.884$; $p<.01$) sensor areas. Again, both picture categories elicited greater temporo-occipital negativity in the anticipation condition than in the standard condition ($F(1,19)=11.446$; $p<.01$).

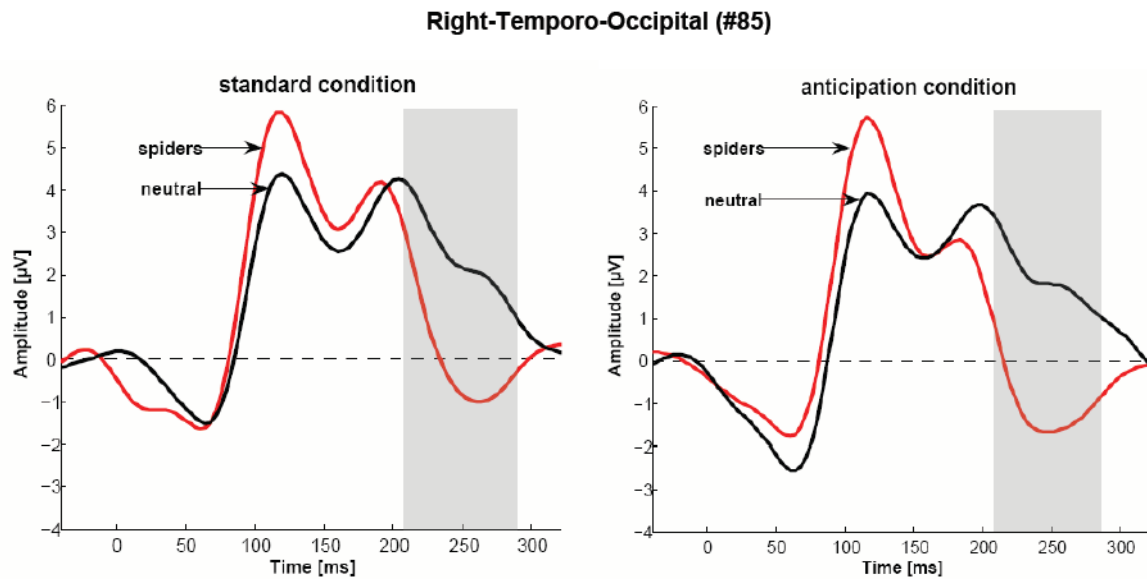


Figure 39. The grand-averaged ERP waveforms elicited over a representative temporo-occipital sensor (#85) by spider pictures and neutral contents presented rapidly to spider phobics in the standard condition (left panel) and in the anticipation condition (right panel). Shaded areas mark the time intervall of 220-280 ms, selected for the analysis of the Early Posterior Negativity.

Figure 40 displays the grand-averaged ERP waveforms elicited over a representative centro-parietal sensor in spider phobics viewing rapidly presented standard pictorial materials under anticipation condition (left panel) and standard condition (right panel). Replicating previous results present the data demonstrated that the LPP was modulated by the emotional relevance of pictorial materials ($F(4,76)=21.152$; $p<.001$). When compared to neutral contents the LPP was more pronounced during the encoding of mutilation pictures, pictures of erotic couples ($F(1,19)>34$; $p<.001$) and pictures of attack ($F(1,19)=6.05$; $p<.05$) but remained comparable with pictures of family and babies ($F(1,19)=3.33$; $p=ns$). Pictures of erotic couples and mutilation pictures elicited similar ERP waveforms ($F(1,19)<1$; $p=ns$). These waveforms were significantly more positive than the waveforms evoked by other affective contents ($F(1,19)>18$; $p<.001$). This pattern of results did not interact with condition ($F(4,76)=2.25$; $p=ns$) and laterality ($F(4,76)=2.67$; $p=ns$).

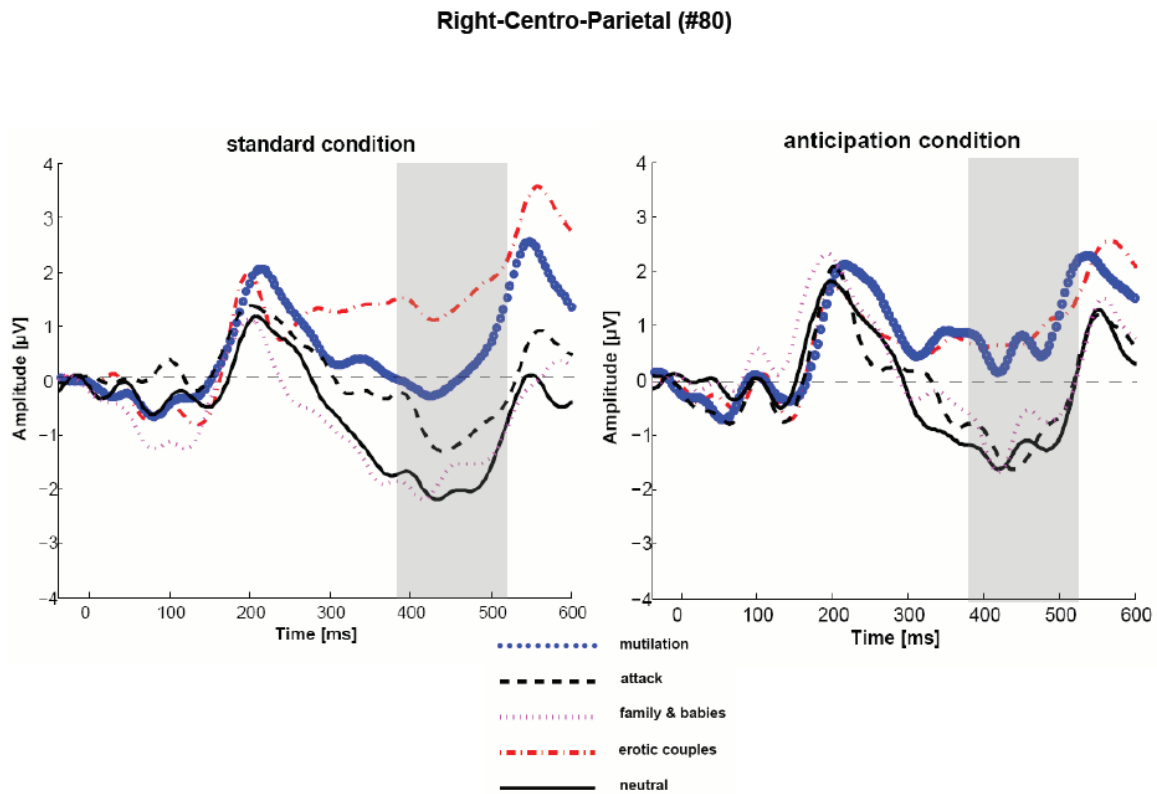


Figure 40. The grand-averaged ERP waveforms elicited over a representative centro-parietal sensor (#80) by standard pictorial materials during their rapid presentation to spider phobics in the standard condition (left panel) and in the anticipation condition (right panel). Shaded areas mark the time interval of 380-520 ms, selected for the analysis of the Early Posterior Negativity.

Figure 41 illustrates the grand-averaged ERP waveforms for a representative centro-parietal sensor evoked by spider pictures and neutral contents rapidly presented to spider phobics under the standard condition (left panel) and the anticipation condition (right panel). As expected, spider pictures elicited more pronounced LPP than neutral pictures ($F(1,19)=24.59$; $p<.001$). This effect did not differ as a function of condition and laterality ($F_s(1,19)<1.2$; $p_s=ns.$). Interestingly, there was a main effect of Condition found in the current analysis ($F(1,19)=8.41$; $p<.01$). That is, for both picture categories LPPs elicited in the anticipation condition were significantly more pronounced than those evoked during the standard condition ($t_s(19)>2.24$; $p_s<.05$).

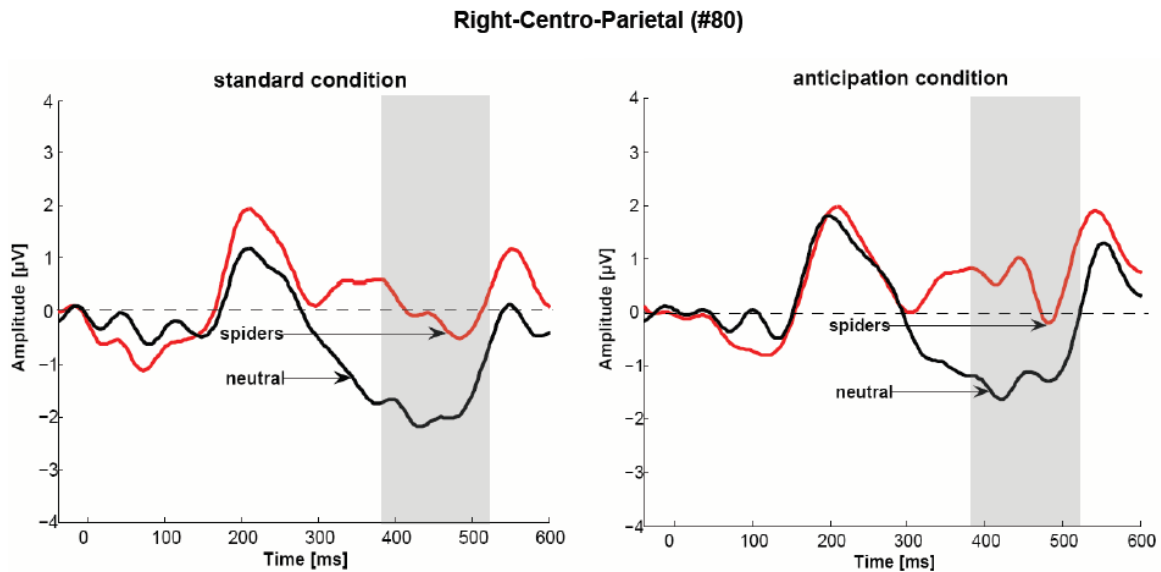


Figure 41. The grand-averaged ERP waveforms elicited over a representative centro-parietal sensor (#80) by spider pictures and neutral contents presented rapidly to spider phobics under the standard condition (left panel) and the anticipation condition (right panel). Shaded areas mark the time interval of 380-520 ms, selected for the analysis of the LPP.

The Estimation of Neural Sources Responsible for the Condition-Related Scalp Potential Difference (Anticipation Condition versus Standard Condition) Observed During the Early Processing (220-280 ms.) of Standard Pictorial Materials in Spider Phobics.

Additional analyses concerned the estimation of brain sources (see Chapter 5.1.2 for a detailed characteristic of the method) involved in the condition-related differences in the early scalp potentials (220-280 ms.) observed during the processing of standard pictorial materials and spider pictures in spider phobics. As demonstrated in Figure 42 the difference in the early processing of rapidly presented standard pictorial materials (top panel) and spider pictures (bottom panel) observed between the anticipation condition and standard condition was generated by the occipito-temporal brain regions. Again, these effects were more pronounced over right than left temporo-occipital areas.

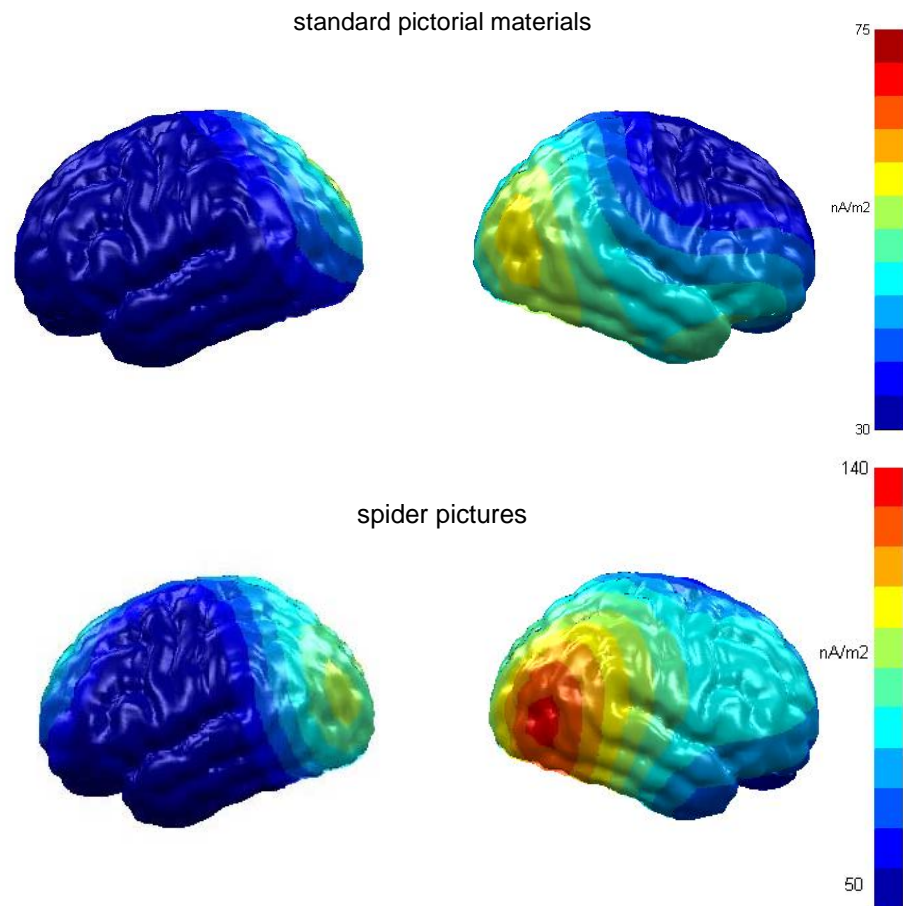


Figure 42. The neural sources responsible for the condition-related difference in the scalp potential (standard condition and anticipation condition) observed during the early processing (220-280 ms) of standard pictorial materials (top panel) and spider pictures (bottom panel) in spider phobics.

The Estimation of Neural Sources Responsible for the Condition-Related Scalp Potential Difference (Anticipation Condition versus Standard Condition) Observed During the Late Processing (380-520 ms) of Spider Pictures and Neutral Contents in Spider Phobics.

Additionally, the estimation of brain sources (see Chapter 5.1.2 for a detailed characteristic of the method) involved in the condition-related differences in scalp potentials observed during the late processing (380-520 ms) of spider pictures and neutral contents in spider phobics was performed. As demonstrated in Figure 43 the changes in the late ERPs observed after the introduction of the anticipation instruction were generated by the occipito-temporal brain regions in case of neutral pictures (left panel) and by the fronto-central brain regions in case of spider pictures (right panel).

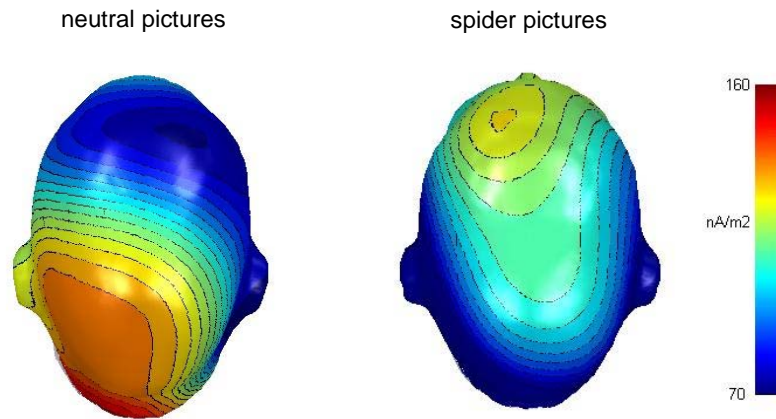


Figure 43. The neural sources responsible for the condition-related difference in the scalp potential (standard condition and anticipation condition) observed during the late processing (380-520 ms) of spider pictures (right panel) and neutral materials (left panel) in spider phobics.

5.3. Subjective Valence and Arousal Ratings

Figure 44 illustrates the valence ratings of standard pictorial materials and concern-relevant contents plotted for spider phobics, high AS subjects and controls. As expected, various valence denotations were assigned to different picture categories ($F(6,420)=505.83$; $p<.001$). When compared to neutral contents pictures of erotic couples as well as pictures of family and babies were judged as more pleasant ($F_s(1,79)>30$; $ps<.001$) whereas pictures of mutilated bodys, pictures of attack and concern-relevant pictures were rated as less pleasant ($F_s(1,79)>230$; $ps<.001$). These effects differed as a function of group ($F(12,420)=10.22$; $p<.001$). Parwise comparisons revealed that the valence ratings of concern-relevant pictures corresponded to participants concerns. Accordingly, high AS participants rated medical emergency pictures as more unpleasant than controls ($t(49)=2.86$; $p<.01$) whereas spider phobics considered spider pictures as more unpleasant than both other experimental groups ($ts>5$; $ps<.001$). The analyses made for standard pictorial materials showed that relative to controls high AS subjects rated mutilation pictures and pictures of attack as more unpleasant ($ts(49)>2.5$; $ps<.05$) whereas spider phobics attributed greater unpleasantness to neutral pictures ($t(46)=2.314$; $p<.05$).

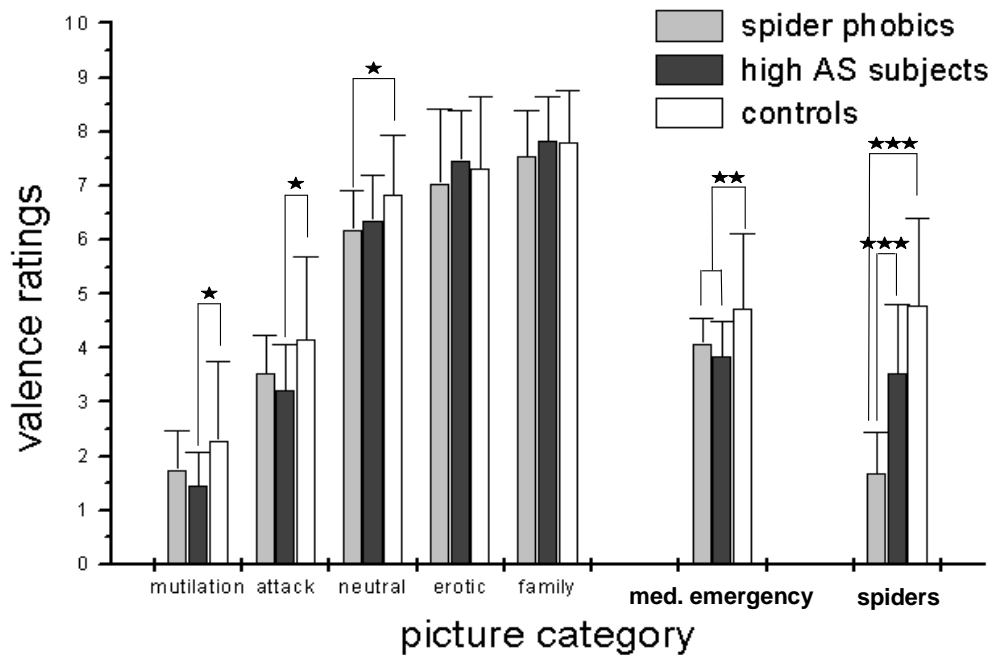


Figure 44. Mean SAM ratings of valence (and standard errors) for standard pictorial materials as well as spider pictures and medical emergency pictures. The data are plotted separately for spider phobics (grey bars), high AS subjects (black bars) and controls (white bars). The levels of significance for group differences are indicated as: * = $p < .05$; ** = $p < .01$; and *** = $p < .001$.

Figure 45 shows the ratings of arousal intensity assigned to standard pictorial materials and concern-relevant pictures by spider phobics, high AS subjects and controls. As expected, various picture categories produced different subjective arousal ($F(6,420)=104.64$; $p < .001$). All emotionally relevant pictures excluding families and babies were rated as significantly more arousing than neutral contents ($F_s(1,79) > 120$; $p_s < .001$). Among these contents, the highest arousal intensity was attached to pictures of mutilated bodies ($M=5.1$; $SD=2.4$) followed by pictures of attack ($M=4.7$; $SD=2.1$), pictures of spiders ($M=4.7$; $SD=2.4$), pictures of erotic couples ($M=4.4$; $SD=2.1$) and panic-relevant materials ($M=4.0$; $SD=1.9$). These effects differed as a function of experimental group ($F(12,420)=7.37$; $p < .001$). Direct group comparisons performed for concern-relevant pictures demonstrated that spider phobics evaluated spider pictures as more arousing than controls ($t(46)=6.44$; $p < .001$) and high AS subjects ($t(45)=2.68$; $p < .05$) whereas high AS participants attributed greater arousal to medical emergency pictures than controls ($t_s(49) > 2$; $p_s < .05$). Further analyses revealed that high AS subjects experienced greater subjective arousal viewing standard affective materials and spider pictures than controls ($t_s(49) > 2$; $p_s < .05$).

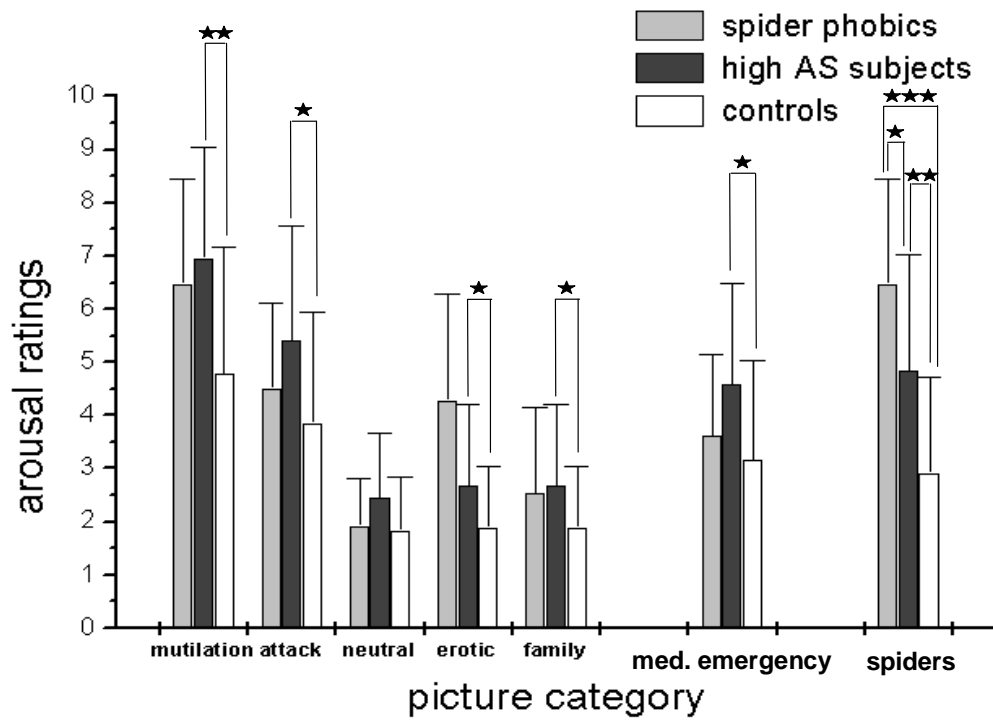


Figure 45. Mean SAM ratings of arousal (and standard errors) for standard pictorial materials as well as spider pictures and medical emergency pictures. The data are plotted separately for spider phobics (grey bars), high AS subjects (black bars) and controls (white bars). The levels of significance for group differences are indicated as: * = $p < .05$; ** = $p < .01$; and *** = $p < .001$.

6. DISCUSSION

The present study analyzed the relationship between the emotional relevance of visual stimuli and the electrocortical activity. To achieve this goal ERPs elicited during passive viewing of standard pleasant, neutral and unpleasant as well as concerns-specific visual materials were measured in spider phobics, high anxiety sensitive subjects and nonfearful controls. It was tested whether the experimental groups differed in the sensory processing of this visual material. By providing a millisecond time resolution of dynamic brain activity, these measures revealed differential effects of selective attention during different processing periods of the emotional cues.

Replicating previous findings the present study showed that the early and late sensory processing of IAPS pictures was modulated by their emotional relevance. Furthermore, fear of spiders was observed to modulate later stages of sensory processing for spider pictures whereas the level of anxiety sensitivity modulated late sensory processing of highly arousing unpleasant materials⁶. Interestingly, these effects were not observed for early processing stages. The only significant group difference observed for early stages of sensory analysis suggests that high level of anxiety sensitivity results in an enhanced automatic attention toward panic-relevant contents⁷. The last important finding of the present study is, that irrespective of experimental group the stimulus material tended to elicit larger EPN amplitudes during the expectation of threat. A detailed presentation of these findings as well as their possible interpretation can be found below.

⁶The findings discussed here originated from the slow picture presentation. Group differences observed during the slow picture presentation were not replicated during the RSVP certainly because, due to the short picture duration, this paradigm allows to observe only very strong LPP effects.

⁷Similarly, this finding originate from the slow picture presentation and was not replicated in the RSVP paradigm. Since pictorial stimuli occurred ten times faster during the RSVP than during the slow picture presentation, it is possible that due to capacity limitations higher task demands inhibited an adequate processing of threatening aspects of incoming information. As demonstrated by Schupp et al. (2007) the high task load interfere with the emotional EPN modulation.

6.1. Sensory Processing of Standard Pictorial Materials

Replicating previous findings (Schupp et al., 2001; 2004b; 2006a), the present study demonstrated an increased negative shift over temporo-occipital brain regions (Early Posterior Negativity) for standard emotionally relevant materials when compared to neutral pictures. This result indicates that the emotional relevance of visual stimuli already modulates very early stages of sensory analysis. Furthermore, similar to previous ERP data, the present study revealed that emotional relevance also modulates later stages of sensory processing, that are considered to be important for stimulus evaluation. As in the previous studies (Cuthbert et al., 2000; Schupp et al., 2000; 2003b; 2004b), this effect was reflected in the amplitude of Late Positive Potentials: pleasant and unpleasant pictorial materials elicited more pronounced Late Positive Potentials over centro-parietal brain areas than neutral contents. Moreover, like in the previous studies (Junghöfer et al., 2001), this effect increased with greater arousal of presented pictures. As expected, the amplitude of LPPs was larger for high arousing contents (pictures of erotic couples and mutilation pictures) than for low arousing materials (pictures of attack and pictures of family and babies). The above described early and late effects of selective attention were observed both, during the long picture presentation as well as in the RSVP paradigm.

6.2. Perceived Arousal and Valence of Pictorial Materials

In accordance with normative valence and arousal ratings of IAPS pictures, ratings collected in the present study from spider phobics, high Anxiety Sensitive subjects and controls showed that pictures of erotic couples as well as pictures of family and babies are commonly judged as pleasant whereas pictures of mutilated bodies, pictures of attack as well as concern-relevant contents are rated as unpleasant. All these materials, excluding pictures of family and babies, were also judged as more arousing than pictures of landscapes, buildings, people and animals that were rated to be relatively neutral in their emotional quality. Furthermore, valence and arousal ratings of concern-relevant material performed by spider phobics and high anxiety sensitive individuals significantly reflected its threatening quality for these individuals and were compatible with their fears as assessed by the Spider Phobia Questionnaire and Anxiety

Sensitivity Index. And so, confirming earlier observations (Hamm and Vaitl, 1993; Miltner, et al., 2005), pictures of spiders were rated as more arousing and more unpleasant in participants with an increased level of spider fear. Similar to the findings obtained by Amrhein (2003), high level of anxiety sensitivity resulted in assessing medical emergency pictures and standard unpleasant material as more arousing and less pleasant. Interestingly, high anxiety sensitive subjects judged standard pleasant contents as more arousing than nonfearful controls.

6.3. Sensory Processing in High Anxiety Sensitive Subjects

6.3.1. Selective Attention to High Arousing Unpleasant Pictures.

Overall, high arousing unpleasant materials evoked significantly larger LPPs from 400 ms to 480 ms after picture onset than neutral pictures. Importantly, this effect of selective attention toward high arousing unpleasant contents was significantly more pronounced for participants with high anxiety sensitivity than for non-fearful controls, both in the within and also in the between group comparison. The analysis of neural sources revealed that the increase of brain activity observed during the processing of high arousing unpleasant pictures in high anxiety sensitive participants originated from neural generators located in the centro-parietal brain regions. Taken together, these findings suggest that a high level of anxiety sensitivity leads to a more elaborated analysis of high arousing unpleasant material. This interpretation is consistent with findings from cognitive psychology which revealed that high anxiety sensitive persons can hardly disengage their attention from threatening contents.

High arousing unpleasant materials evoked a significant relative negative shift in the ERP waveforms over the temporo-occipital areas relative to neutral materials. However, the early encoding of high arousing unpleasant pictures did not differ between groups⁸. The finding that the level of anxiety sensitivity does not modulate the early encoding of high arousing unpleasant material seems to stay in contradiction to the data

⁸These findings originate from individual waveforms analyses as well as conventional ANOVAs calculated for evoked potentials averaged in the time window from 180 to 280 ms over two temporo-occipital sensor clusters: 64,65,66,69,70,71,74,75 in the left hemisphere and 83,84,85,89,90,91,95,96 in the right hemisphere (Picture Category $F(1,43)=69.415$; $p<.001$; Picture Category x Group $F(1,43)=0.206$; ns).

obtained with paradigms of cognitive psychology showing that anxiety sensitivity modulated the processing of subliminally presented threatening contents. However, as already discussed, the effects demonstrated with these paradigms might be generated at the response level and may not reflect sensory processing alone.

6.3.2. Selective Attention to Panic-Relevant Pictures

The present study revealed that panic-relevant medical emergency pictures elicited more pronounced Early Posterior Negativity in the time interval of 176-256 ms after picture onset than neutral contents. More importantly, this early effect of selective attention toward panic-relevant pictures was significantly larger in participants with a high level of anxiety sensitivity than in non-fearful controls. These group differences were identified both in the within and in the between group comparison. Although, the later tests revealed only right hemispheric group differences and lacked to confirm this effect for the left sensor cluster. The analysis of neural sources revealed that the increase of brain activity observed during the processing of panic-relevant pictures in high anxiety sensitive participants originated from neural generators located in the temporo-occipital brain areas. Taken together, these results indicate that a high level of anxiety sensitivity results in a more intensive early processing of panic-relevant contents. These findings do not correspond with the results of an ERP study performed by Amrhein (2003) who did not observe any differences between high and low AS individuals in the early sensory processing of medical emergency pictures. This inconsistency might be explained by methodological differences between the present study and the study by Amrhein. These differences refer to the stimulus material, the duration of picture presentation as well as to the technical equipment.

Moreover, in accordance with the expectations, panic-relevant pictures elicited larger LPPs in the time window of 400-560 ms after picture onset than neutral pictures. Interestingly, high anxiety sensitive participants and controls did not differ in these late periods of sensory processing for panic-relevant pictures indicating that high anxiety sensitive individuals do not spend more attentional resources for evaluation of panic-relevant contents than controls. This finding seems to contradict the results obtained by Amrhein (2003) and Pauli et al. (1997, 2005). Their studies revealed that the fear of anxiety (as assessed in both clinical and nonclinical samples) affects later stages of sensory processing for panic-relevant stimuli (words and pictures). This discrepancy

might have been caused by differences in stimulus materials: apart from panic-relevant contents Amrhein (2003) and Pauli (1997, 2005) utilized relatively neutral stimulus materials whereas the present study also included other emotionally significant contents. Since later stages of sensory processing are considered to be capacity limited, panic-relevant stimuli presented in a context of neutral material might have been able to absorb more attentional resources of high anxiety sensitive participants than those presented in a context of other emotionally significant pictures. In particular, a more intensive processing of high arousing unpleasant material observed in these individuals (see above) might have absorbed their attentional resources that would otherwise be focused on panic-relevant contents.

According to the information processing model proposed by Öhman (1993), stimuli preattentively labelled as dangerous by the “significance evaluation system” engage more processing resources during their conscious analysis. However, Beck and Clark (1997) suggested that the attentional bias toward threat observed in pathological anxiety is rather related to the early sensory processing and might be absent for later (conscious) stages of sensory analysis. Following an initial automatic allocation of attention, anxious individuals might tend to neglect the threat and their reactions to it (Clark, 1988) or direct attention away from threat as a strategy to avoid anxious distress (see Mogg et al. 2004). Such pattern of sensory processing in anxious individuals was observed in several studies. For example, MacLeod and Hagan (1992) observed that high trait-anxious subjects exhibited greater Stroop interference for subliminally presented threat words but this bias was not observed in the unmasked condition. These results were interpreted as a strategic negation of the initial bias of attention. Furthermore, presenting pairs of emotional faces to high and low trait anxious individuals Rohner (2002) demonstrated that after a first fixation at an angry face high trait anxious individuals averted their gaze from it more frequently than persons with low trait anxiety.

In fact, the pattern of sensory analysis for panic-relevant material observed in high anxiety sensitive subjects in the present study seem to partially conform the mechanism proposed by Beck and Clark (1997). And so, relative to nonfearful controls these subjects show an enhanced automatic attention toward panic-relevant pictures but do not direct more attentional resources for conscious analysis of these pictures. Instead, in the course of sensory analysis their mental focus seemed to move away from panic-relevant materials to high arousing unpleasant contents.

In summary, in the present study high anxiety sensitive participants showed an enhanced initial processing of panic-relevant stimuli and subsequently redirected their mental focus toward high arousing unpleasant contents. This finding indicate that despite an increased relevance of panic-relevant material, some attentional mechanism of high anxiety sensitive subjects preclude its further elaborated analysis. Since the sensory analysis executed at the subconscious processing stage is relatively undifferentiated and provides incomplete information (Öhman 1993) it might result in false threat detection and initiate inflexible and non-rational responses. Such model could explain the unpredictability and the uncontrollability of anxiety symptoms occurring in high anxiety sensitive individuals. The findings of the present study suggest that these people might be unable to modify anxious responses by means of a constructive and elaborated processing and may thus play an important role in the maintenance of anxiety. Such attentional avoidance could impede an adequate emotional processing (Rachman, 1980) and interfere with habituation to fear-relevant stimuli (Mogg & Bradley, 1998; Mogg et al. 2004).

6.3.3. Selective Attention to High Arousing Pleasant Pictures

Another goal of the present study was to investigate whether the attentional bias in high anxiety sensitive individuals is specific to emotionally negative stimuli or whether it operates also for emotionally positive materials. As discussed in chapter 3.3, some researchers suggested that anxious people selectively attend to threatening stimuli (threat-relatedness hypothesis) whereas others postulated that anxiety might modulate the sensory processing of all emotional contents independent of their valence connotations (emotionality hypothesis) (Williams et al., 1988).

As expected, in the present study high arousing pleasant materials evoked a significantly larger negative shift in the ERP waveforms over the temporo-occipital areas than neutral materials. Similar effects of selective attention were observed for later stages of sensory analysis - high arousing pleasant contents elicited larger LPP amplitudes than neutral materials. However, high AS individuals and controls did not differ in the early⁹ and late ERP components evoked by high arousing pleasant material.

⁹These findings originate from individual waveforms analyses and conventional ANOVAs calculated for evoked potentials averaged in the time window from 180 to 280 ms over two temporo-occipital sensor clusters: 64,65,66,69,70,71,74,75 in the left hemisphere and 83,84,85,89,90,91,95,96 in the right hemisphere (Picture Category $F(1,43)=191.627$; $p<.001$; Picture Category x Group $F(1,43)= 0.006$; ns).

Demonstrating that high anxiety sensitive individuals and controls differed in the sensory processing for high arousing unpleasant pictures but show similar ERPs for high arousing pleasant materials the present study supports the threat-relatedness hypothesis and discard the emotionality hypothesis.

6.4. Sensory Processing in Spider Phobics

6.4.1. Selective Attention to Phobia-Relevant Stimuli: Late Positive Potentials

Pictures of spiders elicited significantly larger LPP amplitudes from 400 ms to 560 ms after picture onset than neutral pictures. Importantly, this selective attention to phobia-relevant stimuli was significantly larger for participants with specific phobias than for non-fearful controls both in the within and also in the between group comparison, replicating previous ERP-studies (Miltner et al., 2004; Kolassa et al., 2005; Kopp & Altman, 2005). The L2-minimum norm analysis confirmed increased generator strength for participants with specific phobia during processing of phobia-relevant pictures over the centro-parietal brain regions. In a recent study Sabatinelli, Lang, Keil and Bradley (2006) have demonstrated that the increased LPPs evoked by emotional relative to neutral stimuli highly correlated with increased fMRI BOLD signal strength in the secondary visual cortex (parietal and inferior temporal) prompted by the same pictures. Accordingly, fMRI studies that assessed the BOLD signal during processing of phobia relevant cues in animal phobics also found increased signal strength in the secondary visual cortices for this group of participants (Fredrikson et al., 1995; Dilger et al., 2003; Paquette et al., 2003; Sabatinelli et al. 2005). Since, some authors suggested (e.g. Davis & Whalen, 2001; Vuilleumier et al. 2005) that the information about the occurrence of an emotionally relevant stimulus arriving in the visual cortex can originate from the amygdala, an enhanced LPP amplitude observed in our study might reflect the amygdalar input to the visual cortex. Taken together the LPP findings from the present study clearly demonstrate that subjects with specific phobia show facilitated processing of their phobia relevant cues in those networks of the brain that determine the meaning of the feared stimulus. Considered from the perspective of a two stage model of stimulus processing (Chun & Potter, 1995) these enlarged LPP amplitudes to phobia-relevant stimuli in phobics may reflect an enhanced stimulus consolidation in capacity-limited second stage of sensory analysis related to conscious recognition and

elaborated processing (Sergent, Baillet, & Dehaene, 2005; Schupp et al., 2006). This enhanced processing may be connected with the inability of participants with specific phobia to disengage from their feared stimuli (Posner, 1980), since enhanced P3 or LPP amplitudes were observed to be modulated by the explicit attention, i.e. if subjects were instructed to pay attention to one stimulus and ignore the other (Donchin & Coles, 1988; Johnson, 1988; Nieuwenhuis, Aston-Jones, & Cohen, 2005).

6.4.2. Early Selective Detection of Phobia-Relevant Stimuli

In contrast to later processing stages encoding of spider pictures did not result in any group differences during the early processing periods, thus replicating previous ERP data obtained with less electrodes (Miltner et al., 2004; Kolassa et al., 2005). In contrast to these findings, Kopp & Altman (2005) found an early phobia-related ERP modulation during the processing of phobia-relevant pictures. This inconsistency might be generated by methodological differences, such as the variety in stimulus materials used across particular studies. As recently demonstrated by Bradley et al. (2007) Early Posterior Negativity seems to be very sensitive to differences in the figure-ground composition of the visual stimuli. The stimulus materials included in the study by Kopp and Altman (2005) consisted of pictures of spiders, snakes and household objects presented against a simple monochrome background, while spiders used in this study have much more complex figure-ground compositions and thus might have overall increased the EPN in both groups.

This pattern of ERP findings is amazingly consistent with the findings from visual search studies. As demonstrated by Miltner and collaborators (2004), animal phobic participants did not detect spiders more rapidly among non-fearful distractors than non-fearful participants, but phobics showed an increased inability to disengage the attention from spider distractors in order to find a neutral target. The present ERP data supplement these findings. No group differences emerged during early processing of phobia relevant pictures, but clear and robust group differences occurred during later processing periods, during which increased attentional resources are allocated to the feared stimulus for its elaborated processing.

6.5. Is the Selective Attention in Fear and Anxiety Concern-Specific?

Additionally, the present study aimed at investigating whether the effects of selective attention observed in participants with high levels of anxiety and fear would be specific for concern-relevant stimuli as it was observed in studies showing phobia specific defensive response mobilization. The results clearly demonstrate that, although spider phobics and high Anxiety Sensitive individuals showed the attentional bias toward their feared objects, standard pleasant and unpleasant contents also engaged their selective attention. Since high Anxiety Sensitive individuals showed an increased EPN for panic-relevant materials, this effect was even more pronounced for standard pleasant and unpleasant contents. Moreover, spider pictures elicited significantly larger LPPs in spider phobics than neutral pictures but these amplitudes were comparable to those that were evoked by high arousing unpleasant (e.g., pictures of mutilations) or pleasant (e.g., pictures of erotica) pictures in this group. This pattern of results was remarkably comparable to the pattern of findings that was obtained in a recent functional imaging study performed by Sabatinelli et al. (2005). These authors found an increased signal strength in the amygdala and in the inferotemporal cortex during viewing of snake pictures in snake fearful volunteers compared to controls. However, the same increase in activation in both areas was found during the encoding of high arousing pleasant (erotica) and unpleasant (mutilation) pictures.

In summary, present findings demonstrated that although participants with high level of fear and anxiety show an enhanced selective processing of their feared objects, these selective attention effects are not concern-specific but are rather related to the general intensity of the emotional cues. Accordingly, these findings do not support the assumptions formulated in cognitive theories of anxiety that postulate an attentional bias toward threatening stimuli as a vulnerability factor for developing anxiety disorders (Mathews & Mackintosh, 1998; Mogg & Bradley, 1998; Williams, Watts, MacLeod, & Mathews, 1997). While the effects of selective attention observed for phobia-relevant pictures in phobics as well as for high arousing unpleasant and panic-relevant contents in high anxiety sensitive participants support the cognitive hypothesis, it can hardly explain the facilitated processing of the other emotional cues. It is rather more probable that the emotional system automatically drives the cognitive system for elaborated processing of emotional significant cues to facilitate appropriate action (Lang & Davis,

2006). In a consequence, overestimating their emotional value anxious individuals show an enhanced selective processing for their feared materials.

6.6. Selective Attention and Anticipation of Challenge

Another interesting question investigated in the present study was, whether the anticipation of a threatening event influences the pattern of sensory processing. ERP waveforms elicited in the standard condition were compared to those evoked during the anticipation of a threatening event. One of the most apparent findings from this comparison was that the anticipation of a challenge modulated early stages of sensory processing – i.e. pictures presented during the anticipation of a challenge elicited greater temporo-occipital negativity in the time window between 200 and 300 ms after stimulus onset than during the standard condition. This effect was observed to be similar for all experimental groups and for all picture contents apart from medical emergency pictures. The analysis of neural sources revealed that the increase in the EPN observed during the anticipation of a challenge originates from neural generators located in occipito-temporal brain regions. Taken together, the present data indicate that anticipating a challenge generates an increased automatic attention and that this effect is independent on the emotional relevance of visual cues. These results stay in agreement with previous findings obtained by Schupp et al. (2006), who also revealed that a more intensive attending toward pictorial materials resulted in an increased EPN but did not change the pattern of early emotional modulation indexed by this component.

As to the later processing stages, the pattern of emotional modulation observed in the present study during the RSVP was similar to the one known from studies using longer picture durations (Schupp et al. 2003). This pattern did not differ as a function of group when high anxiety sensitive participants and nonfearful controls were compared. Moreover, in these participants the later processing periods did not differ as a function of condition. On the other hand, the analysis revealed that spider pictures and neutral contents elicited larger LPP amplitudes in spider phobics during the anticipation of a threatening event than during the standard condition. No comparable effect was observed for other picture categories. The estimation of neural sources revealed that the increase of LPP observed in spider phobics after the introduction of anticipation instruction originated from occipito-parietal brain regions in case of neutral contents and from frontal brain regions in case of spider pictures. Taken together, the present data indicate that spider phobics anticipating a spider engaged in a more intensive

analysis of spider pictures and neutral contents, as indexed by larger LPP amplitude. It seems to be plausible, that in these participants the anticipation of a confrontation with a spider resulted in an increased activation of a fear system and in a consequence in a more elaborated analysis of fear-relevant visual materials. However, it is not clear why the anticipation of a spider also triggered a more intensive analysis of neutral pictures. It might be hypothesized that, since all other picture categories were rather easy to be categorized as fear-irrelevant, neutral pictures were not univocal enough and were thus elaborated more precisely in order to search for a spider.

In his information processing model Öhman (1993) suggested that a more intensive activation of the fear system caused by a danger expectancy should prime the sensory processing system for an automatic selective attention toward concern-relevant stimuli as well as for their more intensive conscious analysis. As to the automatic selective attention, the pattern of EPN observed in the present study did not support this assumption - although the level of fear and stress in spider phobics and high anxiety sensitive subjects increased during the anticipation of a challenge but did not change in controls¹⁰, these experimental groups did not differ in the EPN elicited by concern-relevant stimuli. As to the later processing stages, the data obtained from spider phobics indicate that an increased danger expectancy results in a more intensive analysis of stimuli that might have signalized a concern-relevant stimulus. However, due to some methodological problems, the results related to the later processing stages should be interpreted carefully. First, as already discussed (see above), due to the short picture duration the RSVP paradigm is not an adequate method for a sufficient exploration of later periods of sensory analysis. Second, because the present experiment did not investigate nonfearful controls when they were anticipating a spider, it is not possible to reason whether the observed effects result from an increased fear intensity or rather because the announcement of a spider triggered an explicit attention toward spiders animating participants to look for these objects. Accordingly, future research has to examine whether the expectancy of danger intensifies the evaluation of concern-relevant cues and whether this effect results from an increased motivational meaning of these stimuli or from an enhanced explicit attention toward them.

¹⁰The manipulation check revealed that the level of fear and stress was significantly greater after the introduction of anticipation instruction than at the beginning of experiment in high anxiety sensitive individuals ($t(8)=2.71$; $p<.05$) and spider phobics ($t(5)=4.48$; $p<.01$). This effect was not observed in nonfearful controls ($t(15)=1.90$; ns).

In summary, the present data revealed that anticipating a challenge results in an increased automatic attention and that this effect is not affected by the level of anxiety and fear. Similarly, this effect was not modulated by the emotional relevance of stimulus materials. Only later processing stages were observed to be modulated by picture content: in spider phobics anticipating a spider resulted in a more intensive encoding of spider pictures and neutral materials.

7. SUMMARY

The primary goal of the present work was to investigate how an increased level of anxiety and fear modulates the visual sensory processing. Previous findings originating from non-fearful individuals clearly showed that the motivational relevance of visual cues modulates attentional mechanisms and that this modulation can be observed already at the very early processing stages. Since subjects with a high level of fear or anxiety assign greater motivational relevance toward concern-relevant stimuli, they are expected to show concern-specific effects of selective attention. Indeed, some research demonstrated that a high level of fear or anxiety modulates the motivated attention toward concern-relevant materials but it is still not clear whether these stimuli affect both early and late processing stages as well as whether anxiety and fear differentially affect the course of sensory analysis. The present study aimed at clarifying the above described uncertainties using dense sensor event-related brain potentials (ERPs) to measure the cortical activity in spider phobic individuals, high Anxiety Sensitive participants and non-fearful controls during viewing of pleasant, unpleasant, neutral, panic-relevant and phobia-relevant pictorial materials.

In the first part of the experiment, the ERPs were collected from participants exposed to the presentation containing 360 randomly ordered pictures that were displayed for 1500 ms each. On the basis of previous findings high Anxiety Sensitive individuals were expected to show the effects of selective attention toward panic-relevant and high arousing unpleasant contents whereas spider phobics were expected to attend selectively toward spider pictures. These hypotheses were supported by the results of the present study. High Anxiety Sensitive participants showed a greater selective attention toward panic-relevant contents at the early periods of sensory processing and a more intensive analysis of high arousing unpleasant materials at the later processing stages related to the conscious stimulus evaluation. Moreover, pictures of spiders elicited significantly larger LPP amplitudes in phobics, indicating a more intensive perceptual analysis of these stimuli. At early stages of sensory processing no difference between phobics and controls in response to spider pictures was found.

In the second part of the study, the participants were exposed twice to a continuous stream of 360 pictures presented for 333 ms each (RSVP). For the first presentation standard instructions were given whereas for the second presentation participants were informed that the picture viewing will be followed by a confrontation

with a threatening event (a hyperventilation test for high AS subjects and controls and a confrontation with a living spider for spider phobics). Since previous data revealed that the anticipation of threat activates the fear system and results in a defensive response mobilization, highly anxious individuals were also expected to show a change in the sensory processing that, according to the information processing model proposed by Öhman (1993), would manifest itself in an increased selective attention toward their feared objects. The results did not supported these assumptions: the anticipation of threat resulted in a more pronounced EPN that tend to be observed for all experimental groups and for all picture contents and most probably indicate an increased vigilance. The effects of increased attention were not content-specific untill the period of conscious stimulus analysis: in spider phobics anticipating a spider resulted in a more elaborated processing of spider pictures and neutral materials.

Moreover, since the present findings indicate that the effects of selective attention are not threat specific but are rather related to the general emotional relevance of visual cues, they did not supported cognitive models of anxiety that consider an attentional bias toward concern-relevant cues as a vulnerability factor for developing anxiety disorders.

8. REFERENCES

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APPENDIX





Contents:

A – Stimulus Materials



















B – Documentation and Questionnaires

C – Instructions

Human and Animal Attack (Numbers from IAPS)

					
1300.jpg	1301.jpg	1525.jpg	1930.jpg	1932.jpg	6190.jpg
					
6200.jpg	6213.jpg	6241.jpg	6244.jpg	6570.jpg	6830.jpg
					
6831.jpg	6836.jpg	6840.jpg	9120.jpg	9160.jpg	9452.jpg

Mutilated Bodies (Numbers from IAPS)

					
3000.jpg	3010.jpg	3015.jpg	3030.jpg	3060.jpg	3062.jpg
					
3063.jpg	3064.jpg	3068.jpg	3071.jpg	3080.jpg	3100.jpg
					
3110.jpg	3120.jpg	3130.jpg	3140.jpg	3150.jpg	3168.jpg





































Family and Babies (Numbers from IAPS)



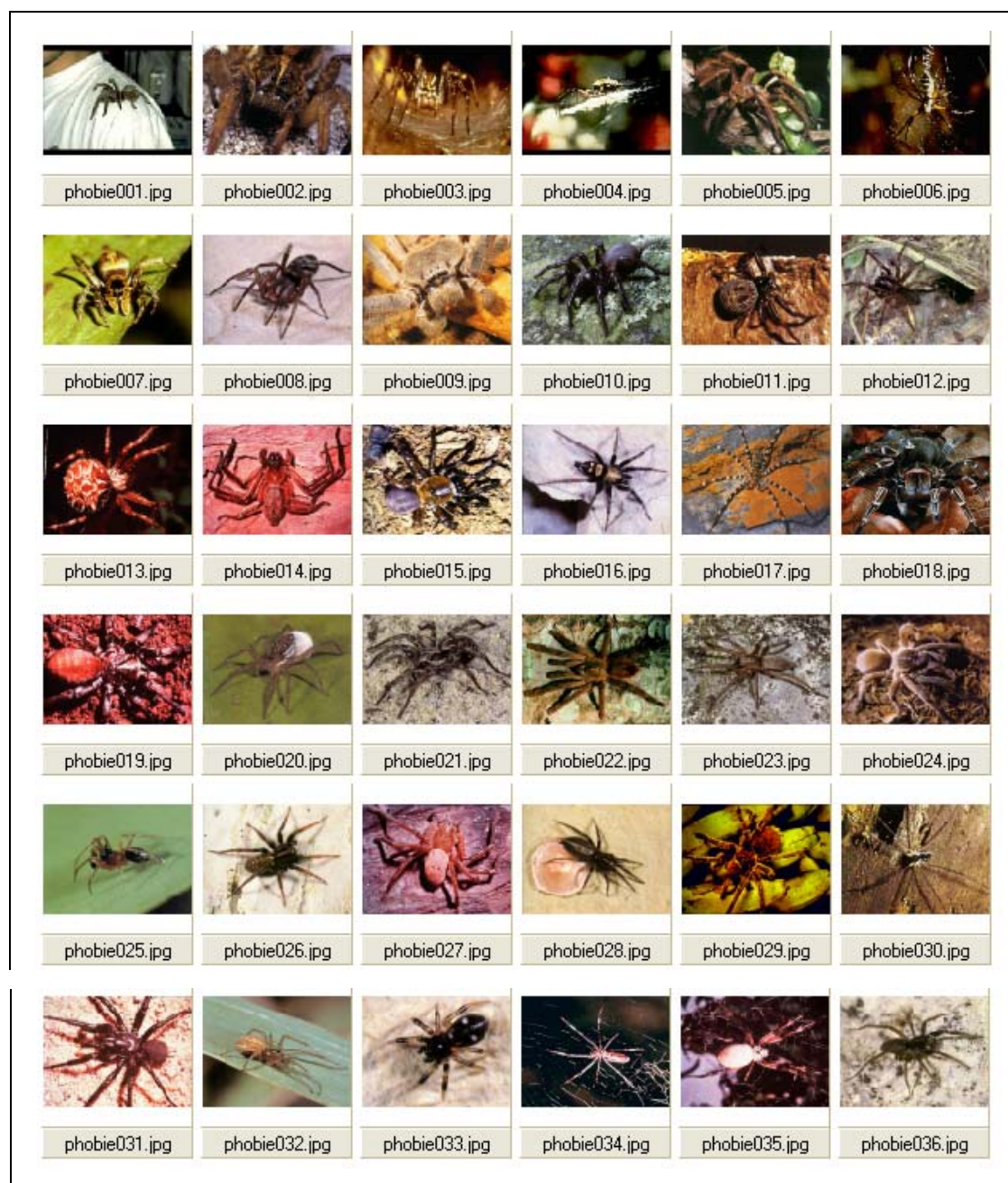
Erotic Couples (Numbers from IAPS)



Neutral (Numbers from IAPS)

					
1333.jpg	1450.jpg	1616.jpg	1661.jpg	1670.jpg	1945.jpg
					
2383.jpg	2485.jpg	2487.jpg	2495.jpg	2518.jpg	2570.jpg
					
2580.jpg	2749.jpg	5390.jpg	5410.jpg	5593.jpg	5635.jpg
					
5661.jpg	5720.jpg	5731.jpg	5740.jpg	5750.jpg	5764.jpg
					
5800.jpg	5875.jpg	5900.jpg	7490.jpg	7491.jpg	7510.jpg
					
7546.jpg	7547.jpg	7550.jpg	7560.jpg	7595.jpg	7700.jpg

Spiders



Medical Emergency



Test



SCREENING INSTRUCTION

Liebe Teilnehmerin, lieber Teilnehmer,

im Rahmen unserer Studien kriegen Sie heute ein Bilderset gezeigt. Wir bitten Sie um Einschätzung dieser Bilder. Anschließend füllen Sie bitte noch den beiliegenden Fragebogen aus. Zu Beginn des Fragebogens finden Sie eine genaue Instruktion zur Durchführung.

Damit wir wissen, wer das jeweilige Ratingset und den Fragebogen ausgefüllt hat, benötigt jeder Teilnehmer ein vertrauliches Kennwort. Um die Anonymität der Teilnehmer zu schützen, bitten wir Sie, Ihr Kennwort nach dem folgenden beschriebenen Muster in die dafür vorgesehenen Kästchen einzutragen:

1. Die ersten 2 Buchstaben des Vornamens Ihrer Mutter (z.B. Monika) ☐ ☐
2. Ihr eigener Geburtstag (nur den Tag, z.B. 14.09.81) ☐ ☐
3. Die ersten 2 Buchstaben des Vornamens Ihres Vaters (z.B. Jochen) ☐ ☐

Des weiteren werden folgende Angaben zu Ihrer Person benötigt:

Alter: _____

Geschlecht: m ☐ w ☐

Neben dem Kennwort können Sie natürlich auch Ihren Namen und/oder Ihre Telefonnummer angeben. Dies würde es uns erheblich erleichtern, Sie gegebenenfalls zu kontaktieren.

Selbstverständlich werden Ihre Angaben vertraulich behandelt.

Name: _____

Telefonnummer: _____

Vielen Dank für Ihre Mitarbeit.

PROCEDURE CHECKUP**Datenblatt KONOR****VPNr.:**Name: _____ Termin:

Versuchsleiter: _____

Händigkeit: links ☐ rechts ☐Einverständniserklärung ☐Elektrodennetz: small ☐ medium ☐ large ☐

Kommentare und Bemerkungen (schlechte Sensoren) während der Untersuchung:

EEG:Gain: ☐ Zero: ☐

Events no:

Konor probe:

Konor random:

Konor movie:

Konor movie-sens:

Presentation:

Konor Probe:

Logfile-Präfix:

Konor Random:

Logfile-Präfix:

Konor Movie:

Logfile-Präfix:

Konor Movie-Sens:

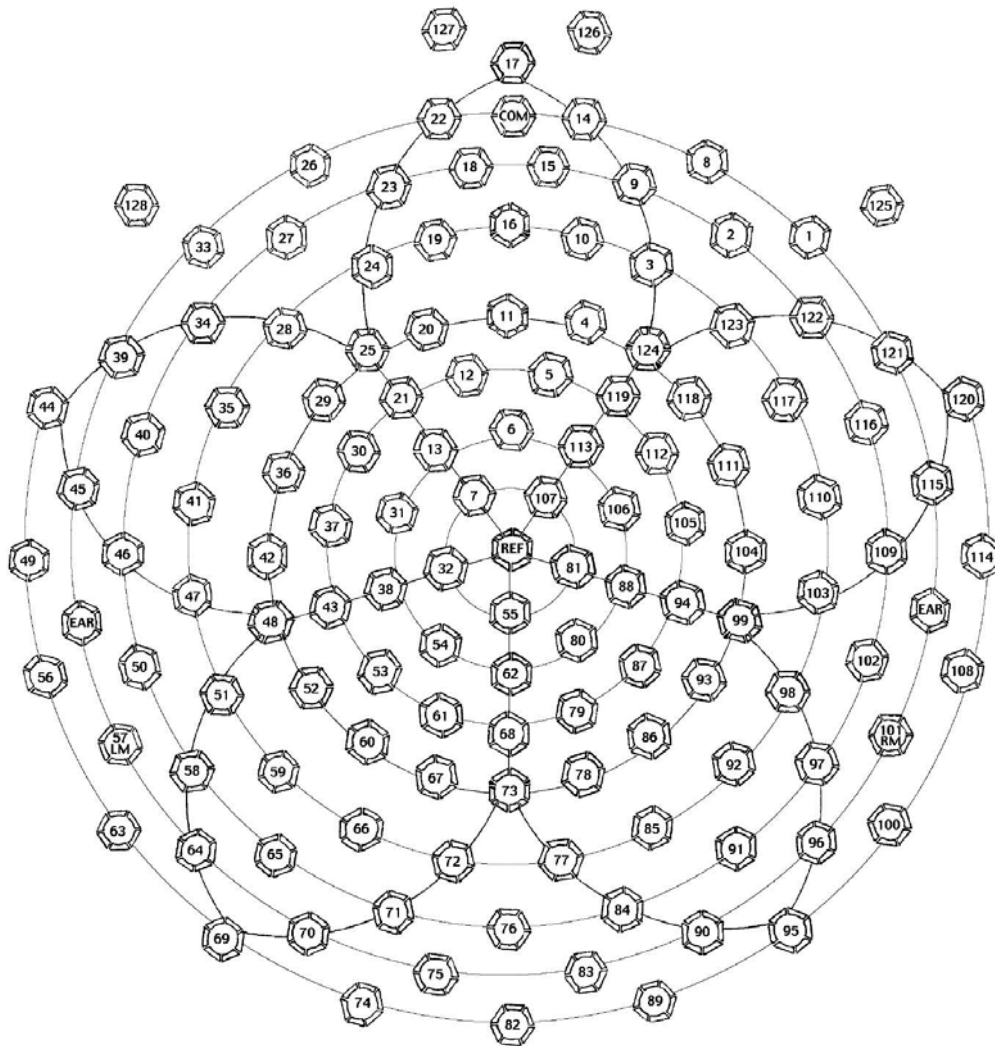
Logfile-Präfix:

Konor SAM Rating:

Logfile-Präfix:

129-CHANNEL GEODESIC SENSOR NET**Geodesic Sensor Net**

128 Channel V2.0



For questions or additional assistance please refer to the Geodesic Sensor Net Manual or contact us at:

Electrical Geodesics, Inc
1850 Millrace Drive, Suite 3
Eugene, Oregon USA 97403
Phone: (541) 687-7962 Fax: (541) 687-7963
Email: info@egi.com or support@egi.com

SPIDER PHOBIA QUESTIONNAIRE

14. Spinnen sind manchmal ganz nützlich..... W F
15. Mich schaudert es bei dem Gedanken an eine Spinne..... W F
16. Es macht mir nichts aus, in der Nähe einer harmlosen Spinne zu sein, wenn jemand bei mir ist, zu dem ich Vertrauen habe..... W F
17. Manche Spinnen sind sehr schön anzusehen..... W F
18. Ich glaube nicht, daß irgendjemand eine Spinne ohne ein bißchen Angst halten kann..... W F
19. Die Art, wie sich Spinnen bewegen, ist widerwärtig..... W F
20. Es würde mir nichts ausmachen, eine tote Spinne mit einem Stock zu berühren..... W F
21. Wenn ich während der Reinigung des Speichers auf eine Spinne treffen würde, würde ich wahrscheinlich weglaufen..... W F
22. Ich habe mehr Angst vor Spinnen als vor allen anderen Tieren..... W F
23. Ich würde nicht nach Mexiko oder Zentralafrika reisen, weil es dort viele Taranteln gibt..... W F
24. Beim Kaufen von Obst bin ich vorsichtig, weil gerade Bananen Spinnen anlocken können..... W F
25. Ich habe keine Angst vor ungiftigen Spinnen..... W F
26. Ich würde bei dem Gedanken, ich müßte mich mit lebenden Spinnen befassen, einen Kurs wie z.B. Biologie nicht belegen..... W F
27. Spinnennetze sind sehr kunstvoll..... W F
28. Ich glaube, daß ich nicht mehr Angst vor Spinnen habe als der Durchschnittsmensch auch..... W F
29. Ich würde eine Geschichte lieber nicht zu Ende lesen, wenn in der Handlung irgendwas über Spinnen zur Sprache käme..... W F
30. Sogar, wenn ich mich für ein sehr wichtiges Treffen verspätet hätte, würde mich der Gedanke an eine Spinne davon abhalten, eine Abkürzung durch eine Unterführung zu nehmen..... W F
31. Ich habe nicht nur Angst vor Spinnen, sondern auch Tausendfüßler und Raupen beunruhigen mich..... W F

SPQ

Dieser Fragebogen besteht aus 30 Aussagen, die Ihre Gefühle gegenüber Spinnen erfassen sollen.

Jede Aussage kann wahr (W) oder falsch (F) sein.

Versuchen Sie, sich zu entscheiden, ob die Aussagen "wahr" oder "falsch" am ehesten Ihre Gefühle repräsentieren. Beziehen Sie sich dabei auf Gedanken oder Ereignisse, die Sie kürzlich erlebt haben.

Kreuzen Sie bitte die zutreffende Antwort an.

Denken Sie daran, daß Ihre Informationen absolut vertraulich behandelt werden.

Arbeiten Sie zügig, ohne lange bei einer Aussage zu verweilen. Wir möchten Ihren ersten Eindruck in diesem Fragebogen erfassen.

Fangen Sie nun an, arbeiten Sie zügig und achten Sie darauf, jede Frage zu beantworten.

1. Ich vermeide es, in öffentliche Parks oder auf Campingplätze zu gehen, weil sich dort Spinnen aufhalten könnten..... W F
2. Ich bekäme es etwas mit der Angst zu tun, wenn ich eine Spielzeugspinne in meiner Hand halten würde..... W F
3. Wenn ich in einem Film sehe, wie eine Spinne auf einer Person herumkrabbelt, wende ich mich ab..... W F
4. Ich schaue mir ungern Bilder von Spinnen in Zeitschriften an..... W F
5. Wenn sich eine Spinne an der Decke über meinem Bett befindet, kann ich solange nicht schlafen, bis sie jemand für mich tötet..... W F
6. Ich erfreue mich daran, Spinnen beim Weben ihrer Netze zu beobachten..... W F
7. Bei dem Gedanken, eine harmlose Spinne zu berühren, bekomme ich fürchterliche Angst..... W F
8. Wenn mir jemand sagt, daß es irgendwo ringsum Spinnen gibt, werde ich nervös und in höchstem Maße angespannt..... W F
9. Ich würde nicht in den Keller gehen, um etwas zu holen, weil ich daran denken würde, daß sich dort Spinnen aufhalten könnten..... W F
10. Ich würde mich unbehaglich fühlen, wenn eine Spinne aus meinem Schuh krabbeln würde, den ich gerade aus dem Schrank geholt hätte..... W F
11. Wenn ich eine Spinne sehe, fühle ich mich angespannt und ruhelos..... W F
12. Ich genieße es, Artikel über Spinnen zu lesen..... W F
13. Mir wird übel, wenn ich eine Spinne sehe..... W F

MUTILATION QUESTIONNAIRE

MQ

Dieser Fragebogen besteht aus 30 Aussagen, die Ihre Gefühle erfassen sollen, die Sie beim Anblick von Wunden oder Verletzungen haben.

Jede Aussage kann wahr (W) oder falsch (F) sein.

Versuchen Sie, sich zu entscheiden, ob die Aussagen "wahr" oder "falsch" am ehesten Ihre Gefühle repräsentieren. Beziehen Sie sich dabei auf Gedanken oder Ereignisse, die Sie kürzlich erlebt haben.

Kreuzen Sie bitte die zutreffende Antwort an.

Denken Sie daran, daß Ihre Informationen absolut vertraulich behandelt werden.

Arbeiten Sie zügig, ohne lange bei einer Aussage zu verweilen. Wir möchten Ihren ersten Eindruck in diesem Fragebogen erfassen.

Fangen Sie nun an, arbeiten Sie zügig und achten Sie darauf, jede Frage zu beantworten.

1. Ich kann nicht den Angelhaken aus einem gefangenen Fisch herausziehen..... W F
2. Ich würde mich etwas ekeln, wenn ich ein präpariertes Gehirn in einer Flasche betrachten würde..... W F
3. Wenn ich im Fernsehen eine schwerverletzte Person sehe, wende ich mich ab..... W F
4. Ich sehe mir nur ungern Bilder von Unfällen oder Verletzungen in Zeitschriften an..... W F
5. Es macht mir nichts aus, im Krankenhaus kranke und verletzte Personen zu sehen..... W F
6. Medizinische Gerüche machen mich angespannt und sind mir unbehaglich..... W F
7. Ich würde nicht auf die Jagd gehen, weil ich den Anblick eines toten Tieres nicht ertragen kann..... W F
8. Es würde mir Angst machen, einem Metzger bei der Arbeit zuzusehen..... W F
9. Der Arzt- oder Krankenpflegeberuf ist für mich sehr attraktiv..... W F
10. Ich würde in Ohnmacht fallen, wenn ich jemanden mit einem verwundeten Auge sehen würde..... W F
11. Es macht mich nervös, Leute zu beobachten, die mit scharfen oder schweren Werkzeugen umgehen..... W F
12. Die Aussicht darauf, eine Spritze zu bekommen oder jemanden dabei zu beobachten, macht mir ganz schön zu schaffen..... W F

13. Mir wird übel oder ich bin einer Ohnmacht nahe, wenn ich Blut sehe..... W F
14. Ich genieße es, Artikel über moderne medizinische Verfahren zu lesen..... W F
15. Verletzungen, Unfälle, Blut usw. beunruhigen mich mehr als irgendwas anderes..... W F
16. Unter keinen Umständen würde ich eine Einladung, als Zuschauer einer chirurgischen Operation beizuwohnen, annehmen..... W F
17. Wenn ich einen Unfall sehe, fühle ich mich angespannt..... W F
18. Es würde mir nichts ausmachen, eine schlimme Schnittwunde zu sehen, so lange sie gereinigt und genäht wäre..... W F
19. Die Benutzung sehr scharfer Messer macht mich nervös..... W F
20. Nicht nur Wunden und Verletzungen bringen mich aus der Fassung, auch der Anblick von Leuten mit amputierten Gliedmaßen oder großen Narben beunruhigt mich..... W F
21. Wenn die entsprechenden Instrumente verfügbar wären, wäre es sehr interessant, die inneren Organe in einem lebendigen Körper in Aktion zu sehen..... W F
22. Der Gedanke, daß mir jemand Blut abnehmen könnte, erschreckt mich..... W F
23. Ich glaube nicht, daß irgendjemand einer Person mit einer blutenden Wunde helfen könnte, ohne zumindest ein bißchen aufgeregt zu sein..... W F
24. Der Gedanke daran, einen chirurgischen Eingriff vor mir zu haben, versetzt mich in Angst und Schrecken..... W F
25. Die Vorstellung, daß ich eines Tages einer schwerverletzten Person in einem Autowrack Erste Hilfe leisten müßte, erschreckt mich..... W F
26. Mich schaudert, wenn ich daran denke, daß ich mich versehentlich schneiden könnte..... W F
27. Der Anblick von geronnenem Blut ist widerlich..... W F
28. Blut und Eiter beunruhigen mich nicht mehr als jede normale Person..... W F
29. Der Anblick einer offenen Wunde erregt bei mir Übelkeit..... W F
30. Ich könnte niemals eine Wunde abtupfen..... W F

ADDITIONAL QUESTIONNAIRES

Abschlussbefragung

V? _____

Alter _____

Sind Sie Rauscher? ☐ ja ☐ nein

Wenn ja, wie viele pro Tag? _____

1. Es gibt Menschen, die grundsätzlich sehr stark auf ihre körperlichen Symptome achten. Diese Personen bemerken z. B. sofort, wenn ihr Herz etwas schneller als normal schlägt oder Muskeln leicht verspannt sind. Wie stark trifft diese Beschreibung auf Sie persönlich zu?

0 - - - - - 1 - - - - - 2 - - - - - 3

trifft überhaupt nicht zu

trifft extrem zu

3. Eine Panikattacke ist eine klar abgrenzbare Episode intensiver Angst und Unbehagens, bei der mindestens 4 der nachfolgend genannten Symptome abrupt auftreten und innerhalb von 10 Minuten einen Höhepunkt erreichen:

1. Herzklopfen, -rasen oder -stolpern
2. Schwitzen
3. Zittern oder Beben
4. Gefühl der Kurzatmigkeit oder Atemnot
5. Erstickengefühle
6. Schmerzen oder Beklemmungsgefühle in der Brust
7. Übelkeit oder Magen-Darm-Beschwerden
8. Schwindel, Benommenheit oder Schwächegefühle
9. Gefühle der Unwirklichkeit oder des Losgelöstseins
10. Angst, die Kontrolle zu verlieren oder verrückt zu werden
11. Todesangst
12. Taubheit oder Kribbeln in den Körperteilen
13. Hitzewallungen oder Kälteschauer

3.1 Hatten Sie schon einmal eine Panikattacke?

☐ nein ☐ ja

3.2 Wenn ja, wie viele? _____

Angaben zur Person

Waren Sie schon Teilnehmer bei einer Studie im EEG-Labor? ☐ ja ☐ nein

Wenn ja, welche Studie(n)? _____

Welche Hand benutzen Sie meist für Alltagsaktivitäten? Die ☐ linke ☐ rechteMit welcher Hand schreiben Sie? Mit der ☐ linken ☐ rechtenHaben Sie früher mit der anderen Hand geschrieben? ☐ ja ☐ neinHaben Sie einen Sehfehler? ☐ ja ☐ nein

Wenn ja:

Sind Sie Brillenträger? ☐ ja ☐ neinTragen Sie Kontaktlinsen? ☐ ja ☐ nein

Sehstörung rechts (Dioptrien): _____

Sehstörung links (Dioptrien): _____

Bemerkungen:

Sind bei Ihnen irgendwelche neurologischen Erkrankungen diagnostiziert worden?

☐ ja ☐ nein

Wenn ja, welche?

(Epilepsie oder Krampferkrankungen als Ausschlusskriterium)

Begrüßung

Die folgende Untersuchung dient der Messung der Gehirnaktivität.

Die gesamte Untersuchung gliedert sich in mehrere Phasen, die ich Ihnen jeweils genau erklären werde. Es ist ganz wichtig, dass Sie wissen, dass die Untersuchung genau so abläuft, wie wir es Ihnen beschreiben. Das heißt, es kommen keine Überraschungen oder unerwarteten Ereignisse in dieser Untersuchung vor. Wenn Sie eine Frage haben, die Sie gerne vor der Untersuchung abgeklärt hätten, beantworte ich diese – soweit möglich – gerne. Eine ausführliche Erklärung über die Ziele dieser Untersuchung erhalten Sie am Ende der gesamten Untersuchung.

Zur Messung Ihrer Gehirnaktivität werde ich ein Netz mit Oberflächen-Sensoren auf Ihren Kopf anbringen. Um das Netz möglichst genau anzupassen werde ich erst einmal Ihren Kopf abmessen. Zur Verbesserung der Leitfähigkeit der Sensoren wird das Netz mit Wasser befeuchtet.

Haben Sie dazu noch Fragen?

Bevor wir beginnen, möchte ich Sie bitten, diese Einverständniserklärung zu lesen und zu unterschreiben.

Einverständniserklärung

Ich erkläre mich hiermit zur Teilnahme an dieser Studie bereit. Ich bin darüber informiert, dass im Rahmen der Untersuchung die Gehirnaktivität durch Oberflächensensoren aufgezeichnet wird. Während der Untersuchung werden Bilder unterschiedlichen Inhalts dargeboten.

Ich wurde darüber informiert, dass ich die Durchführung der Studie jederzeit und ohne Angaben von Gründen abbrechen kann.

Die Anonymisierung der erhobenen Daten wird durch die MitarbeiterInnen der Abteilung Physiologische und Klinische Psychologie/Psychotherapie gewährleistet.

Greifswald, den _____

Unterschrift

Nachnahme in Druckschrift

Instruktion zur langsamen Darbietung

Während der folgenden Untersuchung sind Sie alleine in diesem Raum, wobei ich Sie über eine Kamera zur Sicherheit sehen kann und Sie (falls etwas besonderes sein sollte) mit mir über die Gegensprechanlage Kontakt aufnehmen können.

Auf dem Monitor werden im folgenden verschiedene Bilder präsentiert. Es können sowohl neutrale, negative aber auch positive Bilder erscheinen. Jedes einzelne Bild wird durch ein weißes Kreuz in der Mitte des Bildschirms angekündigt, das Ihnen helfen soll, auf die Mitte zu schauen. Ihre Augen halten Sie bitte auf die Mitte gerichtet, auch wenn in den Pausen zwischen den Bilddarbietungen nur ein schwarzer Bildschirm zu sehen ist. Betrachten Sie bitte die Bilder aufmerksam. Damit die Messung aussagekräftig ist, sitzen Sie bitte entspannt, versuchen Sie sich wenig zu bewegen, nicht auf die Zähne zu beißen und wenig mit den Augen zu blinzeln.

Als Beispiel zeige ich Ihnen noch eine kurze Probepräsentation.

Haben Sie dazu noch Fragen?

Dann werde ich in Kürze den Versuchsdurchgang starten.

Instruktion für „movie“

Nun folgt noch ein weiterer kürzerer Versuchsabschnitt.

Sie bekommen noch mal Bilder in schnellerer Abfolge zu sehen.

Ich bitte Sie wieder:

- die Bilder aufmerksam zu betrachten
- möglichst entspannt zu sitzen und sich wenig zu bewegen
- die Augen auf den Monitor zu richten
- nicht auf die Zähne zu beißen
- und auch möglichst wenig zu blinzeln

Das Experiment wird nur wenige Minuten dauern. Danach werde ich wieder hereinkommen.

Haben Sie noch Fragen?

Instruktion für die Bilddarbietung in der Antizipationsbedingung
(hoch angstensitive Probanden und Kontrollpersonen)

Der folgende Abschnitt der Untersuchung gliedert sich in zwei Phasen.

In der ersten Phase, bekommen Sie wieder Bilder in schnellerer Abfolge dargeboten. Direkt im Anschluss an die Bildpräsentation möchte ich Sie bitten, 3 Minuten lang sehr schnell und tief zu atmen, wie Sie es bereits im vorherigen Experiment in unserem Labor getan haben. Ich werde Ihnen die aufsteigender und absteigender Töne über die Lautsprecher darbieten.

Wie Sie wissen führt schnelles und tiefes Atmen zu körperlichen Symptomen, etwa Schwindel, Benommenheit, einem Gefühl der Kurzatmigkeit oder Atemnot, sowie einem beschleunigtem Herzschlag. Diese Symptome sind ungefährlich und verschwinden, sobald man wieder normal atmet. Es ist sehr wichtig, dass auch wenn bei Ihnen derartige Symptome auftreten sollten, Sie dann bis zum Ende schnell und tief atmen.

Ich bitte Sie wieder:

- die Bilder aufmerksam zu betrachten
- möglichst entspannt zu sitzen und sich wenig zu bewegen
- die Augen auf den Monitor zu richten
- nicht auf die Zähne zu beißen
- und auch möglichst wenig zu blinzeln

Haben Sie noch Fragen?

Instruktion für die Bilddarbietung in der Antizipationsbedingung
(Spinnenphobiker)

Der folgende Abschnitt der Untersuchung gliedert sich in zwei Phasen.

In der ersten Phase, bekommen Sie wieder Bilder in schnellerer Abfolge dargeboten. Direkt im Anschluss an die Bildpräsentation möchte ich Sie bitten sich eine lebende Spinne anzuschauen, die in einem geschlossenen Glasskasten hierher gebracht wird.

Ich bitte Sie wieder:

- die Bilder aufmerksam zu betrachten
- möglichst entspannt zu sitzen und sich wenig zu bewegen
- die Augen auf den Monitor zu richten
- nicht auf die Zähne zu beißen
- und auch möglichst wenig zu blinzeln

Haben Sie noch Fragen?

Instruktion „SAM rating“

In dieser Phase des Experiments geht es um Ihre persönliche Einschätzung der gezeigten Bilder. Hierzu werden die zwei Dimensionen der Valenz und der Erregung verwendet.

Auf dem Bildschirm bekommen Sie einzelne Bilder zu sehen. Diesmal aber betrachten Sie jedes einzelne Bild, solange Sie möchten und drücken dann die „Weiter-Taste“, um die Einschätzung beider Dimensionen abzugeben.

Nachdem Sie die „Weiter-Taste“ gedrückt haben, kommt die Abbildung zur Einstufung der Valenz-Dimension. Sie reicht von „sehr unangenehm, unglücklich, traurig“ (das Männchen mit nach unten zeigenden Mundwinkeln) bis zu „sehr angenehm, glücklich, erfreut“ (das Männchen mit nach oben zeigenden Mundwinkeln). Wählen Sie bitte jeweils eine Ziffer von 1 bis 9 auf der Tastatur.

Wenn Sie eine Ziffer gedrückt haben, erscheint die Abbildung zur Einstufung der Erregung. Sie geht von „sehr ruhig und entspannt“ (Männchen mit geschlossenen Augen) bis zum anderen Extrem – „sehr aufgeregt, stimuliert, rasend, angeregt, erregt“ („explorierendes“ Männchen). Hier wählen Sie bitte wieder eine Ziffer von 1 bis 9.

Wenn Sie die gewählte Ziffer gedrückt haben, wird Ihnen das nächste Bild gezeigt.

Haben Sie dazu noch Fragen?

Ziele der Untersuchung

Es ist bekannt, dass das Wissen um die genauen Hypothesen einer Studie sowohl die Ausprägung der Gehirnaktivität als auch die Bewertung von Sachverhalten verändern kann. Deswegen möchte ich Ihnen erst jetzt ausführlicher die Ziele dieser Studien erklären.

Sie bekamen Bilder von unterschiedlichen Kategorien zu sehen: negative, positive, neutrale, angstrelevante. Die Bilder der verschiedenen Kategorien wecken eine unterschiedliche Gehirnaktivität in dem occipitalen und parietalen Bereich, der an der Verarbeitung visueller Reize beteiligt ist. Wir prüfen die Frage, ob sich das Aktivitätsmuster bei Menschen in Abhängigkeit davon unterscheidet, ob sie viel oder wenig Angst vor Angstsymptomen oder vor Spinnen haben. Die erste Eigenschaft wurde mit dem ASI, dem Angst-Sensitivität-Index und die zweite mit dem SPQ, dem Spinnenphobie Questionnaire, gemessen.

Ich möchte Sie abschließend noch bitten, nicht mit Ihren Mitstudenten über den genauen Ablauf und die Ziele dieser Untersuchung zu sprechen.

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05.1995	Abitur, IV Liceum Ogólnokształcące im. Komisji Edukacji Narodowej in Poznań
10.1995 – 06.2001	Studium der Psychologie an der Adam-Mickiewicz-Universität Poznań
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10.2007	Promotion am 29.10.2007

Eidesstattliche Versicherung

Hiermit erkläre ich, dass die Dissertation von mir selbständig angefertigt wurde und alle von mir genutzten Hilfsmittel angegeben wurden.

Ich erkläre, dass die wörtlichen oder dem Sinne nach anderen Veröffentlichungen entnommenen Stellen von mir kenntlich gemacht wurden.

Datum

Unterschrift