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A comparative DC-EEG study about learned helplessness investigating neural differences and gender differences

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Theoretical Part

1.Introduction

The theory of learned helplessness has been a subject of research for over 30 years, especially in the fields of Clinical Psychology and Experimental Psychology. Learned helplessness is a phenomenon which emerges when individuals experience uncontrollability and subsequently leads to expectations that future events will be uncontrollable as well (Peterson, Maier & Seligman, 1993).The core symptoms of learned helplessness comprise three components: motivational, emotional and cognitive deficits. They include passivity, feelings of anxiety and depression, sadness as well as difficulties in learning that behavioral responses have succeeded (Seligman, 1995). First discovered in animal studies, lots of experiments with humans followed and in turn theories arose that tried to explain learned helplessness and link it with other issues, such as depression, academic failure or poor work performance. Theories of learned helplessness and depression are of peculiar interest in Clinical Psychology, primarily because of the implications for therapy. However, learned helplessness hasn't been studied thoroughly in the field of Cognitive Neuroscience so far. There are only a few studies dealing with this issue and although there is evidence that the anterior cingulate cortex (ACC) plays a role, those findings have to be corroborated by other studies. Most of the studies are electroencephalogram (EEG) studies in which slow cortical potentials (SCPs) were recorded while the feeling of helplessness was induced in healthy subjects. The present study has been conducted in order to check if the recently published findings can be substantiated. Learned helplessness has been induced in 50 healthy subjects by withdrawing control during a cognitive reasoning task. During solving the cognitive tasks, direct-current-EEG (DC-EEG) was recorded and additional questionnaire data was aquired.

The present work will start with an overview about different theories of learned helplessness with an emphasis on the relationship between learned helplessness and depression. Furthermore, gender differences in learned helplessness will be discussed as well as previous data from brain activity measures presented. Subsequently, the present study will be described followed by the results section and finally results will be discussed and interpreted.

2. The concept of learned helplessness

The learned helplessness phenomenon has been discovered first by Overmier and Seligman (1967) when they were conducting dog experiments with an escape-avoidance training,- using painful electric shocks. In these experiments they used a triadic design with three training conditions: no training, training with uncontrollable outcome, and training with controllable outcome. While the no training group received no electrical shocks, the two other groups received 64 electric shocks. However, dogs in the training with controllable outcome group could escape the shocks by pressing a panel, whereas the dogs from the third group could not avoid the shocks at all. The dogs in the two experimental groups were each yoked together, which means, that two dogs of two different groups (control vs. no control) received the same duration, number and pattern of shocks. Twenty-four hours after the training, all dogs had to perform a control task, in which they also received electric shocks, but all had the chance to terminate them by jumping over a barrier during a 10 second tone. The experiments revealed that dogs which were first exposed to uncontrollable shocks (in comparison to those exposed to controllable shocks and those not having any shock experience), did not learn avoidance behavior in the following experiment. Instead they gave up, remained passive and were not trying to avoid the shocks, although they had the chance to do so. Seligman (1972) described this behavior as learned helplessness. Moreover, he not only underlined that this phenomenon also has been shown in several other animal species, such as rats, cats, fish, mice, and men (Seligman, 1972).

One of the first human experiments about learned helplessness was conducted by Hiroto (1974) and included two groups of college students who had been exposed to 50 trials of loud noise and a control group with no exposure to noise. One group could terminate the noise by pressing a button four times (escape group) and the other had no such control over termination, so the noise ceased completely independently of their responses. Like in the animal experiments, both groups received the same amount, duration and pattern of noise. In a following test phase, all groups were exposed to 20 trials of noise and they all could stop it by moving a handle. The results were similar to those of the animal experiments: subjects who had experienced no control over the noise (helplessness training) were less likely to learn to escape the noise than subjects from the two other groups who had experienced control.

Miller, Seligman and Kurlander (1975, p.347) describe the main behavioral characteristics of learned helplessness as follows:

a) deficits in initiating voluntary responses

b) difficulties in learning that responding produces reinforcement

c) during exposure to non-contingent reinforcement subjects learn that reinforcement is independent of voluntary responding.

The behavioral characteristics of learned helplessness are believed to be the result of the subject's tendency to perceive reinforcement as response-independent in new situations where reinforcement is, in fact, response-dependent. Moreover, Seligman (1972) proposed that the expectation of uncontrollable outcome results in a helpless state which is accompanied by three major deficits: cognitive, motivational and emotional deficits.

Seligman (1972) observed that uncontrollable events undermine the motivation to initiate voluntary responses to control future events and can eventually lead to passivity. In animal studies these deficits are reflected in slow escape or avoidance behavior from aversive events. In humans it has been hypothesized that a motivational deficit is manifested in reaction times, e.g. the time it takes to push a button or pull a handle to terminate an aversive event (Mikulincer, 1994). There are several studies which have observed these kind of deficits in animals as well as in humans (e.g. Glass & Singer, 1972; Hiroto & Seligman; 1975; Looney & Cohen, 1972; Maier et al.,1969; Padilla, 1979; as cited in Maier & Seligman, 1976, p.8-9). However, Miller and Norman (1979) criticize that the absolute magnitude of the motivational deficits revealed in learned helplessness studies was relatively small. Besides, there are also studies which show the converse effect, namely a facilitated performance after a helplessness training (Roth & Bootzin, 1974; Roth & Kubal, 1975; Thornton & Jacobs, 1972; as cited in Miller & Norman, 1979, p.94). Difficulties in learning that responses have succeeded, even when responding is actually successful, has been described as one cognitive deficit after helplessness training (Maier & Seligman, 1976). Once subjects actively learn that their reactions and the outcomes are non-contingent, it is very hard for them to recognize or learn that the opposite effect could occur. Generally, motivational and cognitive deficits are very similar and difficult to separate. Hence, Mikulincer (1994) states that performance deficits after helplessness training can have a motivational basis, a cognitive one, or both. The emotional deficits include, as Seligman hypothesized (Miller & Norman, 1979), feelings of anxiety and depression and this assumption has received empirical evidence from several studies (e.g. Gatchel et al., 1975; Griffith,1977; Roth & Kubal,1975; as cited in Miller & Norman, 1979).

It is an interesting and important question whether those deficits transfer to other situations and tasks (generalization) or not:

Maier and Seligman (1976, p.10) believed “that what is learned when the environment is uncontrollable can have consequences for a wide range of behavior“, but this reasoning faces difficulties when it is applied to human learned helplessness. Research on this topic revealed that there are some generalization effects, but most of them included similar training and test tasks, which in turn undermined the validity of the results (Mikulincer, 1994). Moreover, studies with dissimilar test and training phases (e.g. different experimenters, different tasks, different rooms, etc.) were inconclusive (Miller & Norman, 1979). However, other studies found that generalization effects occur under certain situational conditions and among certain groups of subjects. Cohen, Rothbarth and Phillips (1976) for example, observed that subjects with a high external locus of control[1] showed generalized deficits in their performance following a helplessness training across different settings and tasks. To sum up, learned helplessness effects in humans have the potential to generalize, even across dissimilar tasks and situations. However, other mediating factors have also to be mentioned and will be described in the next chapter.

[1] The locus of control refers to the extent to which individuals believe that they can control events that affect them. An external locus of control means that individuals believe that external factors such as their environment or some higher power, controls their decisions and their life.

2.1. Extended and reformulated theories of learned helplessness

2.1.1. The reformulation theory of learned helplessness by Abramson, Seligman and Teasdale (1978)

Abramson et al. (1978, p.49) criticized Seligman's learned helplessness theory in two points. First, they stated that the theory "does not distinguish between cases in which outcomes are uncontrollable for all people and cases in which they are uncontrollable only for some people (universal vs. personal helplessness)" and second, "it does not explain when helplessness is general and when specific, or when chronic and when acute.". The reformulation theory of Abramson and colleagues (1978) is based on a revision of the attribution theory (Weiner 1972, as cited in Abramson et al., 1978, p. 50) and proposes that the attributional process is influencing the effect of learned helplessness. A main assumption of the theory is that when people experience non-contingency, they attribute their helplessness to a cause. Abramson et al. (1978) differentiated the following causes (or attributional styles):

1. internal vs. external attribution

2. global vs. specific attribution

3. stable vs. unstable attribution

The attributional style influences whether expectation of future helplessness will be chronic or acute, broad or narrow, and whether helplessness will lower self-esteem or not.

Abramson et al. (1978) also suggested in their reformulation theory that the affective component of learned helplessness depends on a person's attributional style:

If a specific outcome is highly aversive and attributed to internal causes, the affective component of the learned helplessness effect would be higher. On the other hand, if there is an external attribution of an aversive outcome, this would lead to universal helplessness which – as they hypothesized - is accompanied by a lesser degree of negative affect according to Abramson et al. (1978). The individual attributional style also determines whether learned helplessness which has been experienced in one situation, will transfer or generalize to other situations. Therefore, attributing negative outcomes to global factors will cause helplessness deficits in other situations (similar and dissimilar) while attributing negative outcomes to specific factors will cause helplessness in similar situations as the original situation in which helplessness has been experienced (Alloy, Peterson, Abramson & Seligman, 1984).

2.1.2. The reformulation by Wortman and colleagues

Wortman and Brehm (1975, as cited in Meyer, 2000) reformulated the learned helplessness theory by integrating the reactance theory (Brehm, 1966) and adding a new component.

What brought it about were some human experiments, which in their opinion didn't accord with the predictions of the original helplessness theory. Those studies (Thornton & Jacobs, 1972; Roth & Bootzin, 1974) revealed that subjects who experienced uncontrollability in the phase of training showed an increased performance in the test phase, whereas subjects who had control in the phase of training didn't show any performance differences. Furthermore, Tennen and Eller (1977) found that after a short helplessness training people were rather upset, while people after a long helplessness training felt sad and depressed.

Wortman and Brehm (c.f. Meyer, 2000) explained this discrepancy by suggesting that a small amount of experienced uncontrollability of an event doesn't result immediately in a strong expectancy that this event cannot be controlled in the future. This is why motivational, cognitive and emotional deficits were not observable or only slightly pronounced. Instead, the authors assumed that a small extent of helplessness training causes psychological reactance, as long as the person is expecting to have some control over the event. According to the reactance theory (Miron & Brehm, 2006, p.10) the motivational state of psychological reactance will evolve "if individuals feel that any of their free behaviors, in which they can engage at any moment or in the future, is eliminated or threatened with elimination". Reactance causes individuals to restore their freedom, which can be achieved by enhanced effort to regain control over a situation (Brehm, 1966). Thus, the motivational state of reactance has energizing properties. However, it has to be emphasized that in order to show reactance, an individual must possess freedom at first (or controllability in the context of learned helplessness) initially (Miron & Brehm, 2006).

Even though Wortman and Brehm (cf. Meyer, 2000) postulated enhanced motivation (i.e. reactance), they also emphasized, that a person will become helpless in the course of the helplessness training because eventually he or she won't expect having any control at all. People who expect having control in the beginning, will first show reactance which is subsequently followed by helplessness. The higher a person's expectancy of control, the longer it will take till this person becomes helpless.

Moreover, they claimed, that the intensity of the reactance reaction as well as the intensity of the helplessness consequences doesn't only depend on how strong the expectancy of uncontrollability is, but also on how important the event is for the individual: if an event is trivial and unimportant to a person, the expectancy of uncontrollability won't result in reactance or helplessness deficits depending on its intensity. However, reactance or helplessness will emerge if the personal importance of an event has exceeded a certain threshold (cf. Meyer, 2000).

The reformulation proposed by Wortman and Brehm was empirically supported by several studies (Roth & Kubal, 1975; Tennen & Eller, 1977; Brockner et al. 1983; Thornton & Jacobs, 1972; Roth & Bootzin, 1974). For example, Roth and Kubal (1975) showed that subjects who got a small amount of non-contingent feedback in the phase of training, showed better performance than those subjects who got contingent feedback in the phase of training. Besides they found that subjects who got a high amount of non-contingent feedback and for whom the action results were personally very important, showed the worst performance.

Wortman and Dintzer (1978) criticize the reformulation theory of Abramson and colleagues in several points and suggest some new notions. Mainly, they argued that the implications and the role of attributions made by Abramson et al. (1978) have to be questioned. From their point of view, it is not certain that people use attributional processes to explain their behavior: it could rather be, that they only use attributions in very important situations or that they even give up searching for causes and shy attributions. Besides, authors emphasize that in addition to the attributional styles proposed by Abramson et al. (1978) many other attributional styles are possible (e.g. philosophical or religious rationales). And moreover, other factors than attributions and expectations of control may be responsible for the intensity of experienced uncontrollability, such as anticipation of uncontrollability.

Finally, Wortman and Dintzer claim that after being helpless, individuals experience a problem solving-process, in which they try to cope with the feeling of uncontrollability. Hence, they are proposing three possible phases in the learned helplessness process: reactance, learned helplessness and coping with helplessness, which can be successful or unsuccessful. Mikulincer (1994) strongly emphasizes the coping perspective, too and states that coping responses of individuals mediate between helplessness training and learned helplessness effects.

Among all reformulation theories, Wortman and Dintzer probably provide the most reasonable and empirically well supported model of learned helplessness. Their approach offers plausible explanations for the variability between individuals and between different paradigms used in learned helplessness studies. However, the attributional concept should be taken in account too, when studying learned helplessness. Not every person shows the same reaction after experiencing uncontrollability: some people may not develop symptoms of learned helplessness depending on factors such as the personal importance of the task, coping strategies or their attributional style. The present study considers the diverse effects a helplessness induction can have, assuming that there will be subjects who develop helplessness symptoms and others who will not.

3. Learned helplessness and depression

3.1. The first learned helplessness model of depression described by Seligman

According to the learned helplessness model of depression, depressed patients have difficulties in associating reinforcement with their responses (Miller et al., 1975). Therefore, they experience many situations as uncontrollable which in turn leads to symptoms of depression - like sadness, despair and lack of motivation. Seligman (1995) suggested that learned helplessness and reactive depression are similar disturbances and that human learned helplessness can be considered as a prototypical example of the development of reactive depression. He stated that both phenomena have common etiology, symptoms, course and cure. In his opinion reactive depression as well as learned helplessness is based on the belief that relevant consequences can not be controlled.

3.1.1. Basic rules and assumptions

First of all, Seligman differentiates between an endogenous and a reactive depression, stating that his learned helplessness model mainly accounts for reactive depression (Seligman, 1995). This dichotomization in two different types of depression has been described earlier (e.g. Carney, Roth & Garside, 1965; Kiloh & Garside, 1963) and implies that reactive depression is caused or triggered by any external event such as a sudden death of a close person or unemployment, whereas endogenous depression is a consequence of an unknown or internal process which is not caused by any external event. Endogenous depressions are rather believed to be influenced by hormons or by genetic predisposition (e.g. Aldenhoff, 1997; Seligman, 1995; Winokur, 1973). However, Seligman emphasizes that even though reactive depression is the central figure in his learned helplessness model, he believes that endogenous depression regarded from a psychological point of view, has lots of commonalities with reactive depression. Today, this kind of differentiation is no longer accepted and there is no such classification used in the classification systems such as the ICD-10 (International classification of diseases, World Health Organization). The etiology of depression is more complex and comprises multiple interacting factors such as genetic predisposition, an imbalance in the neurotransmitter system and cognitive factors. It is important to emphasize, that even if a depression is rather caused by biological factors than by external factors, patients cannot be separated on such a basis.

According to Seligman (1995), psychopathological phenomenona in human beings can be elicited and analyzed in a laboratory in the same way as physiological alterations and disturbances. In his opinion, the comparability of two different phenomena can be studied, compared and ensured on four levels (Seligman, 1995, p.76):

1. Behavioral patterns and physiological symptoms

2. Etiology and causation

3. Therapy

4. Prevention

One of Seligman's basic rules (1995, p.76) is that if two different phenomena match in regard to one or two criteria, the model can be tested by searching for other matching criteria, which have been predicted by the model. If such predictions can be verified, the model is underpinned, if not, it becomes less powerful. As already mentioned above, Seligman (1995) suggested a great many of commonalities between reactive depression and learned helplessness, which are going to be presented in the following (cf. Peterson, Maier & Seligman, 1993, p.187):

Symptoms:	Passivity, cognitive deficits, sadness, hostility, anxiety, reduced aggression, sleep loss, norepinephrine and serotonin depletion
Causes:	helpless people have a learned belief that responding is independent of outcomes and depressed people have a generalized belief that responding will be ineffective

Treatments: Time, REM deprivation[2], ECT[3], antidepressants

Prevention: in learned helplessness a possible prevention is immunization, in depression invulnerability factors can be preventive.

On the contrary, Mikulincer (1994) holds that the link between learned helplessness and depression is not absolute and that learned helplessness deficits should not always be seen as a sign of depression. Instead he proposes that those deficits "may sometimes reflect a functional trade-off by which people sacrifice performance in exchange for adaptation and long-term wellbeing" (Mikulincer, 1994, p.269) and that learned helplessness deficits can be signs of psychopathology, but only when the expectancy of not having control leads to avoidance coping.

3.1.2. Review and critique

Seligman's suggestion is mainly based on limited therapeutic findings and research showing that depressed patients and non-depressed controls exposed to a learned helplessness training, exhibited similar cognitive and behavioral reactions (e.g. Klein & Seligman, 1976; Miller & Seligman, 1973; Seligman & Kurlander, 1975; as cited in Miller & Norman, 1979, p.102-103). According to Seligman (1995), the main goal in the therapy of depression is to rebuild the patient's belief that personally important consequences can be controlled. However, the studies supporting Seligman's hypothesis have been criticized in terms of a general lack of relevance for clinical depression (Miller & Norman, 1979), and there were studies, which could not find similarities (e.g. Klein & Seligman, 1976; Miller & Seligman, 1973; Seligman & Kurlander, 1975; as cited in Miller & Norman, 1979, p.102-103).

[2] Deprivation of REM means deprivation of rapid eye movement (REM) sleep, which is a distinctive sleep stage in mammals. REM sleep is critical for memory processing and improvement of learning. (Binder, Hirokawa & Windhorst, 2009)

[3] ECT is short for electroconvulsive therapy

3.2. The attributional helplessness theory and depression

According to Abramson et al. (1978) Seligman's original theory has four deficiencies when it comes to the explanation of depression:

1. The type of the uncontrollable event

Seligman suggests that the expectation of uncontrollability of events is a sufficient cause for depressed affect (Miller et al., 1975; Seligman, 1995), regardless of the type of the event (which can be positive or negative). In contrast Abramson et al. (1978) state that this assumption is implausible, because the expectation of uncontrollability of positive events mostly does not cause depressed affect: "People do not become sad when they receive $1,000 each month from a trust fund, even though the money comes regardless of what they do" (Abramson et al., 1978, p.65). They assume that a negative affect is rather the result of the expectation that something negative or aversive will occur and not the result of uncontrollability itself.

2. Low self-esteem

Abramson criticizes that "a major shortcoming of the old model of depression is, that it does not explain the depressive's low opinion of himself" (Abramson et al.,1978,p.66) and argues that lower self esteem in depressed people depends on whether they attribute their helplessness on internal causes or on universal causes. He states that "depressed individuals who believe their helplessness is personal show lower self-esteem than individuals who believe their helplessness is universal" (Abramson et al., 1978, p.66).

3. Chronicity and generality

Seligman (1995) did not mention anything about the chronicity and generality of depressive symptoms in his learned helplessness model. Learned helplessness induced in the laboratory can sometimes elicit general helplessness that also affects other situations (Hiroto & Seligman, 1975) but it can be limited to only the laboratory situation, too (Cole & Coyne, 1977). Some researchers observed that negative events initiate depressive reactions (Peterson, Maier & Seligman, 1993) while others did not report such a connection (e.g., Brown & Harris, 1978; Lloyd, 1980, as cited in Peterson & Seligman, 1984 p.348). Abramson et al. (1978, p.68) try to resolve this shortcoming by proposing the following postulates: “The generality of the depressive deficits will depend on the globality of the attribution for helplessness, the chronicity of the depression deficits will depend on the stability of the attribution for helplessness.” Consequently, the more an individual attributes uncontrollability to a global cause (e.g. his lack of ability in general), the more situations will be affected by depressive deficits. The more stable an individual attributes a cause, the more chronic these deficits will become.

4. Attributional styles in depressed individuals:

According to Abramson et al. (1978) depressed individuals tend to attribute their own failures to internal factors, especially to lack of ability. Seligman’s original theory does not explain why depressive patients mostly have an internal and global attributional style. Abramson and his colleagues (1978) postulated a characteristic depressive or pessimistic explanatory style which is responsible for the typical attributions depressed individuals have.

Peterson and Seligman (1984) describe the explanatory style as a chronologically relative robust and general trait, which is characterized by a person’s tendency to have very similar explanations (attributing negative events to internal, stable, and global causes) for lots of different events. In the case of negative life events, such as an own failure, those explanations are internal, stable and global (e.g. ‘I am a loser and always will be’). In the case of positive life events, such as prosperity and success , depressed people tend to reduce them to external, specific and variable causes (e.g. ‘I was only lucky this time’). In the literature the explanatory style is also mentioned as depressive, depressogenic or pessimistic explanatory style (cf. Meyer, 2000).

Moreover, Peterson and Seligman (1984) found that the attributional concept is supported by many empirical reports: they analyzed data from different studies (e.g. longitudinal, cross-sectional or laboratory experiments) and revealed that taken together, all lines of research support the attributional reformulation of the learned helplessness model of depression. The explanatory style assumption got support by cross-sectional studies, which showed that a “characteristic way of explaining bad events with internal, stable, and global causes co-occurs with depressive symptoms" (Peterson & Seligman, 1984, p. 369).

3.3. The diathesis-stress-model:

In their attributional model of learned helplessness and depression Abramson and his colleagues (1978) suggested a depressogenic explanatory style which is regarded to be a vulnerability factor for depressive deficits and plays the major role in the model. Due to this assumption, the model has been described as a "diathesis-stress model" of reactive depression (Metalsky, Abramson, Seligman, Semmel & Peterson, 1982) in which the recently specified depressogenic explanatory style is a "diathesis" and negative life events are the "stress".

According to this model, the depressogenic attributional style is a "distal contributory cause of the symptom of hopelessness depression that operates in the presence, but not in the absence, of negative life events"(Abramson, Metalksy & Alloy, 1989), i.e. it is not a sufficient cause for the pathogenesis of a reactive depression. Moreover, Metalsky et al. (1982) emphasize that the depressogenic explanatory style is not a necessary cause for depressive reactions, which can be elicited by many other causes, such as the death of a partner (cf. Meyer, 2000) or norepinephrine depletion (Metalsky et al, 1982).

3.4. The hopelessness theory

About ten years after publishing their reformulation theory of helplessness and depression, Abramson et al. (1989) presented a revision and called it the "hopelessness theory of depression". Abramson, Alloy and Hogan (1997) refer to it as the theoretical "grandchild" of the original learned helplessness theory.

The authors claim that even though their reformulation model (Abramson et al., 1978) resulted in an enormous amount of empirical work on depression (e.g. Swee, Anderson & Bailey, 1986, as cited in Abramson et al., 1989, p.358), it "did not explicitly present a clearly articulated theory of depression" (Abramson et al., 1989, p.358) and moreover, they question the empirical support: some research revealed strong empirical evidence (Peterson &Seligman, 1984), whereas other researchers claim that the theory has only a weak empirical base (Barnett & Gotlib, 1988; Coyne & Gotlib, 1983).

In contrast to the original helplessness theory and to their former reformulation model, the hopelessness model introduces a new major concept which is called “hopelessness” (and not “helplessness” any more) as well as a yet unidentified subtype of depression: the hopelessness depression. Following this theory (Abramson et al., 1989, p.359), hopelessness is ”a proximal sufficient cause of the symptoms of hopelessness depression”. The authors consider the term hopelessness to be comprised of two core elements:

“(a) negative expectations about the occurrence of highly valued outcomes (a negative outcome expectancy) and

(b) expectations of helplessness about changing the likelihood of occurrence of these outcomes (a helplessness expectancy).“ (Abramson et al., 1989, p.359)

Hence, the implication is,- that helplessness is a component of hopelessness, but it is not sufficient to cause hopelessness or depressive reactions.

3.4.1. Determinants of hopelessness

Abramson et al. (1989) suggest a causal chain model (see figure 1) which basically represents a diathesis-stress-model.

The important thing in the causal chain model is that every element or event is a contributory cause leading to the proximal sufficient cause, thus it is neither necessary nor sufficient for the emergence of hopelessness depression reactions. From a diathese-stress-model point of view, the negative life events represent the stress-component, which can lead to hopelessness and depressive affect, but only under certain conditions emphasized by the authors (Abramson et al, 1989, p.360): “people do not always become hopeless and depressed when confronted with negative life events”.

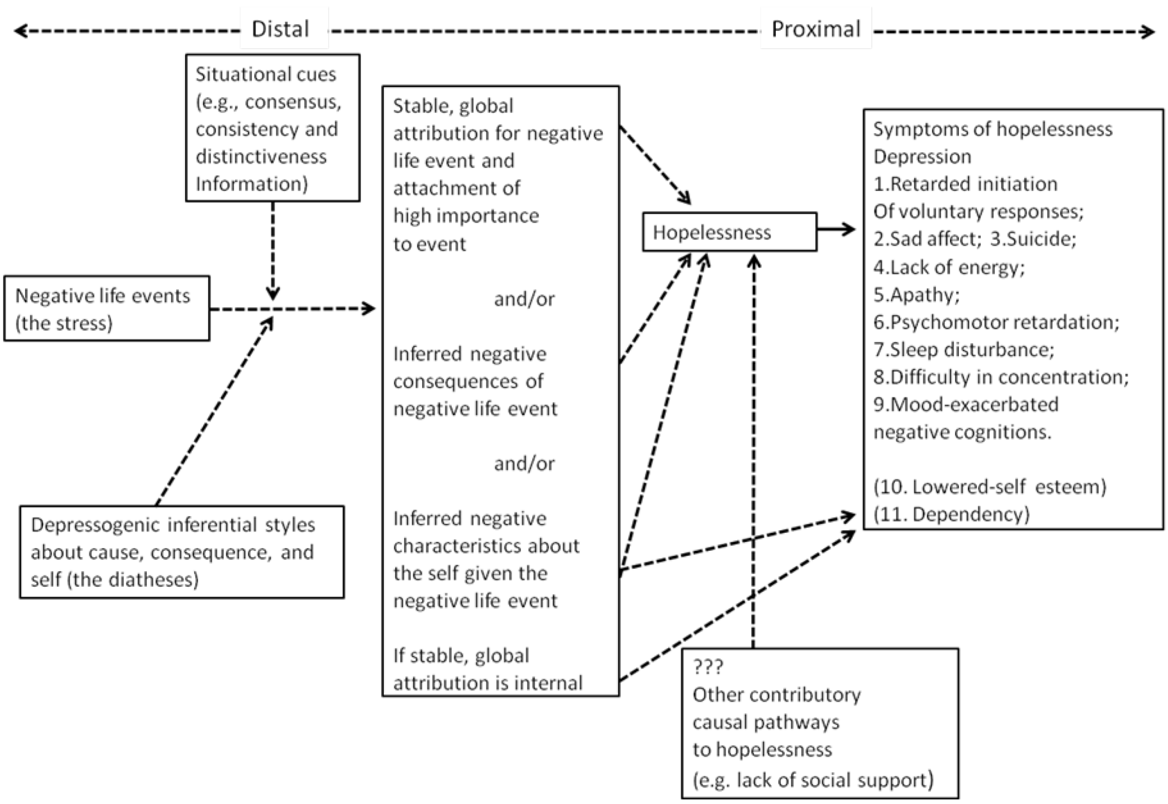

Figure 1. Causal chain specified in the hopelessness theory of depression. (Arrows with solid lines indicate sufficient causes. Arrows with broken lines indicate contributory causes.)

Figure 1 depicts the inferences individuals sometimes make when they face negative life events. The authors differentiate between three types of inferences:

(a) inferences about why the event occurred

(b) inferences about consequences that will result from the occurrence of the event

(c) inferences about the self given that the event occurred " (p.360-361)

Whether a person makes such inferences or not and which kinds of inferences they make, depends on situational cues (Meyer,2000) as well as on the importance they attach to the negative event (Abramson et al., 1989). People who exhibit a depressogenic attributional style are more likely to make global and stable attributions for a particular negative life event and hence they are more likely to become hopeless in comparison to people who do not have a hypothesized depressogenic attributional style (Abramson et al., 1989).

The depressogenic attributional style is the "diathesis-component" as it provides a special vulnerability and the authors refer to it as a "cognitive diathesis". Further cognitive diathesis-components are the inferring of negative consequences of a negative event as well as having negative inferences about the self.

In terms of the relationship between negative life events and cognitive diatheses, Abramson et al. (1989) propose to regard both as continua suggesting a titration model of the diathesis-stress-model (cf. Zubin & Spring, 1977, as cited in Abramson et al. 1989, p.362). According to the titration model, " the less negative a person's cognitive style, the more negative an event needs to be in order to interact with that style and contribute to the formation of symptoms" (Abramson et al., 1989, p.362).

4. Learned helplessness and brain activity measures

Until now there are only a few studies which have investigated the neural correlates of learned helplessness. There is only one neuro-imaging study conducted by Schneider et al. (1996) which used positron emission tomography (PET) and studied learned helplessness by presenting unsolvable anagram tasks. However, most studies involve EEG recordings using either unsolvable reasoning tasks or uncontrollable and inescapable electric shocks. Due to the small amount of neuroscientific helplessness studies, findings from research in emotions and mood induction are going to be discussed as well, especially involving emotions of sadness, as those represent one of the major deficits in learned helplessness.

To begin with, Schneider et al. (1996) measured regional cerebral blood flow (rCBF) in a PET scanner while inducing learned helplessness using unsolvable anagrams, which was the experimental condition. The control condition was composed of the resting baseline and solvable anagram tasks. Learned helplessness increased activity in frontal and temporal regions and it was associated with an increased rCBF to the mamillary bodies and amygdala as well as a decrease in hippocampal activity (Schneider et al., 1996). In contrary, while resting and processing solvable anagrams (control condition) subjects showed an inverted pattern: there was an increase in the rCBF in hippocampal activation and a decrease in mamillary bodies' activation. The authors suggest that there might be a limbic network involved, integrating negative emotion and cognition. Because another PET-study (Heiss, Pawlik, Holthoff, Kessler & Szelies, 1992) observed prefrontal and limbic abnormalities in depression, and due to the fact that learned helplessness is linked to depression, the authors suggested a link between the amygdala model of depression and the learned helplessness paradigm. This leads to the conclusion that "the activation of the amygdala seems related to the negative affect, while deactivation of the hippocampus may relate to passivity and cognitive retardation" (Schneider et al., 1996, p.210).

A few mood induction studies showed similar results: Posse et al. (2003) found that amygdala activation was closely associated with self induced sadness in healthy subjects and Schneider et al., (1997) reported enhanced left amygdala activation during sadness. Research with depressed patients seems to affirm this hypothesis, as patients showed enhanced amygdala activation in comparison to controls during rest (Drevets et al., 1992) as well as during processing different tasks, involving sad facial expressions (Fu et al 2004; Sheline et al 2001), emotional scenes (Anand et al 2005) and masked negative stimuli (Suslow et al., 2010).

Those findings get further empirical support by Wang, LaBar and McCarthy (2006), whose study revealed increased amygdala activation in healthy adults to sad distractors after presenting sad movies relative to happy movies. Besides, other structures such as the anterior cingulate cortex (ACC), the insula and the ventromedial and orbitofrontal cortex also showed enhanced responses to sad distractors during sad mood induction.

However, the authors emphasize (Wang et al., 2006) that although the amygdala is a key brain region for fear perception and memory, its role in processing other emotions still needs to be studied and to be debated, arguing that other mood induction studies showed variable results (Aalto et al 2002; George et al., 1996; Lévesque et al., 2003; Liotti et al., 2000, as cited in Wang et al., 2006). They claim that the type of cues (internal versus external cues) in mood induction as well as gender effects may be responsible for this variability. Gender differences in processing of emotions are reported by Hofer et al. (2006, 2007), who found significant differences between female and male participants in the regional cerebral activity during processing negative and positive emotions. During positive mood induction, Hofer et al. (2006) reported increased activity in the right posterior cingulate, the left putamen and the left cerebellum for female participants and during negative mood induction females showed increased activity (compared to men) in bilateral temporal gyri and cerebellar vermis.

Besides the amygdala, there are many other brain structures which play a role in mood induction, sadness and depression, of which the most important are presented in the following:

According to the meta-analysis by Vytal and Hamann (2010, p.2870) "the most prominent clusters associated with sadness are located in left caudate head and left medFG[4] (BA 9) and right IFG[5] (BA 9)". Moreover, they state that the ACC is uniquely associated with sadness and happiness respectively. In the mood induction study conducted by Baker, Frith and Dolan (1997), depressed mood in healthy subjects was specifically associated with an attenuation of ACC activation, which could be explained as a reflection of the characteristic motivational impairment of depressed mood. Another neuro-imaging study revealed similar results (Bench et al., 1993) as well as an EEG-study (Bauer et al., 2003), using neuroanatomical source localization (Loreta) but those will be discussed later. Correspondingly, a neuro-imaging study (Drevets & Savitz, 2008) showed that the mean gray matter volume of the subgenual ACC (sgACC) was abnormally reduced in depressed patients (subjects with major depressive disorder and subjects with bipolar disorder). These results are strengthened by postmortem anatomical findings from depressed subjects, which show reduction in gray matter volume that is interestingly associated with a decrease in glia and no equivalent loss of neurons (Drevets & Savitz, 2008).

The anterior cingulate cortex (ACC):

The ACC is a brain region that lies ventral, rostral and dorsal to the corpus callosum and has a considerable number of projections into motor systems (Devinsky,Morell & Vogt, 1995), which can be understood as one of the three subdivisions of the "functionally heterogeneous ACC " (Baker et al., 1997). The other components are the affective and the cognitive subdivision. The affective subdivision consists of the most ventral ACC, including Brodman area (BA) 25, 33, and rostral areas 32 and 24 (Baker et al., 1997) It is connected to the amygdala as well as to the periaqueductal grey and it has projections to autonomic

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[4] medFG: medial frontal gyrus

[5] IFG: inferior frontal gyrus

brainstem motor nuclei (Devinsky et al., 1995; Vogt, 2005). The affective subdivision regulates autonomic and endocrine functions and furthermore "it is involved in conditioned emotional learning, vocalizations associated with expressing internal states, assessments of motivational content and assigning emotional valence to internal and external stimuli, and maternal-infant interactions" (Devinsky et al., 1995, p. 279). The third subdivision, the cognitive component, comprises caudal areas 24 and 32, the cingulate motor areas and the nociceptive cortex. The cognitive subdivision is associated with response selection and with skeletomotor activity as well as responses to noxious stimuli. Cytoarchitecturally the ACC can be divided in to a subgenual (sACC) and a pregenual (pACC) part (Vogt, 2005). While the subgenual ACC is believed to store negatively valenced memories and shows activation during sad events, the pregenual part of the ACC is activated during the experience of happy emotions (Vogt, 2005).

In total, the ACC plays a role in emotion and motor functions and it seems to be crucially involved in initiation, motivation, and goal-directed behaviors (Devinsky et al., 1995).

Supporting evidence derives from patients with lesions in the ACC: those lesions involve "diminished motivation, lethargy, loss of interest in reading and sports, and decreased affective range" (Devinsky et al., 1995, p. 298) which are main symptoms of depression as well as partially of learned helplessness.

Besides, subjects with depressed mood showed a decrease in activation in rostral medial prefrontal cortex (Baker et al., 1997) and rCBF increases in the lateral orbitofrontal cortex were associated with both depressed and happy mood relative to the neutral mood condition, which is –as the authors argue - critical for the experience of emotions.

EEG studies:

So far there are four EEG-studies which investigated the phenomenon of learned helplessness, using different approaches. Two of them (Bauer et al., 2003; Fretska et al., 1999) conducted SCP studies using cognitive reasoning tasks (numerical series) in which they induced learned helplessness by withdrawing control. Both studies used the same design: first the tasks were solvable in order to induce control, then some unsolvable tasks were presented and in the last part, subjects had to solve only unsolvable numerical series, with the purpose to withdraw control and to induce learned helplessness.

SCPs are positive or negative changes in cortical polarization of the electroencephalogram, that last from 300 ms up to several seconds and their amplitude on the scalp ranges from several microvolts (e.g. during cognitive tasks) up to 100 µV (during seizures) and will be discussed more precisely in the next section.

Fretska et al. (1999) observed positive going DC-shifts during withdrawal of control (except for the very frontal sites) and positive DC-shifts which were correlated with strong negative emotions. As it follows from the traditional interpretation of SCP changes, positive-going changes equate with reduction of cortical activation, which is in accordance with the fact, that learned helplessness is associated with passivity and feelings of depression, therefore an activity decrease is reasonable.

A similar study (Bauer et al., 2003) revealed significant differences between highly emotional reactive subjects and lowly emotional reactive subjects, showing, that only emotionally high reactive people had significantly different slow cortical potential shifts. These shifts were found in occipital and parietal regions and extended to frontal regions as the task-outcome became more uncontrollable and the subjects became more helpless. Additionally, high emotionally reactive people had more electrically negative activity at fronto-polar sites during withdrawal of control. Neuroanatomical source localization with low resolution electromagnetic tomography (LORETA; Pascual-Marqui, 2002) identified a significant decrease in activity of the ACC in BA 24 during withdrawal of control, but only in the high emotionally reactive group. The authors suggested, that one of the functions of the ACC (namely monitoring the conflicts among brain regions) is no longer maintained when people get helpless possibly due to inhibitory activity of the amygdala.

More importantly, the study conducted by Fretska et al. (1999) revealed, that only female participants - except one male participant - were highly emotionally reactive. Emotionally high reactive subjects showed higher demotivation scores and it seemed that they became more helpless than low emotionally reactive subjects, which would be consistent with the findings of Bauer, Pripfl, Lamm, Prainsack and Taylor (2003), who report significant differences in SCP shifts for the emotionally high reactive group only as well as a significant decrease in activity of the ACC for that particular group only. Those results indicate that gender has an influence on learned helplessness which is perceivable in neuronal activity. Gender differences will be discussed more thoroughly in the next chapter.

Other researchers (Diener, Struve, Balz, Kuehner & Flor, 2009; Diener, Kuehner & Flor, 2010) studied learned helplessness in association with the postimperative negative variation (PINV) using uncontrollable electric shocks. The PINV is a slow negative variation in the EEG following imperative stimuli in a signaled fore-period-reaction time task and has been described as a suitable indicator of information processing during lack of control over aversive events (Rockstroh, Elbert, Canavan, Lutzenberger & Birbaumer, 1989). However, other studies discovered, that a PINV indicated rather stimulus ambiguity than helplessness (Elbert et al.,1982; Kathmann et al., 1990; Klein et al., 1993; as cited in Fretska et al., 1999). Conducting a standardized low resolution electromagnetic tomography analysis (sLORETA; Pascual-Marqui, 2002), Diener et al. (2010) found a link between activation of the ACC and PINV generation, however their results which showed a significant activity increase of the ACC during withdrawal of control, are inconsistent with the findings reported by Bauer et al. (2003). It is also worth mentioning that Schneider et al. (1996) did not find any significant activation differences in the ACC. In regard to gender differences, Diener et al. (2010) did not find any differences between male and female participants, neither on the behavioral, subjective or cortical level.

5. Gender differences in learned helplessness

Although the great majority of learned helplessness studies didn't investigate gender differences, there are some studies concerning this issue and the results are mixed:

On one hand, there is research suggesting that female subjects become rather helpless than male subjects and that there are significant differences in their attributional style, which also contributes to the learned helplessness effect. Studies with children (Dweck et al. 1976, Erkut 1983, Stipeck 1984; as cited in Mikulincer, 1994, p.133) revealed that girls, as opposed to boys, are more likely to make stable attributions for failure and to expect less success/control for a new task after a helplessness-training. Dweck and Reppucci (1973) reported that boys attributed outcomes to the amount of effort more often than girls, and attributions to effort resulted in significantly smaller performance deficits.

In another study (Dweck & Bush, 1976) fifth-grade female and male children have been exposed to non-contingent failure from both an adult and a peer evaluator. Negative feedback from adults led to an impaired performance for girls but to an improved performance for boys. A different pattern occurred when a peer evaluator was used: girls improved their performance significantly whereas boys showed no improvement. Similar effects have been reported for children's attributions, which varied with the type of the evaluator. With an adult evaluator giving failure feedback, boys attributed failure to the amount of effort and girls attributed it to their performance. Most likely, boys were more concerned with the opinions of their peers while girls attached more importance to the opinion of adults.

A study conducted by Dweck and Licht (1980, as cited in Peterson & Seligman, 1984) revealed that after presenting unsolvable problems to fourth-grade pupils, girls were more susceptible to helplessness than boys. However, they also found that teachers criticized boys with rather unstable and specific explanations while girls got criticized with internal, stable and global explanations of their failure. Thus the authors (Dweck & Licht, 1980, as cited in Peterson & Seligman, 1984) claim that the pessimistic explanatory style of the girls (in comparison to the boys) may come from learning their teachers' criticisms which is in accord with the opinion of Radloff (1975), that the higher rate of depressive symptoms in women may originate from their childhood when they learned a negative explanatory style which in turn made them vulnerable to depression.

Although this opinion gets empirical support by other studies with adolescents, which suggest inferential styles as moderators of the relationship between negative events and depressive reactions in girls and boys (Abela, 2001; Abela & McGirr, 2007), other studies revealed an inverse pattern (Hankin et al., 2001; Morris et al., 2008; as cited in Stone, Gibb & Coles, 2010) or even no significant effects in adolescents (Abela, 2002; Hankin, 2008; as cited in Stone et al., 2010). The mediation model however did not get any empirical support in the study done by Stone et al. (2010), which did not find any significant sex differences in the inferential styles of young men and women, although they did find sex differences in depressive symptoms, which is not surprising as women are more vulnerable to depression (Stone et al., 2010; Valas, 2001) and research often shows that depression is twice as common among women as among men (Panayiotou & Papageorgiou, 2007)

This important fact leads to a hypothesis regarding the construct of hopelessness (Abramson et al.,1989): as women have a vulnerability to depression that is significantly higher than those of men (e.g. Nolen-Hoeksma, 1987; Nolen-Hoeksma, 2002; as cited in Stone et al., 2010; Valas, 2001), and hopelessness is regarded to be one of the factors that contribute to depression (Beck et al., 1962; Beck et al., 1974; Ellis, 1962; as cited in Rubinstein, 2004), gender differences in hopelessness can be expected. Rubinstein (2004) conducted a study with bereaved parents and non-bereaved parents (control group) whose results support this hypothesis. Women were significantly more hopeless than men and the bereaved mothers had the highest hopelessness scores in comparison to the other groups. Rubinstein (2004) explains those gender differences in the light of gender-role-socialization, meaning that women experience less control over negative life events because of their social roles. He infers that the women's helplessness may be a result of gender specific discrimination (e.g. in professional life), higher rates of sexual and physical abuse and from the dual burden of being a working mother.

Other researchers also reported gender differences in studies with different experimental designs: LeUnes, Nation and Turley (1980) induced helplessness with an unsolvable anagram task. Helplessness was assessed only by behavioral measures such as the mean response latency and performance (number of failures to solve the task) for a control task (solvable anagrams) which was presented after helplessness induction. Female participants showed more helplessness effects than males. Gannon, Heiser and Knight (1985) reported similar results. After a discrimination task with non-contingent reinforcement (helplessness induction), female participants showed more helplessness effects on a control task that included math problems and anagrams. However, the study only measured helplessness by assessing the performance on the control task and did not include any measures of subjects' mood. The same effect was also found in a helplessness study (Petiprin & Johnson, 1991) where female participants showed significantly worse performance on mathematical tasks after a helplessness training. It is worth mentioning that the reported effects may be also caused by variable abilities of the subjects for solving math problems and anagrams which was not controlled for in the above mentioned studies . Mal and Jain (1990) investigated learned helplessness in students and assessed helplessness effects by performance on anagram tasks (mean response latency, numbers of failures to solve the task). They reported that female subjects developed greater helplessness in comparison to male subjects and that female students also made more internal, stable and global attributions than the male students.

On the other hand, there is also empirical evidence suggesting no gender differences at all:

Baucom and Danker-Brown (1979) investigated the involvement of sex roles for gender differences in learned helplessness: college students were classified into different sex-role types (masculine, feminine, androgynous and undifferentiated types) by a self-rating scale and underwent a helplessness induction with unsolvable concept formation problems. The study revealed that different sex-role types caused different helplessness effects. For example helpless androgynous participants only showed dysphoric mood while feminine- and masculine sex-typed helpless subjects equally showed motivational and cognitive deficits as well as dysphoric mood. Although sex roles played a role, gender per se did not, as there were no differences between female and male participants regarding their susceptibility for helplessness. These results get empirical support by a study with adolescents (Overton & Meehan, 1982) which showed that sex-roles had an influence on helplessness effects, but it did not reveal any differences between male and female participants in learned helplessness.

No gender differences were also reported in a study (Rozell, Gundersen & Terpstra, 1997) with undergraduate students that underwent a helplessness training where they had to solve classification tasks and the situation was created in a way that failure was inevitable including negative feedback. Helplessness was measured by a self-rating scale. A behavioral study with college students (Cemalcilar, Canbeyli & Sunar, 2003) induced learned helplessness by using an unsolvable maze. Helplessness was assessed by using behavioral measures (performance on anagram task) and mood measures (assessed by emotional ratings for pictures). Furthermore, the study included a therapy session, applied subsequently after the helplessness induction in order to revise the induced helplessness effect. Cemalicilar, Canbeyli and Sunar (2003, p.68) used a simple cognitive therapy approach consisting of a retroactive reevaluation of the failure experience. The study didn't reveal any gender differences in the effects of either helplessness induction or the results of therapy.

Moreover, a rat experiment (Dalla, Edgecomb, Whetstone & Shors, 2008) in which learned helplessness has been induced with electric shocks, showed that female rats did not get helpless in comparison to the male rats. Importantly, the authors emphasize that these findings are independent of gonadal hormones, which needs further proof in human subjects.

Taken together behavioral studies about learned helplessness, including attributional styles, as well as neuroscientific studies, show that the findings of gender differences are ambiguous. On the one hand, there definitely is some empirical evidence supporting gender differences in helplessness or hopelessness. Some researchers suggest causal explanations such as gender-specific socialization and that different learning histories lead to different attributional styles. These explanations need further scientific investigation and since many studies in this field of research were conducted with children, more gender studies with adults have to be carried out in the future. On the other hand there is also research that does not support gender differences in helplessness or hopelessness, which indicates that definite statements cannot be made yet. However, the studies that observed gender differences in learned helplessness, consistently report about women showing a greater tendency for learned helplessness. Due to the mixed results, it is very important to restudy the possible influence of gender on learned helplessness, especially with neuronal measures as there are only few studies that investigated this issue. Therefore, the primary aim of the present study is to explore, whether gender differences can be found in EEG measures as well as in subjective data (assessed via questionnaires).

6. Slow cortical potentials (SCPs)

SCPs are positive or negative going changes in the cortical polarization of the electroencephalogram, which last from 300 ms up to several seconds and their amplitude on the scalp ranges from several microvolts (e.g. during cognitive tasks) up to 100 microvolts (during seizures), creating mean shifts of up to 50 µV (Bauer, 1998; Rockstroh, Elbert, Canavan, Lutzenberger & Birbaumer, 1989).

It is believed that their main physiological basis are electrical depolarizations, specifically excitatory postsynaptic potentials (EPSPs) (He & Raichle, 2009) of the apical dendritic tree of neurons in the upper cortical layers, which are caused by synchronous firing, mainly from thalamocortical afferents (Birbaumer, 1999). Strong empirical evidence indicates that SCPs which are recorded from surface-EEG-electrodes, originate primarily in neocortical pyramidal cells (McCallum & Curry, 1993; Speckmann et al., 1984; as cited in Khader, Schicke, Röder & Rösler, 2008) which is in accordance with the findings described above.

However, there are researchers who suggest (Khader et al., 2008) that inhibitory postsynaptic potentials (IPSPs) play a crucial role in the SCP generation as well and that glia cells play a minor role, too. On the one hand there is research indicating that neuroglia depolarizations moderately contribute to the slow waves (Birbaumer, Elbert, Canavan & Rockstroh, 1990; Khader et al., 2008) but,- on the other hand Khader et al. (2008) argue that they rather make a small contribution to SCP’s.

Besides, there is evidence that post synaptic potentials (PSPs) which are believed to cause SCPs, are rather long-lasting PSPs in the apical dendrites and not many short living PSPs (Libet, 1979; Marczynski, 1993; as cited in Khader et al., 2008)

Lately, a relationship has been reported between slow waves in the EEG and the BOLD-signal in functional magnetic resonance imaging (fMRI). Several independent research groups studying parallel measures of SCPs and rCBF (regional cerebral blood flow) as well as event-related fMRI, found "that pronounced negative slow waves emerge over those cortical areas that showed a task-related increase of the hemodynamic response" (Khader et al., 2008, p.254). Overall these findings provide evidence that there is a systematic relationship between hemodynamic and electrical brain signals in humans performing cognitive tasks (Khader et al., 2008).

Additionally, these results get empirical support by neurophysiological research. Voipio, Tallgren, Heinonen, Vanhatalo & Kaila (2003) demonstrated significant associations between tissue oxygenation and slow wave shifts. Voipio et al. (2003) observed DC-EEG shifts in healthy subjects elicited by hypo-or hypercapnia. They had three different conditions: voluntary hyperventilation[6], voluntary hypoventilation[7] and hypercapnia[8] evoked by letting the subjects inhale a mixture of 5% CO_2-95% O_2. The experiment revealed that hyperventilation induced negative shifts in several electrodes. In turn, hypoventilation and breathing 5% CO_2 in air resulted in a positive shift.

Typically, SPCs precede voluntary movements or an expected imperative event (Rockstroh et al., 1989) and they play a major role in the preparatory distribution of motor, sensory and attentional resources into respective cortical areas (Birbaumer et al., 1990). Rockstroh et al. (1989, p.4) describe SCPs to represent a higher level of processing than the common event related potentials and states that they "reflect a basic link in the organization of all voluntary and evoked behavior.

[6] A state of breathing faster than normal at rest (overbreathing).

[7] Also known as respiratory depression, characterized by a reduced amount of air entering the lungs.

[8] A condition where there is too much carbon dioxide in the blood, often caused by hypoventilation.

Traditionally, a negative potential shift is interpreted as an increased cortical excitability, whereas a positive shift goes along with a reduction of cortical activity (He & Raichle, 2009) which is also in line with the findings of Bauer et al. (2003), who found a relationship between positivity and neuronal deactivation. Fretska et al. (1999) observed positive going SCP-shifts during withdrawal of control (except for the very frontal sites). Moreover, positive SCP-shifts correlated with strong negative emotions. These findings are in accordance with the fact that learned helplessness is associated with passivity and feelings of depression,- therefore, an activity decrease is reasonable. Furthermore there is also research indicating associations between SCPs with attention, consciousness and volition (He & Raichle, 2009).

SCPs are recorded with a direct-current-EEG (DC-EEG) because their frequencies are low and they need to be recorded with a DC-amplifier that passes those low frequencies, whereas an alternating-current (AC-EEG) amplifier omits those frequencies.

Altogether, the empirical findings show that SCPs can be regarded as correlates of higher cognitive processes, which is why the present study uses SCPs for the investigation of neural correlates of learned helplessness.

7. Aims

The main goal of this study is to investigate brain activity measures of subjects who get helpless and those who do not, as well as comparing male and female participants while inducing learned helplessness by using cognitive reasoning tasks. Brain activity has been measured by registering EEG signals from the scalp in order to analyze slow SCP shifts and to investigate if there are any significant differences in the shifts between the groups. Additionally neuronal source localization with sLORETA will be conducted to analyze differences in cortical activation between the groups. On the basis of previous research, the region of interest has been the ACC in BA 24 and 32.

8. Hypotheses

1. There are significant differences in SCP changes between those subjects who become helpless and those who do not, expecting significant positive going SCP shifts in the helplessness group (Bauer et al.,2003 ;Fretska et al., 1999)

2 .Subjects which are highly emotionally reactive (measured with questionnaires) will get more helpless than lowly emotionally reactive subjects (Bauer et al., 2003; Fretska et al., 1999)

3. There are significant gender differences:

   a. It is expected that more women are significantly highly emotionally reactive (measured with questionnaires) than men (Fretska et al., 1999)
   b. and that more women will become helpless (Fretska et al., 1999)
   c. Significant differences in SCP changes (in anterior, middle and posterior regions) between female and male subjects are expected (Fretska et al., 1999)

4. There is a significant positive correlation between positive going SCP changes and strong negative emotions: thus, it is expected, that the more negative emotions the subjects will experience, the more positive the SCPs will be (Bauer et al., 2003; Fretska et al., 1999)

5. There are significant differences in the activation of cortical sources between helpless subjects and those who do not become helpless, especially in the ACC (BA 24 and 32), which is the region of interest.

Empirical Part

9. Methods

9.1. Subjects

Fifty right handed, German speaking male and female subjects participated in the experiment (25 women and 25 men). They were recruited by advertisements at a job market page in the internet (www.unijobs.at) as well as by posters which hung in different places of the University of Vienna. Subjects received 20 Euro as a financial remuneration for their participation. Due to strong electroocular- and electromyogram-artifacts in their EEG recordings, eight subjects had to be excluded from further analysis. Thus, the final sample consisted of 42 subjects (23 male and 19 female, aged between 19 and 40 with a mean age of 26.14 [SD=4.46]). Male and female participants did not differ regarding their age (p= 0.552) as well as helpless and non-helpless participants did not show any significant age differences. Prior to the recordings all subjects were screened for possible neurological or psychiatric disorders as well as for taking drugs or psychiatric medication using the German version of the Structured Clinical Interview (SCID, Wittchen, Wunderlich, Gruschwitz & Zaudig, 1996). Handedness was assessed by using the Edinburgh Handedness Inventory (Oldfield, 1971) and written informed consent was obtained. The study was accomplished in accordance with the ethic guidelines of the revised Declaration of Helsinki (1983) as well as with local guidelines of the Brain Research Lab (University of Vienna).

9.2. Study Design

First of all, subjects had to fill in the Positive and Negative Affect Schedule (PANAS, Watson, Clark & Tellegen, 1988), followed by preparation for the EEG recording. Thereupon they had to logically continue a series of numbers while their EEG was recorded. After the task, they had to fill in two questionnaires (PANAS and helplessness questionnaire, Bauer et al., 2003) and had a short break. Subsequently, they participated in another experimental task which won't be discussed here any further as it is subject to another diploma thesis. Finally, after taking part in the second experiment the subjects had to fill out some more questionnaires (Attributional Style Questionnaire, Poppe, Stiensmeier-Pelster & Pelster, 2005; Saarbrückener Persönlichkeitsfragebogen, Paulus, 2008) and got their monetary compensation (20€). The whole experiment lasted between two and a half and three hours on average.

9.3. Procedure and task

DC-EEG was recorded while the subjects were sitting in a chair in front of a CRT-monitor in a dimly lit and sound-attenuated room. They had to solve cognitive reasoning tasks (series of numbers) with a total of 60 trials. The recordings were carried out in two different laboratories and subjects used different input devices. However, the type of amplifier was the same and all subjects sat in front of a 19'' CRT screen, only the type of the monitor was a different one (Sony- Multiscan G520 and Sony – GDM-F520). Usually they used a response box with five buttons, of which they had to use four and in some other cases subjects used a conventional keypad, on which they pressed the numbers 1-4 on the numeric keypad. Subjects were explicitly told to only use their index fingers (of both hands) for pressing the buttons. Visual stimuli were presented on the screen using the software E-prime 2.0 (Psychology Software Tool, Inc., Sharpsburg, USA).

The series of numbers were taken from a previous study which was conducted in the Brain Research Lab (University of Vienna) by Bauer et al. (2003). Half of the 60 items were solvable and half of them were unsolvable. Each item comprised a series of seven numbers arranged according to a logical rule. The subjects' task was to continue the sequence logically by choosing one of four given answers (multiple-choice format). Thereby, they had to type in the position of the correct answer (or the answer the subject thinks is correct): 1, 2, 3 or 4. Below, a sample of a solvable item is given with the correct answer underlined:

3 5 9 15 23 33 45

55 57 58 <u>59</u>

In the case demonstrated above, the subject would have to press button Nr. 4 to give a correct answer.

The unsolvable items were series of numbers with only wrong answers to choose from. Consequently, regardless of the choice, the feedback was always negative for unsolvable items or “faster” if a subject did not respond in the given time range. Here is an example of an unsolvable item:

2 11 8 4 3 19 15

4 7 5 8

Consequently, there were two conditions for the eventual analysis: solvable trials and unsolvable trials. The goal was to withdraw control in subjects by presenting numerical series they couldn’t solve. All subjects got the instruction that they would have to solve simple reasoning tasks. Prior to the recordings, a short training phase with three easy sample items and detailed instructions was given in order to make sure that the subjects understood the task properly. Subsequently, the participants were asked if they had any further questions before the recording started. Based on traditional learned helplessness experiments there were two phases in the experiment:

1) A phase with control, in which most of the items were solvable (24 of 30 were solvable and 6 unsolvable items) in order to induce controllability.

2) A helplessness training-phase, in which the control was withdrawn by presenting mostly unsolvable items (24 of 30 were unsolvable and 6 solvable items).

The participants received feedback after each item, depending on their performance:

a)Right answer (only possible in solvable trials): right (German: “Richtig”)

b)Wrong answer: wrong (German: “Falsch”)

c)No answer (this was the case when the subject didn’t answer within the given time range of 30 seconds): faster (German: “Schneller”)

All 60 items were presented in a row without a break and the the timeline for each trial is depicted in figure 2:

1 sec	**max 30 sec RESPONSE**	**1 sec**	**1-2sec**
cross lines	cognitive task	feedback	cross lines

Figure 2. Timeline

9.4. Apparatus and EEG recordings

Slow cortical potentials were recorded from 61 electrodes on the scalp placed in an elastic cap (EASYCAP GmbH, Herrsching, Germany) using a 64-channel low-input impedance amplifier (Ing. Kurt Zickler GmbH, Pfaffstätten, Austria). The electrodes consisted of sintered silver/silver-chloride (Ag/AgCl) and were equidistantly positioned to each other (M10 system) in the elastic cap. The data was recorded with a sampling rate of 250 Hz in a frequency range from DC to 125 Hz. The individual 3D electrode coordinates of each subject were measured with a photogrammetric head digitizer (3D-PHD; Bauer, Lamm, Holzreiter, Holländer, Leodolter & Leodolter, 2000) in order to get more accurate EEG mappings of the subject's scalps, which is essential for precise source localization with sLORETA. Prior to the recording procedure, 17 light markers were attached to the electrodes on predefined positions on the cap. The subject had to take seat in an apparatus with black light where the head is surrounded by twelve calibrated cameras. The cameras took pictures of the subjects' head from different angles and thus the 17 marked positions were captured. To reconstruct all individual electrode positions, interpolation was applied in order to reconstruct the remaining electrode positions.

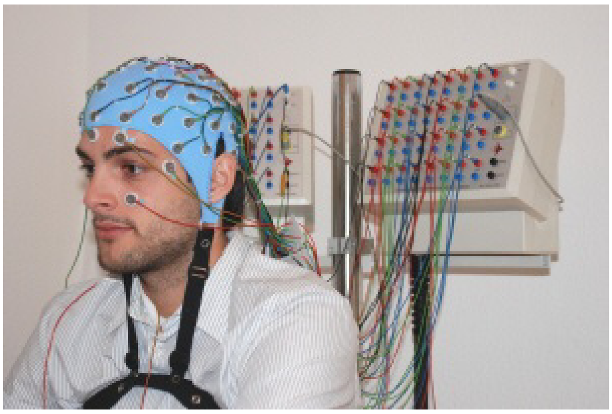

Figure 3. Subject with an elastic electrode cap sitting in front of a monitor (http://brl.psy.univie.ac.at/, 02.12.2010).

In order to adjust for eye movement artifacts, eye movements were recorded by vertical and horizontal electrooculogram (EOG) electrodes. Therefore, two EOG electrodes were applied underneath and above the left eye to control vertical eye movements and two more EOG electrodes were applied at the outer canthi of each eye to control horizontal eye movements. All EEG recordings were referenced to the electrodes placed on the vertebra prominens and on the sternal end of the right clavicula. The grounding electrode was placed on the forehead.

In order to keep the electric impedance as low as possible, the skin at all electrode positions was scratched with a sterile disposable needle prior to filling the electrodes with an air-vacuumed electrode-gel (Electrode-Cap International, Inc., Eaton/Ohio; USA). Afterwards, electrode impedance values of each electrode were checked and kept under 3 k Ω.

9.5. Questionnaires

Positive and Negative Affect Schedule – PANAS (Watson, Clark & Tellegen, 1988):

Subjects had to fill in the German version of the PANAS twice during the experiment: first, when they arrived at the Lab and then after finishing the helplessness experiment. This was done to measure whether the helplessness induction had any influence on the subjects' mood. According to the authors, positive affect (PA) can be understood as the extent to which an individual feels active, alert and enthusiastic. It has been shown that the PA-scale is related to social activity. On the other hand, the negative affect scale (NA-scale) -which is associated with perceived stress and negative affect- is defined as a general dimension of subjective distress and unpleasurable engagement including nervousness, anger, fear, disgust, guilt and contempt (Watson et al., 1988). The PANAS is comprised of two 10-item scales which have been demonstrated to be "highly internally consistent, largely uncorrelated, and stable at appropriate levels over a 2-month time period" (Watson et al., 1988, p.1064). The German version used in the present study required the subjects to report on a five-point scale how they had felt in the last minutes. The scale ranged from 1 (not at all) to 5 (extremely). Here is an example-item:

Please describe, how you felt during the last minutes:

Interested: 1 (not at all) – 2 (a little) – 3 (moderately) – 4 (quite a bit) – 5 (extremely)

Attributional style questionnaire = Attributionsstilfragebogen für Erwachsene (ASF-E) (Poppe, Stiensmeier-Pelster & Pelster, 2005):

The AFS-E was handed out after finishing both experiments (helplessness induction and flanker task). It was constructed on the basis of the GASQ (German attributional style questionnaire; Stiensmaier et al., 1985; as cited in Poppe et al., 2005), which in turn was guided by the ASQ (attributional style questionnaire; Peterson et al., 1982; as cited in Poppe et al., 2005). The ASF-E includes 16 vignettes which describe situations most adults know from their own life experience or which they can imagine very well. Half of the vignettes have a positive outcome, the other half has a negative one. Furthermore, half of them are performance-related and the other half describes interpersonal incidents. The different kinds of vignettes are presented alternately with a positive situation at the end. The ASF-E instructs subjects to imagine each situation very vividly and to think about what may have caused the situation. Then, the subjects have to write down the main cause and subsequently rate it on three attributional dimensions (internal, stable and global attributions). There are two items for each dimension and each item had to be rated on a seven-point semantic differential.

Helplessness questionnaire (Bauer et al., 2003):

Immediately after finishing the recording, subjects were asked to fill in a helplessness questionnaire which has been constructed by Bauer et al. (2003) and used for their helplessness experiments. The questionnaire contains 12 questions in total, whereby 11 of them have to be answered on a 5-point scale (from 1- very strong to 5-not at all) and one question has an open answering format. The questions are concerned with controllability during the experiment, motivation to succeed, motivational effects of items, personal importance of the task and the subjects' feelings (aggression, depression, demotivation, passivity, upset) after recognizing they couldn't solve any items any more.

Saarbrücker Persönlichkeitsfragebogen (SPF; Paulus, 2008):

Additionally to the attributional style questionnaire, subjects completed the SPF, which is the German version of the Interpersonal Reactivity Index (Davis, 1996) after finishing the recording session. The SPF consists of 16 items, which are presented as short statements and have to be rated on a 5-point scale (from 1-not true at all to 5-very true).There are four factors underlying the SPF, each consisting of 4 items: Fantasy, perspective taking, empathy and distress. Additionally, sub-scores can be calculated as well as an overall score.

10. Analysis

10.1. EEG analysis

First of all, the raw EEG data was preprocessed including the following working steps:

- Creating epochs: in the present study the pre-stimulus baseline has a duration of 500 ms and the timeframe from stimulus onset (series of numbers) has a duration of 5000 ms. During preprocessing datasets for each subject and each condition were compiled by merging the matching epochs together. There are two conditions in the present study based on the phase of the experiment and the kind of item:
  - Condition 1: solvable items
  - Condition 2: unsolvable items
- Trigger correction: corrects those triggers that were set wrong by the presentation programme.
- Baseline correction: provides flatter baselines and averages the baseline to zero.
- Electrooculography (EOG) movement and blink correction:

  Eye movement artifacts were corrected by successively subtracting the weights of vertical and horizontal EOG signals from every EEG channel. Prior to the experiment, calibration trials for horizontal and vertical eye movement were recorded to calculate those weights as the ratio of the covariance between each EEG channel and the EOG (Fretska et al., 1999).

As an example for the Fp1 channel the algorithm reads:

$$Fp1_{corr} = Fp1 - (w_V * VEOG) - (w_H * HEOG)$$

with

$$w_V = Cov(Fp1, VEOG)/Var(VEOG)$$

and

$$w_H = Cov(Fp1, HEOG)/Var(HEOG)$$

Eye blink artifacts were corrected by using a template matching procedure which identified the time windows that contained blinks. Those time windows were corrected based on blink correction coefficients which were calculated for each EEG channel by employing linear regression (Lamm, Fischmeister & Bauer, 2005).
Further EEG data analysis was carried out by using EEGLAB 6.03b (Delorme & Makeig, 2004), a toolbox imbedded in Matlab 7.5.0 (The MathWorks Inc., Natick, USA). The EEG data was filtered by using a 30 Hz low pass filter. Subsequently, electrode coordinates (assessed by the 3D-PHD; Bauer et al., 2000) were inserted and the two pre-auricular channels were excluded from further analysis. For ten subjects a few channels had to be interpolated in cases where no signal was recorded for the particular cannel (due to technical problems) or where the signals were extremely noisy. In order to exclude artifacts in trials, a semi-automatic artifact-rejection procedure was applied. Using the automatic artifact rejection in EEGLAB, all trials were labeled which met one of the following criteria: a voltage value exceeding the threshold of +/- 100 µV and/or a linear voltage drift with a slope exceeding the threshold of 50 µV. Additionally, all trials were inspected visually. Trials were rejected in case of drifts in the baseline and/or artifacts which were caused by muscular and eye-blink activity. Due to strong muscular and eye blink artifacts, an extra EOG- and electromyography (EMG) correction based on Blind Source Separation (BSS) was applied as well as an additional baseline correction. The algorithm used for the EOG-correction was SOBI (Second-order blind source separation based on multi-dimensional autocovariances) and the algorithm used for the EMG-correction was BSSCCA (Blind Source Separation Canonical Correlation Analysis).

However, eight subjects had to be excluded from further analysis due to excessive eye-movement artifacts.

In order to inspect slow cortical potentials for a group visually, the EEG data of each group (male/female and helpless/non-helpless) was averaged over the whole time range (5500 ms including baseline) and all subjects of each group resulting in a grand mean average. Thus, each group and each condition has one grand mean average, which can be illustrated with plots of the amplitude over the whole time range as well as with 2D-plots where one can observe graphically cortical activation over the timeframe. Plots for amplitudes courses were made for clusters of electrodes and SCP amplitudes were analyzed statistically in clusters as well. Each cluster consisted of six or seven electrodes as presented in figure 4.

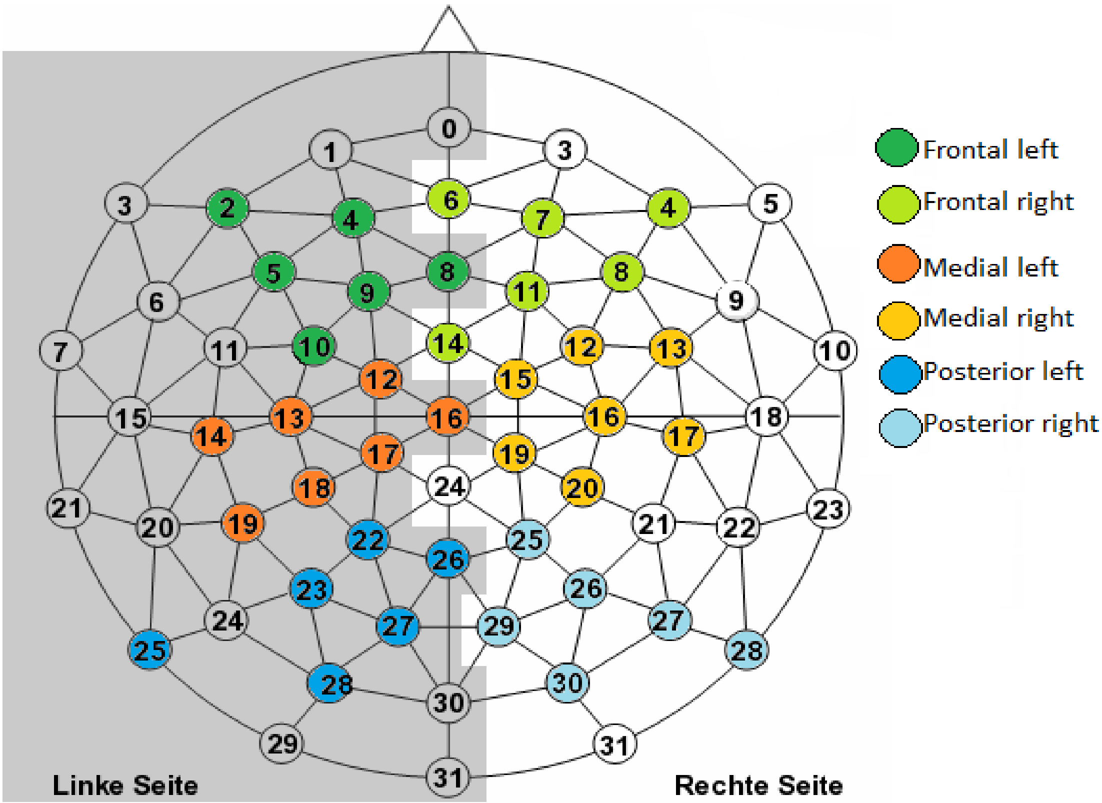

Figure 4. Electrode clusters used for SCP-analysis.

For the statistical analysis cluster-mean amplitude values were used which were calculated as a mean of the electrode mean amplitude values.

10.2. Statistical analysis

First of all, the sample was analyzed descriptively and proportional distributions of gender and helplessness in the sample were computed with a contingency table. For the statistical analysis of the questionnaire data, subjects were divided into different groups. On the one hand, gender-specific groups (male and female group) were compiled and on the other hand, subjects were assigned to either the helpless group (subjects who became helpless) or the non-helpless group (subjects who didn't become helpless). The seperation into helpless subjects and non-helpless subjects was based on the scores of two questions (6.3 and 6.4.) from the helplessness questionnaire used (Bauer et al., 2003) which assessed feelings of demotivation and depression shortly after the helplessness training. Participants with a total score of seven (and more) in both questions were classified as helpless, whereby the maximal possible score was ten. Group comparisons of the means of questionnaire scores and scales were done with independent two-factorial ANOVA's (Analysis of Variance) or U-tests if assumptions for ANOVA weren't met. For the PANAS scores a dependent t-test has been computed as those scores are repeated measures (before and after the experiment). Behavioral data (amount of correct given answers) was analyzed with a two-way ANOVA with gender and helplessness as between-subject factors.

For the statistical analysis of the EEG data, a time range of 4960ms duration (post-stimulus: after the onset of the item) was divided up into 20 time-frames of 248ms each. A mixed ANOVA with repeated measurements was conducted for each timeframe with SCP amplitudes as the dependent variable. Therefore, 20 ANOVA's have been conducted. There were 2 between-subject factors: (1) gender (male, female) and (2) helplessness (yes/no). The within-subject factors were: (1) condition (solvable, unsolvable), (2) hemisphere (left, right) and (3) location (frontal, medial, posterior). Additionally, Tukey-post-hoc tests were conducted for interesting significant effects and correlations between questionnaire data and SCP amplitudes were computed. Additionally, an analysis of covariance (ANCOVA) was computed for each timeframe with performance (number of correct answers) as the covariate. A significance level of $\alpha = 0.05$ was used for all analyses.

10.3. Standardized low resolution brain electromagnetic tomography = sLORETA (Pascual-Marqui, 2002)

To put it briefly, sLORETA computes probability maps of EEG or MEG data indicating the locations of the underlying neuronal sources, assuming that adjacent voxels[9] have similar activity and intensity. The computations are based on estimations of the current density distribution. By standardizing those estimations, the source localizations are deduced. According to the author (Pascual-Marqui, 2002) sLORETA has zero localization error. However, it is limited to cortical grey matter and the hippocampus. sLORETA calculates the estimated distribution of current density in 6430 voxels in the grey matter with a spatial resolution of five mm, based on the Talairach Human Brain Atlas (Talairach & Tournoux, 1988). The output of sLORETA is a three dimensional brain-activity map which has relatively low spatial resolution but very high temporal resolution.

Source localization of neural activity was conducted with the software sLORETA for all subjects, and subsequently group comparisons (helpless subjects vs. non-helpless subjects) were assessed. Three dimensional distribution of estimated current density was calculated for mean amplitudes of slow cortical potentials between 1 and 5000 ms (starting at onset of the item) with a step size of 500 ms. All sLORETA data files were analyzed with a signal-to-noise-ratio of 1 to 100. The individual electrode coordinates, which were assessed earlier by the 3D-PHD, were loaded as transformation matrices.

In order to inspect activation patterns for specific groups and conditions, grand means were computed and inspected visually. In order to find any significant differences in activation patterns between the groups, paired-sample and independent-sample t-tests using log-transformed sLORETA values were conducted. The significance level was set at $p \leq 0.05$, two-tailed.

Altogether 11 comparisons were computed:

- Male subjects vs. female subjects
- Solvable tasks vs. unsolvable tasks
- Helpless subjects vs. non-helpless subjects

[9] A volumetric pixel, representing a value on a regular grid in a three dimensional space.

- Helpless subjects with solvable tasks vs. helpless subjects with unsolvable tasks
- Non-helpless subjects with solvable tasks vs. non-helpless subjects with unsolvable tasks
- Helpless subjects with solvable tasks vs. non-helpless subjects with solvable tasks
- Helpless subjects with unsolvable tasks vs. non-helpless subjects with unsolvable tasks
- Female subjects with solvable tasks vs. female subjects with unsolvable tasks
- Male subjects with solvable tasks vs. male subjects with unsolvable tasks
- Female subjects with solvable tasks vs. male subjects with solvable tasks
- Female subjects with unsolvable tasks vs. male subjects with unsolvable tasks.

11. Results

11.1. Descriptive statistics and questionnaires

Overall 57.1% subjects became helpless (24 of 42 subjects) and there were no crucial differences between men and women: slightly more women (63.2%) were classified as helpless in comparison to male subjects (52.2%). The chi -square test revealed that there were no significant differences in the distribution of helplessness depending on gender (chi-square= 0.51, $p=0.47$, $df=1$).

Helplessness questionnaire:

A U-test revealed that helpless subjects differed from non-helpless subjects only in their feelings of aggression ($z=-2.33$, $p=0.02$) and nervousness ($z=2.08$, $p=0.04$). Surprisingly, those groups didn’t show a significant difference in passivity ($z=-0.80$, $p=0.42$). There were no significant differences regarding the items of the helplessness questionnaire between male and female participants. The mean scores and standard deviations are listed in table 3 in the appendix.

PANAS:

Significant differences between the groups were observed for NA-scores (before and afterwards) between helpless and non helpless subjects. Helpless participants had significantly ($z=-2.31$, $p=0.02$) higher NA-scores before the experiment compared to participants who didn't become helpless, as well as significantly higher NA-scores after the experiment ($z=-3.26$, $p<0.01$). The means and standard deviations are shown in Table 1.

Moreover, the dependent t-test revealed significant differences between PA-scores before and after the experiment ($t=3.58$, $p<0.01$, $df=23$) as well as between NA-scores before and after the experiment ($t=-2.56$, $p=0.02$, $df=23$) in helpless subjects. However such differences couldn't be found in non helpless subjects. The findings show, that the helplessness induction affected the emotional state of helpless subject towards more negative affect and less positive affect. PANAS scores of participants who didn't become helpless remained stable after the experiment. There were no differences in the PANAS scores between men and women (PA before: $p= 0.690$, PA after: $p= 0.693$, NA before: $p= 0.725$, NA after: $p= 0.152$).

Group	NA before		NA after	
	mean	SD	mean	SD
Helpless group	14.04	3.40	16.96	6.81
Non- helpless group	11.83	2.33	12.11	2.22
	PA before		PA after	
	mean	SD	mean	SD
Helpless group	30.50	5.04	26.79	5.77
Non-helpless group	29.10	6.86	28.89	6.87

Table 1. Scores of the PANAS (Watson, Clark & Tellegen, 1988)

ASF-E:

The independent two-way ANOVA didn't reveal any significant differences for the scales of the ASF-E, neither for gender ($F_{(6, 33)}$ =0.65, p=0.69) nor for helplessness ($F_{(6,33)}$ =1.38, p=0.27). Means of all scales and scores with standard deviations can be found in table 4 in the appendix.

SPF:

There were no significant differences between male and female participants regarding SPF-scores (all ps> 0.061 and only one significant difference between helpless and non-helpless subjects (z=-2.59, p=0.01) regarding the distress-scale: helpless subjects showed significantly higher distress-scores than non-helpless subjects. The remaining means and standard deviations are shown in table 5 in the appendix.

11.2. Behavioral data

Altogether, subjects solved on average 65% of the items correctly. There were no significant differences ($F_{(1, 38)}$=0.046, p=0.831; η^2=0.001) between helpless and non-helpless participants regarding their amount of correct answers, but there was a significant gender difference ($F_{(1, 38)}$=5.64, p=0.02, η^2=0.13): men solved significantly more items than women. Means, standard deviations and percentages are listed in table 2.

Correct answers (out of 30 items)			
Group	Percentage	Mean	SD
Helpless	65%	19.54	7.28
Non-helpless	65%	19.55	6.47
Male	73%	21.83	6.24
Female	56%	16.79	6.72
Total	65%	19.55	6.87

Table 2. Behavioral data: means, standard deviations and percentages of correct answers for different groups and the whole sample.

11.3. Grand Mean Average-2D Plots

As already described above, grand mean averages including subjects of each group and all timeframes were computed and can be illustrated as a 2D-Plot. In the plots each depicted circle (head) shows an average over 100 ms. As the whole timeframe recorded is 5500 ms long, we have 55 averages and thus 55 heads.

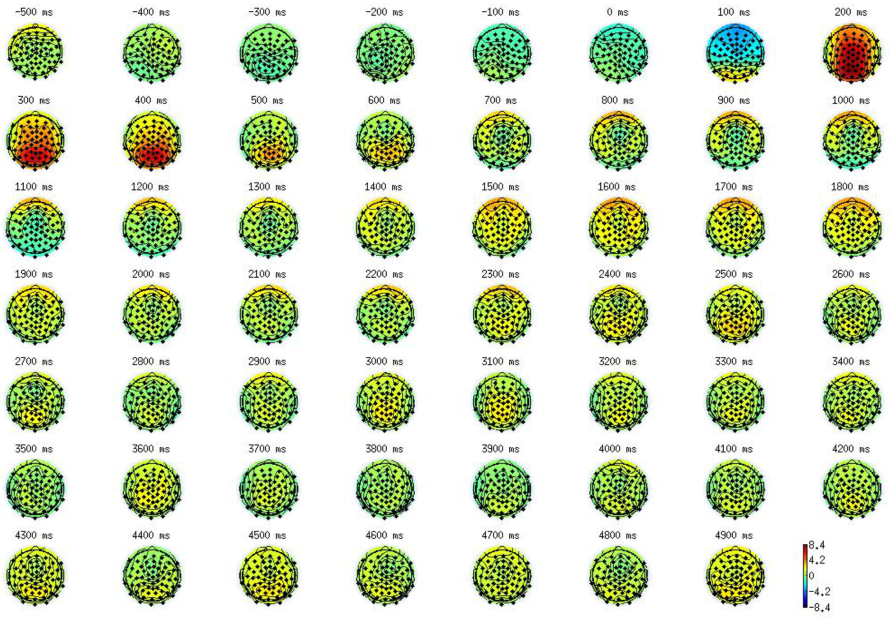

Figure 5. Two dimensional Grand Mean average plots for helpless subjects processing solvable items.

Figure 5 shows the cortical activation for helpless subjects dealing with solvable items. Shortly after stimulus presentation (100ms) they showed a strong negative activation in frontal regions, which represents an event-related potential (ERP) known as the N1. It is then followed by a strong positive activation over the whole scalp at 200ms which represents the ERP P2. Over the next 200 ms the positive activation is limited to posterior regions and after 500 ms post-stimulus, the images don't differ very much: they show rather less activation than before.

Figure 6 shows activation for the same group of subjects (helpless subjects) but this time dealing with unsolvable items (helplessness condition). The difference to the solvable condition is, that they did not show such a strong negativity at 100 ms and overall they showed more positive activation over the whole time after stimulus presentation. The N1 wave for visual stimuli is believed to be influenced by spatial attention, but generally many factors play a role such as the variability between subjects and external circumstances (Luck, 2005). It may be that unsolvable items had an influence on the attention processes in helpless subjects, which in turn influenced the N1. However, as we only inspected the ERPs visually and they were not the main subject of this study, any further conclusions cannot be done.

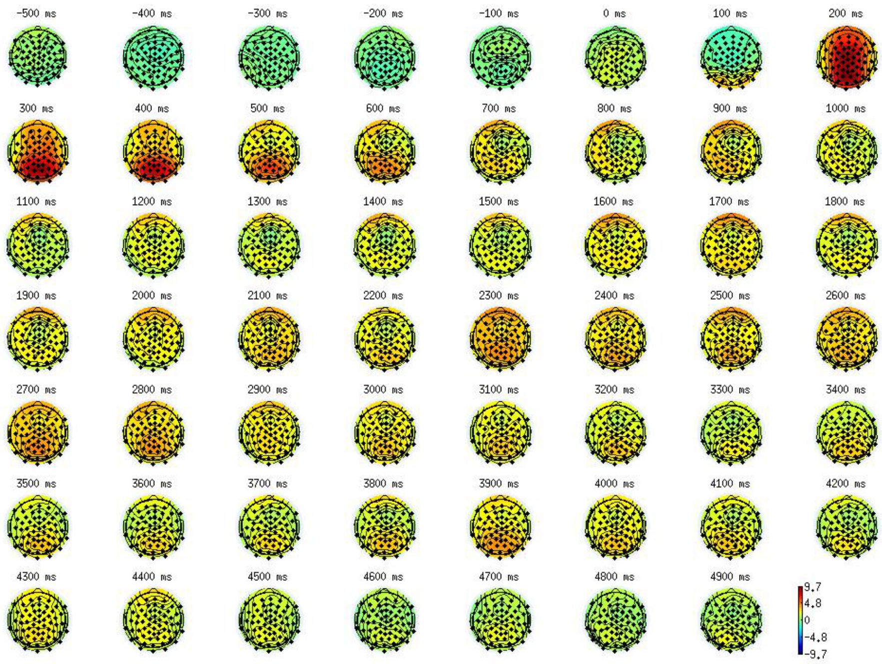

Figure 6. Two dimensional Grand Mean average plots for helpless subjects processing unsolvable items.

2D-plots of subjects who did not become helpless as well as for gender groups (male and female) can be found in the appendix and are discussed only shortly as they didn't differ crucially from the plots of helpless subjects. Generally, they all showed the same activation pattern over time: a strong positive activation over the whole scalp at 200 ms post-stimulus which then concentrates in posterior regions at 300-400 ms and gets less from 600 ms post-stimulus. The activation from 600ms post-stimulus till the end (5000ms) didn't change substantially, which represents the SCPs.

11.4. Grand Mean Average-plots for SCPs

By inspecting the amplitude courses of SCPs of each group and condition visually, there seems to be a major difference between helpless and non-helpless subjects in posterior regions: helpless participants showed a greater difference in SCP-amplitude-levels between the conditions (solvable vs. unsolvable) than those participants who didn't become helpless. While the non-helpless group had amplitude values in about the same range, amplitude values of helpless subjects showed an obvious difference with more negative amplitude courses in the solvable condition, and more positive amplitude courses in the unsolvable condition. Consequently, non-helpless subjects showed no behavioral or cortical differences regarding the solvability of items. Their SCPs of unsolvable items were comparable to those SCPs elicited by the processing of solvable items.

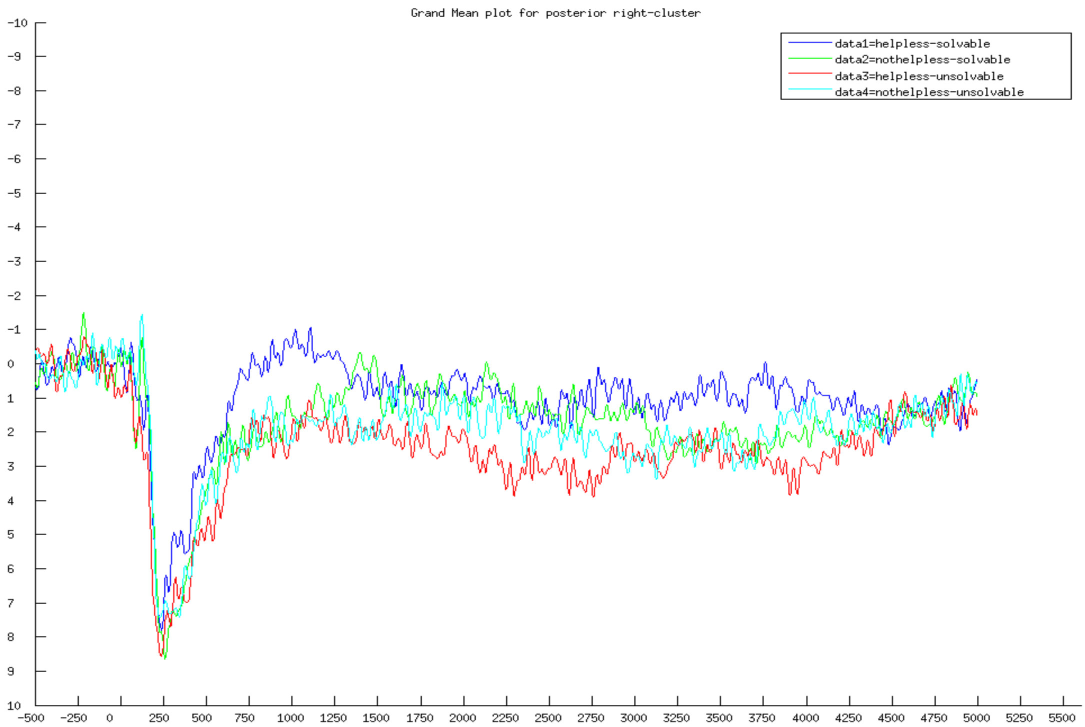

Figure 7. Grand Mean average plot for helpless versus non-helpless subjects of electrodes in the posterior-right cluster.

Equally, for the posterior clusters a similar observation was made for female participants who also showed positive SCP shifts in the unsolvable condition compared to the solvable one. The SCPs of male participants however were quite similar to those of the "non-helpless" subjects. It is important to emphasize that the trend described above only accounts for posterior regions and not for medial and frontal regions. Grand Mean plots for frontal and medial clusters rather showed overlapping amplitudes, as depicted in Figure 8.

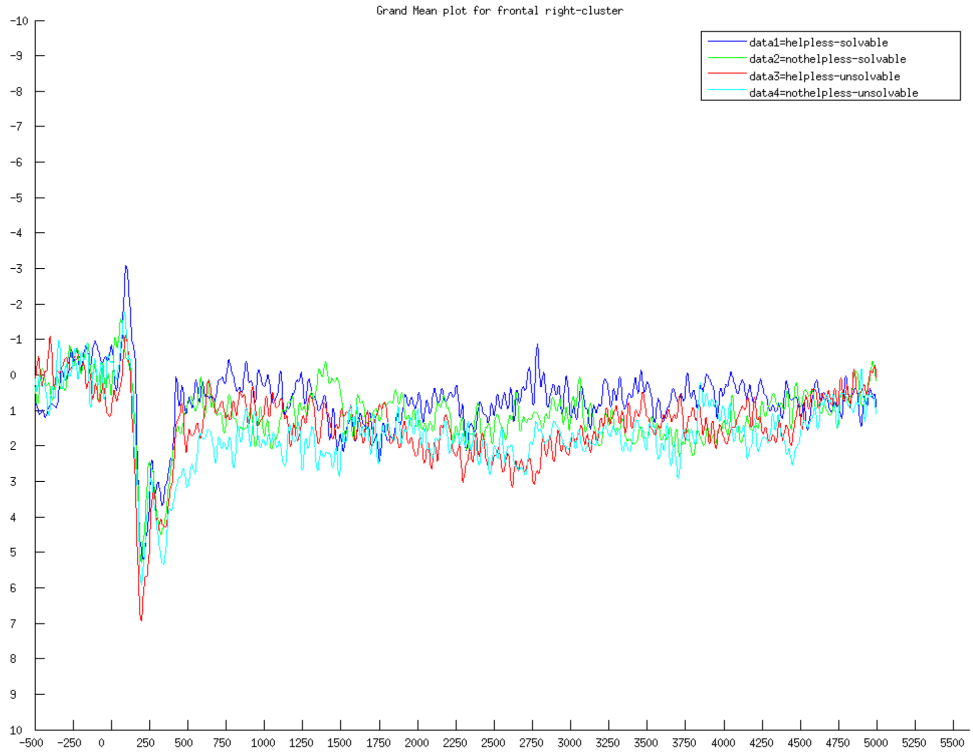

Figure 8. Grand Mean average plot for electrodes in the frontal-right cluster.

11.5. Statistical results of SCP-analysis

As the Mauchlys Test revealed, the assumption of sphericity was violated in all 20 repeated measurement ANOVAs as well as in all 20 ANCOVAs for all factors and therefore the Greenhouse-Geisser correction was applied.

ANOVAs:

There were no significant effects for the between-subject factors helplessness and gender (all ps>0073). Only timeframe 17 and 18 (3472-3720ms and 3720-3968 ms) showed significant interaction effects between gender and helplessness (t17: $F_{(1, 38)}$= 6.22, p= 0.02, η^2= 0.14; t18: $F_{(1, 38)}$= 4.23, p= 0.05, η^2= 0.10). Visual inspection indicated that in both timeframes women who did not become helpless had significantly more positive SCP-amplitudes in comparison to those who became helpless. Likewise, men did not show any significant differences in their amplitudes in dependence of helplessness. However, in the post-hoc test only timeframe 17 (p= 0.031) showed a significant difference between the female groups. Regarding the within subject factors, there were significant main effects for location and hemisphere in 19 of 20 conducted ANOVAs. Only the ANOVA for the timeframe three did not reveal any significant effects for those inner subject factors. In those timeframes where the factor location reached significance, the frontal electrode clusters were significantly more positive than medial and posterior clusters. Regarding the significant hemisphere effect, all timeframes showed significantly more positive amplitudes in the right hemisphere. Additionally there were significant interaction effects between location and hemisphere in all timeframes. This interaction effect means that amplitudes in the frontal-right cluster were significantly more positive than all other clusters in all timeframes.

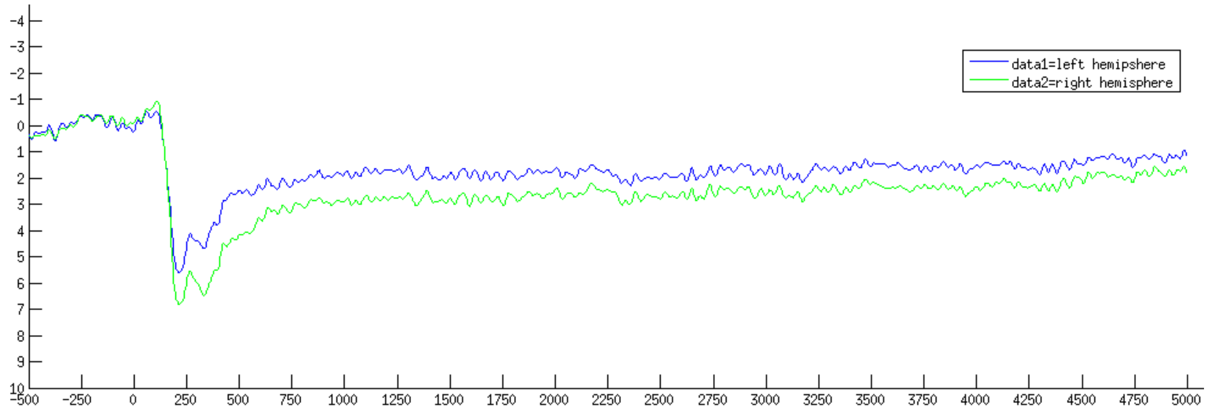

Figure 9. Grand Mean average plot (including all subjects) for right and left hemisphere.

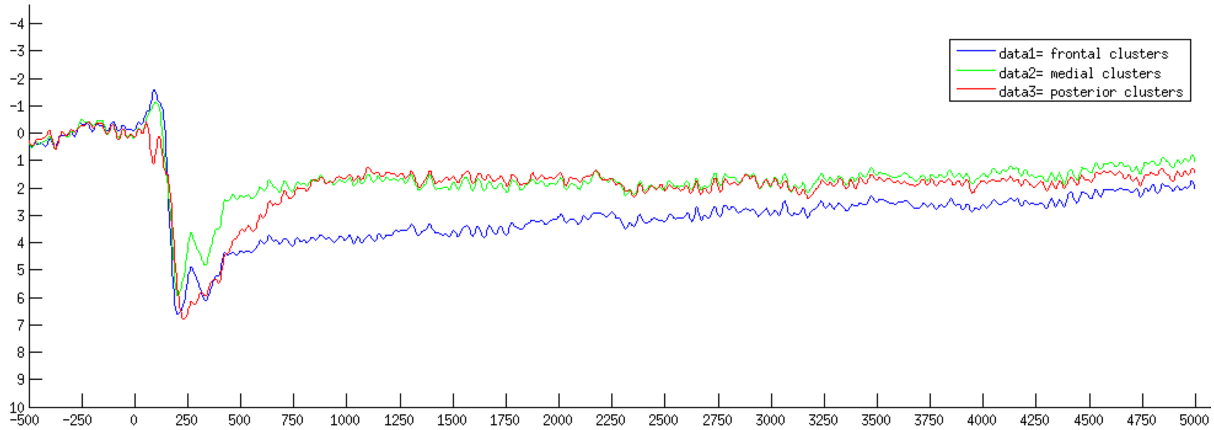

Figure 10. Grand Mean average plots (including all subjects) for different clusters (frontal, medial and posterior).

Besides, there were significant interaction effects between location and condition in timeframe four ($F_{(1.28,\ 52.40)}$= 4.26, p= 0.04, η^2= 0.10) with significant higher amplitudes in frontal clusters in the unsolvable condition in comparison to frontal clusters in the solvable condition. In timeframe 22 there were significant interaction effects between location, hemisphere and condition ($F_{(1.19,\ 45.27)}$= 6.59, p= 0.01, η^2= 0.15). There were also significant fourfold interaction effects between the within-subject factors hemisphere, condition, helplessness and gender in timeframe three ($F_{(1, 38)}$= 4.67, p= 0.04, η^2= 0.11), fifteen ($F_{(1, 38)}$= 5.30, p= 0.03, η^2= 0.142 and nineteen ($F_{(1, 38)}$= 5.49, p= 0.02, η^2= 0.13). In timeframe 13, 14 and 15 significant main effects for condition were found (t13: $F_{(1, 38)}$= 6.39, p= 0.02, η^2= 0.14; t14: $F_{(1, 38)}$= 5.00, p= 0.03, η^2= 0.12; t15: $F_{(1, 38)}$= 4.29, p= 0.03, η^2= 0.12) with higher amplitudes in the unsolvable condition but incongruously the post-hoc tests revealed that the observed effects were not significant (all ps>0.328). The exact values for all significant effects are listed in table 15-36 in the appendix.

ANCOVAs:

The results of the ANCOVAs for the SCPs in 20 timeframes revealed that the covariate 'performance' (measured by the amount of correct answers) had a significant influence on SCP amplitudes in ten timeframes (main effect for performance in ten timeframes with ps< 0.04; exact values are listed in table 37 in the appendix). The parameter estimates showed that performance was negatively related with SCP amplitudes in nearly all timeframes and electrode clusters. This means that the better the performance of a subject was, the more negative were the SCP amplitudes. There were no other significant main effects for the between-subject factors gender (p> 0.29) and helplessness (p> 0.075). However, there were significant interaction effects between gender and helplessness in five timeframes (t5: $F_{(1, 37)}$= 4.28, p= 0.05, η^2= 0.10; t12: $F_{(1, 37)}$= 6.04, p= 0.02, η^2= 0.14; t16: $F_{(1, 37)}$= 4,16, p=0.05, η^2= 0.10; t17: $F_{(1, 37)}$= 7.12, p= 0.01, η^2= 0.16; t18: $F_{(1, 37)}$= 4.63, p= 0.04, η^2= 0.11). Those interaction effects were similar to those in the ANOVAs: non-helpless women had higher mean amplitudes than helpless women. Additionally, visual inspection indicated that helpless men showed more positive amplitudes than helpless women. Conversely, non-helpless women had more positive amplitudes than non-helpless men. Regarding the inner-subject factors, a significant condition effect emerged in four timeframes (t3: $F_{(1, 37)}$= 4.17, p= 0.05, η^2= 0.10; t4: $F_{(1, 37)}$= 4.83, p= 0.03, η^2= 0.12; t21: $F_{(1, 37)}$= 4.81, p= 0.04, η^2= 0.11; t22: $F_{(1, 37)}$= 6.63, p= 0.01, η^2= 0.15) with more positive mean amplitudes in the unsolvable condition. Furthermore, there were interaction effects between condition and performance in the same four timeframes (t3: $F_{(1, 37)}$= 7.52, p= 0.01, η^2= 0.17; t4: $F_{(1, 37)}$= 7.22, p= 0.01, η^2= 0.16; t21: $F_{(1, 37)}$= 6.44, p= 0.01, η^2= 0.15; t22: $F_{(1, 37)}$= 8.23, p= 0.01, η^2= 0.18). Interaction effects were also observed between the factors condition and gender in two timeframes (t21:

$F_{(1,37)}$=5.34, p=0.03, η^2= 0.13; t22: $F_{(1, 37)}$= 4.16, p= 0.05, η^2= 0.10) showing that female participants had significantly more positive SCP amplitudes in the unsolvable condition than in the solvable condition compared to male participants. Female subjects in the unsolvable condition showed the most positive mean amplitudes compared to the others. In comparison to the results from the ANOVAs, the ANCOVAs did not reveal as many main effects for location and hemisphere. In fact, there were location effects in only three timeframes (t6: $F_{(1.43, 52.95)}$= 8.70, p< 0.01, η^2= 0.19; t7: $F_{(1.36, 50.36)}$= 8.43, p< 0.01, η^2= 0.19; t10: $F_{(1.29, 47.73)}$= 4.13, p= 0.04, η^2= 0.10) and the other 17 timeframes did not reach significance (all ps> 0.06). With regard to the factor hemisphere, the analysis revealed significant main effects in six timeframes (t6: $F_{(1, 37)}$= 4.37, p= 0.04, η^2= 0.12; t7: $F_{(1, 37)}$= 5.88, p= 0.02, η^2= 0.14; t9: $F_{(1, 37)}$= 4.16, p= 0.05, η^2= 0.10; t17: $F_{(1, 37)}$= 3.98, p= 0.05, η^2= 0.09; t18: $F_{(1, 37)}$= 4.88, p= 0.03, η^2= 0.12; t20: $F_{(1, 37)}$= 5.79, p= 0.02, η^2= 0.14) and the other 14 timeframes did not reach significance (all ps> 0.06). However there were significant interaction effects between hemisphere and location in twelve timeframes (p< 0.05; exact values are listed in table 38 in the appendix). Corresponding to the results from the ANOVAs, SCPs in the frontal-right cluster showed the most positive amplitudes compared to the other electrode clusters.

11.6. Correlations

There were 26 significant correlations between different questionnaire scales. Most of them involve the scales from the PANAS. The PA-scale scores gathered pre-experimentally, correlated positively with feelings of aggression and depression. The PA-scale scores gathered post-experimentally correlated positively with feelings of aggression and negatively with feelings of demotivation as well as with passivity. NA scale values gathered pre-experimentally correlated positively with the globality scale for negative situations (ASF-E), the generality-scale for negative situations and the overall score for negative situations. The NA-scale scores gathered post-experimentally correlated positively with feeling upset, aggressive and depressed. The helplessness-score correlated positively with the NA-score gathered post-experimentally (r=0.35, p=0.02). The correlation coefficients range between 0.31 and 0.47. The exact values are all listed in Table 8 in the appendix.

There were also significant correlations (94 in total) between questionnaire scales and SCP-amplitudes in different electrode clusters for different conditions and different timeframes. It is remarkable that 71 of the significant correlations involved SCP-amplitudes for the unsolvable condition (condition 2). There was only one significant correlation with the helplessness score. Most of the significant correlations with SCP-amplitudes involved the PANAS-scales and the fantasy-scale from the SPF. There were nine significant negative correlations between SCP-amplitudes for solvable items in the medial-left-cluster, the medial-right-cluster and the posterior-left-cluster with the PA-scale scores gathered pre-experimentally. Twenty-three significant negative correlations were found between the PA-scale scores gathered post-experimentally and SCP-amplitudes in all clusters except the frontal-right-cluster (22 of 23 significant correlations included SCP-amplitudes for the unsolvable condition). The NA-scale scores gathered pre-experimentally correlated with SCP-amplitudes in 14 timeframes and in different electrode clusters (medial-left, medial-right, posterior-left, posterior-right). Five significant positive correlations have been found between the NA-scale scores gathered post-experimentally and SCP-amplitudes for the unsolvable condition in the frontal-left-cluster, in both medial- and posterior clusters. SCP-amplitude values in the frontal-right-cluster only correlated significantly with the empathy-scale (SPF): the correlations were positive and only involved the unsolvable condition. Three more significant, positive correlations between the empathy-scale and SCP-amplitudes were found in the frontal-right-cluster and in the posterior-right-cluster. The subscale "ability for empathy", which includes the empathy-scale, correlated significantly negatively with SCP-amplitudes in the frontal-left-cluster, both medial-clusters and the posterior-cluster. Moreover, there were 23 significant negative correlations between the fantasy-scale (SPF) and SCP-amplitudes for both conditions in the following clusters: frontal-left, both medial-clusters, posterior-left. All significant correlations with p-values are listed in tables 9-13 in the appendix.

11.7. sLORETA

As described above, the t-tests revealed no significant differences between the groups (helpless vs. non-helpless and female vs. male) regarding their activation patterns. By inspecting the grand means of each group visually, a salient similarity has been observed: they all had an almost identical activation pattern over the whole time range. In t1 (first 500 ms after stimulus onset) the activity was located in the frontal lobe (right hemisphere, middle frontal gyrus, BA 10) and then moved to BA 8 (superior frontal gyrus) at 1000 and 1500 ms. Between 1500 and 2000 ms the activity was still in the frontal lobe, but in BA 6 (superior frontal gyrus) and distributed in the left as well as in the right hemisphere. Between 2000 and 3000 ms the activity was in the parietal lobe (BA 1, postcentral gyrus and BA 2, postcentral gyrus) and then moved to the temporal lobe (BA22, middle temporal gyrus) at 3500 ms. Between 3500 and 4500 ms the activation was highest in the parietal lobe (BA 7, precuneus and superior parietal lobule) and then to the end it went to the frontal lobe (BA 10, medial frontal gyrus). It is notable that except for two timeframes (t4 and t10), the maximum activity found by sLORETA was located only in the right hemisphere.

Even though the differences between helpless and non-helpless subjects were not significant, the visual inspection showed that generally helpless subjects displayed higher activation patterns than those who didn’t become helpless. Only in the first 500 ms participants who weren’t classified as helpless showed more activation, whereas helpless participants had more activation over all other timeframes. Strongest activity in helpless subjects was found in parietal and occipital areas (best match at BA7, superior parietal lobule, t5, t=3.98, tkrit.=5.088, MNI coordinates: X= -10, Y= -70, Z=55).

There was only one t-value which was very close to the critical t-value and therefore is presented here: a t-test analyzed the difference between helpless subjects and non-helpless ones for unsolvable items and revealed a t-value of 4.48 (tkrit.=4.652, MNI coordinates: X= -45, Y= -20, Z= 50) at timeframe 8 (3500-4000ms). The best match was found in Brodmann area 3, in the postcentral gyrus of the parietal lobe and is illustrated (yellow colour) in figure 11. The figure shows that helpless subjects showed more activity in the areas that are red and yellow than non-helpless subjects.

Overall at all timeframes the same phenomenon occurs which has been described above: helpless subjects showed more activation compared to non-helpless subjects in the unsolvable condition. In the solvable condition a similar effect was observed.

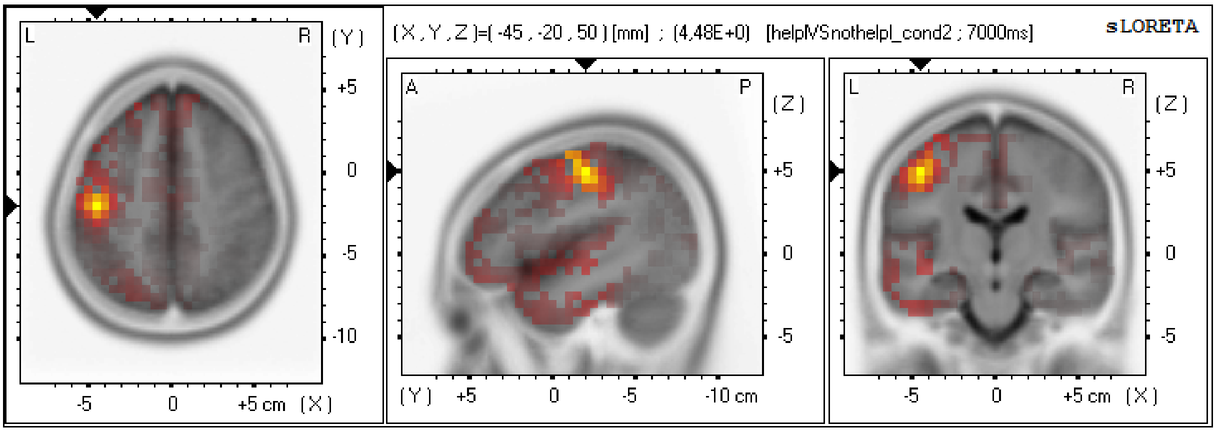

Figure 11. sLORETA image for helpless (yellow-red colour) vs. non-helplessness subjects at timeframe 8 (2500-4000 ms post-stimulus) showing a maximal activity at BA 3 in the postcentral gyrus of the parietal lobe.

Discussion

The main goal of the study was to investigate gender differences in neural activity during helplessness induction. We hypothesized that there would be significant SCP shifts between groups and conditions. We found a trend in the posterior electrode clusters that is in accordance with our assumptions: helpless participants showed positive slow cortical potential shifts in the unsolvable condition (helplessness induction) compared to the solvable condition (control phase). However, the observed trend could not be verified statistically. Thus, helpless and non-helpless participants also did not show any significant differences in their neural activity. The other hypotheses refer to gender differences: based on previous literature, we expected women to become more helpless than men and thus assumed that women would also show significant differences in their neural activity compared to men. Besides, we hypothesized that female subjects would be more emotionally reactive than male subjects. There were no significant gender differences regarding learned helplessness, but we found some differences between female and male participants in their SCP amplitudes. In accord with Bauer et al. (2003), women showed significant positive going SCP shifts in the unsolvable condition compared to men.

12. Behavioral and questionnaire data

Women solved significantly less items correctly than men did. However, this finding cannot be generalized and interpreted as a gender effect because we did not control possible confounding variables such as education, cognitive abilities (especially reasoning abilities) and profession. Thus it is unclear what really caused this difference between male and female subjects. Helpless and non helpless subjects did not differ regarding their performance on the solvable items. This finding indicates that both groups had similar reasoning abilities and that no group had an advantage or disadvantage due to its cognitive abilities.

As for the questionnaire data, there were only a few differences between the groups. It is surprising that none of the groups differed regarding their scores on the attributional style questionnaire and in regard to their SPF scores except for the distress scale. Helpless subjects showed significant higher distress values than non-helpless subjects. This finding can be interpreted considering the diathesis-stress model (Abramson et al., 1989) that proposes that people who are specifically vulnerable are more likely to get helpless, hopeless or depressed. In the present study participants who were more vulnerable to stress and became more stressed in different situations were affected by the helplessness induction, whereas people with lower distress scores were not affected and remained stable. It is remarkable that helpless subjects did not show any difference regarding their attributional styles in comparison to those who did not become helpless. According to the learned helplessness literature (Yee, Pierce, Ptacek & Modzelesky, 2003) the helpless explanatory style or attributional style represents a mediating mechanism between the experience of uncontrollable events and learned helplessness deficits. It has been assumed that the individual attributional style of a person can be a useful explanation for the fact that some people who experience uncontrollability develop helplessness symptoms and others do not. In the diathesis-stress model (Abramson et al., 1989) the depressogenic attributional style is a vulnerability factor for the development of depressive symptoms and deficits which are typical in learned helplessness. People having a depressogenic attributional style are more likely to make more stable and global attributions for negative life events and therefore we would have expected at least some differences in the scales concerning negative events in the ASF-E.

Equally there were no differences between men and women in our sample in regard to their attributional style. . Thus, our results do not support the gender difference effects reported in studies with children (Dweck et al. 1976, Erkut 1983, Stipeck 1984; as cited in Mikulincer, 1994, p.133; Dweck & Repucci, 1973). Those studies indicate that girls are more likely to make stable attributions for failure and that they attribute outcomes to their amount of effort less often than did boys. However, there is also research which does not support the gender hypothesis (e.g. Cemalcilar et al., 2003; Diener et al., 2010; Rozell et al., 1997) and our results can be deemed as an underpinning of this research.

Helpless participants had significantly more feelings of aggression and nervousness when they experienced uncontrollability in comparison to those who did not become helpless. However, anger and nervousness are not characteristic helplessness symptoms and they could be also classified as symptoms of reactance which is believed to have energizing properties and to enhance motivation (Meyer, 2000). This is quite the opposite of what happens in the state of learned helplessness: individuals who become helpless have been reported to have less motivation and show stronger passivity. Oddly, in our study helpless participants did not differ in their passivity scores from participants who did not become helpless. Passivity is one of the main symptoms in learned helplessness. Hence, according to the theory, helpless people should differ significantly from people who are not helpless. In this context, the question arises if our helplessness group really became helpless. The classification in the helpless group and non-helpless group was based on a cut-off score comprised of two items: feeling demotivated and feeling depressed when experiencing uncontrollability. It could be that, the cut-off score we used was too low and therefore people who did not really become helpless were included into the helpless group. There is also the possibility that some of the subjects who were classified as being helpless actually felt reactance and not helplessness. Moreover the passivity-score should have been included in the calculation of the helplessness-score as it is a major symptom of learned helplessness. Besides, the helplessness questionnaire used in our study has not been validated thoroughly and it is questionable if it measures the construct of learned helplessness correctly and reliably. According to the classical learned helplessness experiments, there should be a test-phase after the training-phase. However, our study only included a training-phase in which the control was withdrawn in order to induce helplessness. In a test-phase the performance of the subjects can be monitored and those subjects who become helpless usually show poorer performance on given tasks than those who do not become helpless. To get a more precise and more valid assessment of learned helplessness in subjects it may be advisable to include a test-phase and to assess the subjects' performance on similar and different tasks (in this case generality effects can be investigated).

If the group assignment was not correct, it would be a possible explanation for the lack of differences between helpless and non-helpless subjects regarding their attributional styles. Another point is that the attributional style is a factor that influences whether the state of learned helplessness in a person will manifest itself and/or generalize in other situations. Due to our study design we could not investigate such effects. It would be interesting to include additional test-phases a few days or weeks after the helplessness training in order to find out which subjects show symptoms of helplessness further on and which subjects generalize their learned helplessness to other situations.

Regarding the affect of our sample, only helpless subjects showed significant differences due to the helplessness induction: they showed significantly less positive affect and more negative affect after the helplessness induction. Besides, helpless subjects had significantly higher NA-scores before the experiment as well as after the experiment in comparison to non-helpless subjects. One could hypothesize that helpless subjects are generally more prone to negative affect or that negative affect reinforces the development of learned helplessness. Whether or not, it is likely that those subjects who had higher scores of the NA-scale before the helplessness training have been stronger affected by the training and therefore felt more depressed and demotivated after the training than other subjects.

13. Correlational Analysis

Correlational analysis revealed that positive affect before the training was positively associated with feelings of aggression and depression and that positive affect after the experiment was positively related with feelings of aggression. Those findings are baffling because positive affect is believed to be associated with positive feelings and not negative feelings such as aggression or depression. But on the other side high scores in positive affect after the training were associated with low scores in passivity and demotivation, which represents the mood changes after helplessness induction. Congruously, enhanced negative affect was related with enhanced scores of upset, depression and helplessness.

Besides two significant correlations with timeframes in the posterior-right cluster and one significant correlation in the frontal-left cluster, empathy scores (empathy-scale from the SPF, Paulus, 2008) correlated significantly with amplitudes in the frontal-right cluster (in six timeframes). As the correlations are positive, enhanced empathy scores are associated with enhanced (more positive) SCP-amplitudes in the frontal-right cluster. Interestingly there were no other significant correlations between any other questionnaire scales for this particular electrode cluster.

Another important finding was that questionnaire scores mostly correlated with amplitudes in the unsolvable condition were subjects were withdrawn of control. The scores correlated four times as much with SCP-amplitudes in the phase of helplessness induction as in the phase where subjects had control (23 of 94 significant correlations were correlations in the solvable condition). That means that questionnaire data is far more associated with SCP-amplitudes in the phase of withdrawal of control than in the phase in which subjects had control.

It has been revealed that the fantasy-scale scores correlated significantly negatively with 23 timeframes from different clusters (frontal-left, both medial-clusters, posterior-left): the higher the fantasy-score of a subject, the lower or more negative his or her SCP-amplitude. This is the opposite of the relation between empathy scores and the SCP-amplitudes. While the fantasy scale assesses the tendency to put oneself in the position of fictional characters (Paulus, 2009), the empathy scale measures warm-heartedness and the ability to have feelings for other people (Paulus, 2007). According to Paulus (2009), the fantasy scale also measures the intensity of emotionality. Therefore one could assume that people with higher scores on the fantasy scale are more emotional reactive: something we hypothesized, to be associated with positive SCP-amplitudes. However, the significant correlations with the fantasy scale demonstrate the opposite, namely an association with negative SCP-amplitudes. In contrary, but in accordance with our assumptions empathy-scale scores were associated with more positive SCPs, but only in frontal-right electrodes.

However, out of the 94 significant correlations, there was only one significant correlation between the helplessness-score and the electrophysiological data (posterior-left cluster, unsolvable condition, at 0-250ms post-stimulus). This finding is in accordance with the other results of our study which demonstrate a lack of significant differences between the groups of interest.

Regarding the association between affect and SCP-amplitudes, the analysis revealed that enhanced positive affect was solely related with lower (more negative) SCP-amplitudes. On the contrary, increasing negative affect was rather associated with higher (more positive) SCP-amplitudes (only two out of 19 significant correlations were negative). This is in line with our hypothesis, although we have rather expected significant correlations between SCPs and helplessness-related feelings (especially demotivation and depression).

Summarizing the results, it appears that our paradigm rather induced negative affect than learned helplessness.

14. Neuronal correlates

As already mentioned there were no significant main effects for gender or helplessness, but there was a trend which was observed by visual inspection of the grand mean average plots. In the posterior electrode clusters (left as well as right cluster) it appeared, that the amplitudes of helpless subjects in the unsolvable condition (withdrawal of control) were visibly higher (more positive) than those in the solvable condition. While the difference between the two phases was obvious in helpless subjects, participants who did not become helpless did not show similar differences in their SCP-amplitudes. From that observation we can conclude that people who were affected emotionally by withdrawal of control (demotivation and depression) were also affected on an electrophysiological level. In turn, people who did not respond emotionally to withdrawal of control and remained stable, also did not respond to withdrawal of control electrophysiologically. Certainly, the observed trend is congruent with the findings of Bauer et al. (2003) who reported positive SCP shifts for their helpless group. Furthermore, the statistical analysis revealed significant positive going SCP shifts for the unsolvable condition (helplessness induction) in the timeframes between 2500 ms and 3250 ms for the whole sample. Although post-hoc tests for the condition-effect (more positive SCPs in the unsolvable condition) were not significant, the results parallel the observed trend in helpless subjects and also correspond with findings in other studies (Bauer et al., 2003; Fretska et al., 1999). It has to be mentioned, that main effects for condition were also found when the covariate 'performance' was kept constant, which substantiates our findings. Because positive going SCP shifts are associated with a reduction of cortical activity, it can be concluded that subjects made less effort to solve the unsolvable items.

As similar effects for gender as well as for helplessness were hypothesized, it is interesting that the described trend in the posterior electrode cluster was the same for women and men: female participants showed visible differences in amplitude values between the conditions, just as helpless participants did. In male subjects however, we observed a similar pattern as in non-helpless subjects: their amplitude values did not differ very much dependent on the condition. Despite those observations that seem to be crucial, the statistical analysis (ANOVA) did not confirm the trend in the posterior clusters. However, when holding the covariate 'performance' constant, the analysis revealed that women showed significantly more positive going SCP-amplitudes in the unsolvable condition compared to men. It is interesting that we could not find a similar effect for helpless versus non-helpless females and males. As a matter of fact, the statistical analyses revealed a converse effect: helpless women appeared to have less positive SCP amplitudes compared to helpless men. Those results support the assumption that subjects may have been classified wrongly.

On account of the statistical results and of the fact that only posterior regions showed such a pattern, we cannot draw any further conclusions and future studies are needed that could replicate those findings. For that reason we want to concentrate on the main effects of our analyses of variance, which include the whole sample.

Across females and males, there were significant differences in SCP-amplitudes between different locations and hemispheres: there were main effects in the right hemisphere in nearly all timeframes indicating that the amplitudes in the right hemisphere were significantly higher than those in the left hemisphere. The other main effect which was observed in nearly all timeframes was an effect in the frontal clusters indicating that slow cortical potential amplitudes in frontal areas were higher in our sample compared to medial and posterior areas. However, the ANCOVA revealed, that performance had a significant influence on the SCPs, too, and the effects for location and hemisphere were diminished when taking performance as a covariate in to account.

There were also significant interaction effects in all timeframes which show that the SCP-amplitudes were significantly higher in the frontal-right cluster compared to other clusters. Overall, the electrodes in the frontal-right cluster were the most positive ones. The effect in the frontal-right cluster appears to be very strong as the ANCOVAs showed equal interaction effects in twelve timeframes.

Following the traditional interpretation of SCP shifts, positive going shifts equate with a decrease in cortical activity, which means that our sample showed reduced cortical activity over frontal and right hemisphere sites. Laterality effects would be expected while inducing negative emotions, but the literature points to increased activity in the right hemisphere during processing of negative emotions (e.g. Ahern & Schwartz 1979, 1985; Berthoz, Blair, Clec'h & Martinot, 2002; Harmon-Jones, 2004; Hecht, 2010) and not to a reduction of cortical activity. Those effects will be discussed more precisely in the next section where they will be compared to the results of the sLORETA-analysis.

When it comes to frontal activity, the results are controverse: Fretska et al. (1999) as well as Bauer et al. (2003) who used the same helplessness induction method as in the present study, reported that during withdrawal of control the scalp potential of the learned helplessness group became more negative at frontal sites. In accordance with those findings, Diener et al. (2009, 2010) report enhanced PINV (postimperative negative variation) magnitudes over frontal sites during uncontrollability. Previous research also showed enhanced PINV magnitudes in healthy subjects over frontal sites during an unexpected change from an escape paradigm to uncontrollability (Delaunoy et al., 1978; Elbert et al., 1982; Rockstroh et al., 1979; as cited in Diener et al., 2009, p. 190). Generally the empirical evidence indicates that uncontrollability is rather associated with enhanced negativity at frontal recording sites.

However, it has to be emphasized that the greater positivity for frontal sites in our study has been found in the whole sample including subjects who did not get demotivated or depressed by uncontrollability. For this reason we have to be cautious and cannot compare those results with findings that only include helpless subjects. Furthermore, the studies conducted by Fretska et al. (1999) and Bauer et al. (2003) had a different experimental design which included a training session prior to the recording as well as a longer helplessness training itself. In the training session prior to the recording, the subjects had to solve only simple, solvable numerical series to assure the subjects that the task was easy and solvable. Hence, the helplessness induction effects in those studies (Bauer et al., 2003; Fretska et al., 1999) may have been stronger than in our study.

The localization of the neuronal source with sLORETA did not reveal any differences between the groups or conditions. By inspecting the grand mean maps of each group we observed that they all showed the same activation pattern distributed over time. Thereby we noticed a striking laterality effect: except for two timeframes, the activity maxima were limited to the right hemisphere. Moreover we also found maximum activity in frontal regions in five of 10 timeframes. Frontal activity appeared especially in the first two seconds post-stimulus and then in the last 500 ms of the recording (4500-5000 ms post-stimulus). These findings do not match the results of the SCP-analysis which revealed main effects for reduced frontal and right-hemisphere activity and therefore represent a striking contrast.

The previous research investigating helplessness – or more generally speaking – uncontrollability (Bauer et al., 2003; Diener et al., 2009, 2010; Fretska et al., 1999), did not find any laterality effects, although Schneider et al. (1996) expected to find greater right hemispheric activation during learned helplessness induction. This assumption derived from a number of studies that demonstrated right hemisphere dominance in emotional processing (Ahern & Schwartz, 1985; Tucker, 1981; Berthoz et al., 2002), especially for negative emotions (Hecht 2010, Harmon-Jones, 2004; Natale, Gur, & Gur, 1983). It is a well reported observation that the two halves of the brain are differently involved in emotional processing and behavior and lots of research has been done on this particular topic. Nevertheless, results are quite inconsistent. While some authors argue that there is a quantitative difference with the right hemisphere having a relative dominance for emotional responding (e.g. Ross 1984, Ruckdeschel-Hibbard, Gordon & Diller 1984; as cited in Berthoz et al., 2002, p. 195), other authors support the qualitative difference-hypothesis, claiming that each hemisphere is specialized in processing positive or negative emotions (e.g. Ahern & Schwartz 1979; 1985, Sackeim et al. 1982; as cited in

Berthoz et al., 2002, p.195). Hecht (2010) claims that right hemisphere activity is generally associated with processing that involves negative emotions such as pessimism, negative thinking patterns, guilt or self-blame thoughts. Harmon-Jones (2004, p. 51) outlines that previous research suggested “that left frontal brain activity is associated with positive emotions and approach behavior and right frontal brain activity is associated with negative emotions and withdrawal behavior”. Although Harmon-Jones (2004) as well as Harmon-Jones, Gable and Peterson (2010) doubt that stronger left frontal activity is always associated with positive emotions, it is established from the previous findings that stronger right frontal brain activity is associated with withdrawal-related negative emotions and withdrawal motivational processes in general. Additionally there is empirical evidence for a hyperactive right hemisphere in depression (Hecht, 2010). Since depressed mood is a main symptom of learned helplessness and the majority of our subjects reported that they felt depressed during the helplessness induction, greater right hemisphere activity would be expected. However, with respect to our study, we cannot support those findings as the SCP analysis showed statistically significant reduction of cortical activity in the right hemisphere despite the fact that sLORETA showed the opposite. This is because SCPs constitute a more exact measure of cortical activity than the results of sLORETA. Generally, neuronal source localization of EEG measures is problematic and too uncertain when only based on EEG data (Luck, 2005). sLORETA has been widely criticized by different authors, claiming that exact localization can only be achieved under ideal conditions of no noise (Cao & Slobounov, 2010; Khemakhem, Ben Hamida, Feki & Taleb-Armed, 2008). In reality, however, there is always some kind of noise and EEG artifacts such as heart beating and eye blinks significantly contaminate the correct estimation of the source distribution (Cao & Slobounov, 2010). Other authors point out that the sLORETA technique is rather appropriate for assessing the center of an area of activation, but is not appropriate for assessing the extent of activation (Luck, 2005). Moreover, weak or deep sources may remain invisible as well as nearby sources tend not to be separated (Wagner, Fuchs & Kastner, 2004). Therefore they are interpreted as one source or as false or false-positive sources around the actual source (Sakomoto et al., 2010).

Enhanced frontal activity can be linked to working memory processes. Generally the term working memory refers to temporary storage of information that is limited in its capacity and that requires constant repetition. Referring to the task in our study, such working memory processes are required in order to solve the task and to find a solution. Neuroscientific research in the last decades showed that working memory processes are associated with prefrontal cortex activity (e.g. Bear, Connors, Paradiso & Engel, 2008; Curtis & D'Esposito, 2003; Passingham & Sakai, 2004). Curtis and D'Esposito (2003, p. 415) describe the prefrontal cortex as the "the most important substrate for working memory" The first experiments indicating such an association involved monkeys performing delayed response tasks. Those experiments revealed sustained prefrontal activity during the retention interval of delayed response tasks. Furthermore, big lesions in the prefrontal cortex lead to significantly worse performance in delayed response tasks (Bear et al., 2008, Curtis & D'Esposito, 2003).

Subjects in our study showed maximum prefrontal activity (Brodman Area 10) in two timeframes: right after stimulus-onset and between 4500 and 5000 ms at the end of the recording. Interestingly, recent studies indicate that the prefrontal cortex is especially involved in such working memory processes that involve problem solving and action planning. Empirical evidence comes from lesion studies in humans, which demonstrate that subjects with prefrontal lesions show even better performance in simple retrieving tasks in comparison to subjects with temporal lobe lesions. However, subjects with prefrontal lesions have substantial deficits when they are confronted with complex memory tasks (Bear et al., 2008). Additionally, it is important to emphasize that sustained activity in working memory tasks has also been found in other cortical areas such as the parietal cortex (Passingham & Sakai, 2004), which were activated in subjects of our study too. In contrary to the sLORETA analysis, the results of the SCP analysis revealed reduced activity in frontal areas and therefore indicate that working memory processes were reduced while processing the task. That may have been the result of the helplessness induction with unsolvable items as subjects became passive and made less effort to solve the items.

We observed maxima of parietal activity (sLORETA) in four of ten timeframes in our sample. These observations are not surprising as they are in accord with research findings from numerical-processing studies (e.g. Dehaene et al., 1996; Dehaene, Piazza, Pinel & Cohen, 2003). The involvement of the parietal cortex has been first described in lesion studies and following research discovered systematic activation of the parietal lobes during calculation (Dehaene et al., 2003). Those findings have been replicated in numerous studies using PET (e.g. Dehaene et al. 1996, Pesenti et al. 2000; Zago et al. 2001; as cited in Dehaene et al., 2003, p.488) and fMRI (e.g. Burbaud et al. 1999; Rueckert et al. 1996; as cited in Dehaene et al., 2003, p.488).

However, as already mentioned above, sLORETA results have only small empirical significance and should not be interpreted without taking other, more reliable measures into account.

15. Conclusion

Regarding the neuronal source localization there is inconclusive data from different studies. While the ACC appears to play a crucial role in the development of learned helplessness in some studies, it has not even been mentioned in the study by Schneider et al. (1996) which is the only study using neuro-imaging. Furthermore, the EEG-studies which report an involvement of the ACC in learned helplessness show mixed results: while Bauer et al. (2003) found a significant decrease in ACC activity in the helplessness induction-condition, Diener et al. (2010) reported a significant increase of ACC activation. Both studies used low resolution tomography techniques (LORETA, respectively sLORETA). In order to elucidate those inconclusive findings, it is important to conduct helplessness-studies with neuro-imaging techniques such as PET and fMRI.

In summary, it can be stated that we couldn't observe any substantial differences between helpless subjects and non helpless subjects. In the context of previous research it is unusual that we couldn't find any differences between those groups. It is arguable whether helplessness has been assessed properly and if the subjects were thus assigned correctly to the particular group. However, there was a trend indicating that more women became helpless than men. EEG- data provided significant differences between male and female participants, although the effects were mixed, which may be due to a potential false classification regarding helplessness. Women showed significant positive going SCP shifts for unsolvable tasks compared to men, which parallels the findings of Fretska et al. (1999) and Bauer et al. (2003).

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Appendix

Abstract (English)

Learned helplessness emerges when individuals do not have any expectancy of control any more and therefore become passive. So far only a few studies have dealt with the question how learned helplessness is associated with neuronal processes. EEG studies (Bauer et al., 2002; Fretska et al., 1999) showed that helpless subjects had significant positive going slow cortical potential shifts (SCP-shifts) during helplessness induction compared to the control phase. Furthermore, the studies indicated that women became more helpless or more often helpless than men. Moreover, analysis of neuronal source localization with LORETA demonstrated a significant decrease in activity of the anterior cingulate cortex (ACC) during helplessness.

Based on the study of Bauer et al. (2003), the present study investigated SCPs in 42 subjects (23 females). Helplessness was induced by unolvable numerical series and was assessed via a score from the helplessness questionnaire (Bauer et al., 2003).

Data analysis revealed that overall 57.1 % of the participants became helpless. Although slightly more women became helpless (63.2%) than men (52.2%), this effect was not significant. Helpless subjects showed positive going SCP shifts during the helplessness induction compared to non-helpless subjects. However these trends were only limited to posterior regions and were statistically not significant. Female participants though, showed significant positive going SCP shifts in the unsolvable condition (helplessness induction) which is consistent with the findings of Fretska et al. (1999) and Bauer et al. (2003). For the whole sample, SCPs appeared to be most positive in frontal-right electrodes. The neuronal source localization analysis with sLORETA did not reveal any significant differences between the groups (helpless and non helpless subjects, male and female) and could not confirm the findings of Bauer et al. (2003).

Abstract (German)

Erlernte Hilflosigkeit tritt auf wenn ein Individuum keine Erwartung mehr hat Kontrolle ausüben zu können und dadurch passiv wird. Der Frage wie Hilflosigkeit mit neuronalen Prozessen zusammen hängt sind bisher nur wenige Studien nachgegangen. EEG-Studien (Bauer et al., 2002; Fretska et al., 1999) zeigten dass hilflose Personen signifikant positive Veränderungen der langsamen kortikalen Potentiale während der Hilflosigkeitsinduktion aufwiesen im Vergleich zur Kontrollbedingung. Darüber hinaus gab es Hinweise darauf dass Frauen eher zu Hilflosigkeit neigen und auch auf neuronaler Ebene signifikante Veränderungen zeigen im Vergleich zu den Männern die eher weniger emotional reagierten. Die Analyse der neuronalen Quellenlokalisation mit LORETA wies auf eine erniedrigte Aktivität des anterioren cingulären cortex (ACC) während der Hilflosigkeitsinduktion hin. Die vorliegende Studie untersuchte angelehnt an Bauer et al. (2003) langsame kortikale Potentiale bei Personen die hilflos wurden und Personen die nicht hilflos wurden. Hilflosigkeit wurde mit Hilfe von unlösbaren Zahlenreihenaufgaben induziert und die Hilflosigkeitsklassifikation wurde anhand eines Scores aus dem Hilflosigkeitsfragebogen (Bauer et al., 2003) ermittelt. Insgesamt wurden 57,1 % der Teilnehmer hilflos. Obwohl etwas mehr Frauen (63,2 %) als Männer (52,2%) hilflos wurden, war dieser Effekt nicht signifikant. Hilflose zeigten Veränderungen ihrer langsamen kortikalen Potentiale in Richtung Positivität während der Phase der Hilflosigkeitsinduktion im Vergleich zu nicht hilflosen Personen. Dieser Trend stellte sich als statistisch nicht signifikant heraus. Jedoch ergaben sich Geschlechtsunterschiede in der Hinsicht, dass Frauen signifikant positivere langsame kortikale Potenziale während der Bearbeitung unlösbarer Aufgaben zeigten. Diese Ergebnisse stimmen mit den Studien von Fretska et al. (1999) und Bauer et al. (2003) überein. Für die gesamte Stichprobe hat sich gezeigt dass langsame kortikale Potenziale am positivsten in den Elektroden frontal-rechts waren. Die Analyse der neuronalen Quellenlokalisation mit sLORETA brachte keine signifikanten Unterschiede zwischen den einzelnen Gruppen (hilflos und nicht hilflos, Männer und Frauen) und konnte somit das Ergebnis von Bauer et al. (2003) nicht bestätigen.

Questionnaire data

Items	Group	Mean	SD
Personal importance of good overall performance in the experiment	helpless	3.88	0.69
	non helpless	3.94	0.87
	male	4.00	0.60
	female	3.79	0.92
Personal importance of solving at least some of the difficult tasks	helpless	4.04	0.68
	non helpless	4.11	0.90
	male	4.22	0.52
	female	3.89	1.15
If you couldn't solve any tasks in the long run, how did you feel?			
→Feeling nervous	helpless	2.38	1.01
	non helpless	1.66	0.91
	male	2.17	1.11
	female	1.95	0.91
→Feeling aggressive	helpless	2.38	1.01
	non helpless	1.66	0.91
	male	2.17	1.11
	female	1.95	0.91
→Feeling depressed	helpless	3.96	0.62
	non helpless	2.33	0.90
	male	3.04	1.15
	female	3.53	1.02

→Feeling demotivated	helpless	4.13	0.61
	non helpless	2.55	0.98
	male	3.30	1.10
	female	3.63	1.12
→Feeling passive	helpless	3.42	1.02
	non helpless	3.11	1.18
	male	3.17	1.03
	female	3.42	1.17

Table 3. Scores from the helplessness questionnaire (Bauer et al., 2003).

ASF-E-scores			
Group	Scale	Mean	SD
Helpless	Internality-positive situations	75.25	10.87
	Stablility-positive situations	78.04	14.65
	Globality-positive situations	80.88	14.19
	Generality-positive situations	158.92	23.22
	Overall score-positive situations	234.17	31.83
	Internality-negative situations	64.54	11.758
	Stablility-negative situations	67.29	15.99
	Globality-negative situations	58.92	14.79
	Generality-negative situations	126.21	25.25
	Overall score-negative situations	190.75	31.430
	Internality-positive situations	77.27	8.15
	Stablility-positive situations	78.83	10.70

Non-helpless	Globality-positive situations	76.11	10.80
	Generality-positive situations	154.94	18.35
	Overall score-positive situations	232.22	23.65
	Internality-negative situations	69.2	11.44
	Stablility-negative situations	65.56	13.49
	Globality-negative situations	52.72	14.40
	Generality-negative situations	118.28	22.14
	Overall score-negative situations	187.50	28.96

Table 4. Mean scores and standard deviation values for the helpless- and non-helpless-group in the ASF-E (Attributionsstilfragebogen für Erwachsene).

SPF-scores			
Group	Scale	Mean	SD
Non-helpless	Fantasy	13.11	2.61
	Perspective taking	15.27	2.78
	Empathy	14.00	3.07
	Distress	7.72	2.72
	Ability for empathy	42.38	6.20
	Overall score	34.66	5.94
Helpless	Fantasy	14.16	2.71
	Perspective taking	15.33	2.21
	Empathy	15.62	2.06
	Distress	10.37	3.34
	Ability for empathy	45.12	4.42
	Overall score	34.75	5.62

Table 5: Mean scores and standard deviation values of the SPF (Saarbrückener Persönlichkeitsfragebogen) for helpless and non-helpless participants.

Grand Mean Average 2D-Plots:

Notice: different scalings of plots need to be regarded.

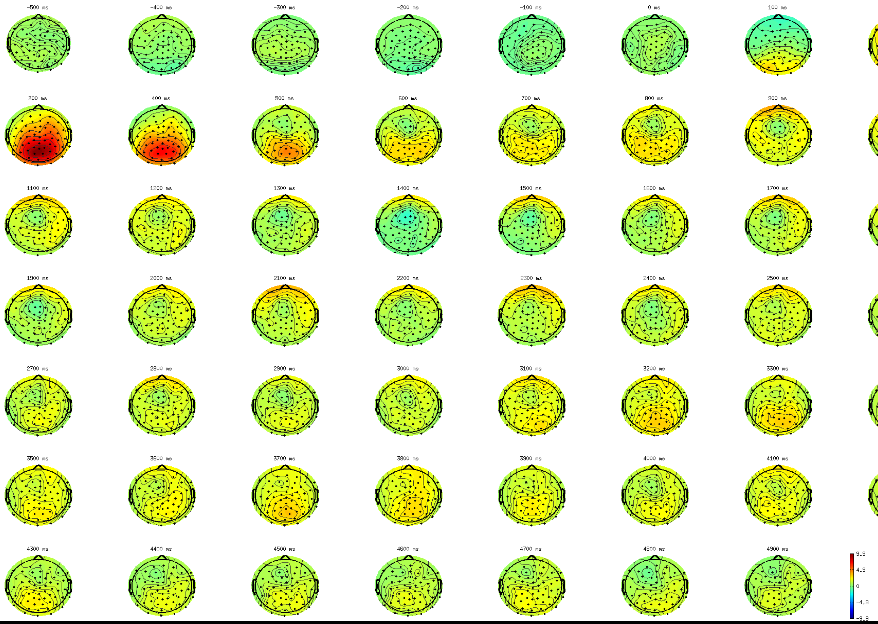

Figure 12. Grand Mean Average 2D-Plot for non-helpless subjects processing solvable tasks (time range: 500 ms pre-stimulus baseline and 5000 ms post-stimulus with a step size of 500 ms).

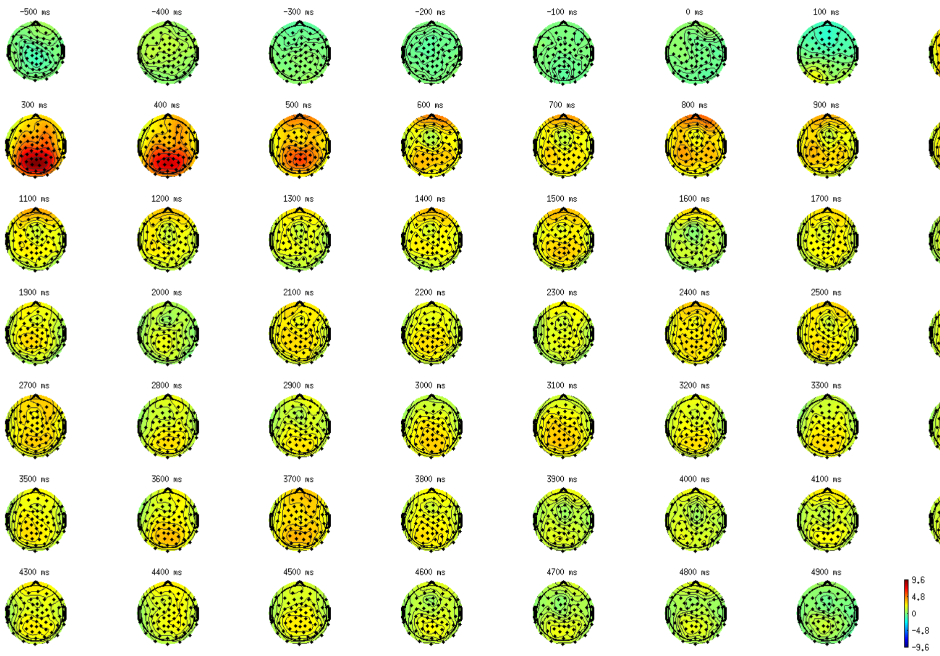

Figure 13. Grand Mean Average 2D-Plot for non-helpless subjects processing unsolvable tasks (time range: 500 ms pre-stimulus baseline and 5000 ms post-stimulus with a step-size of 500 ms).

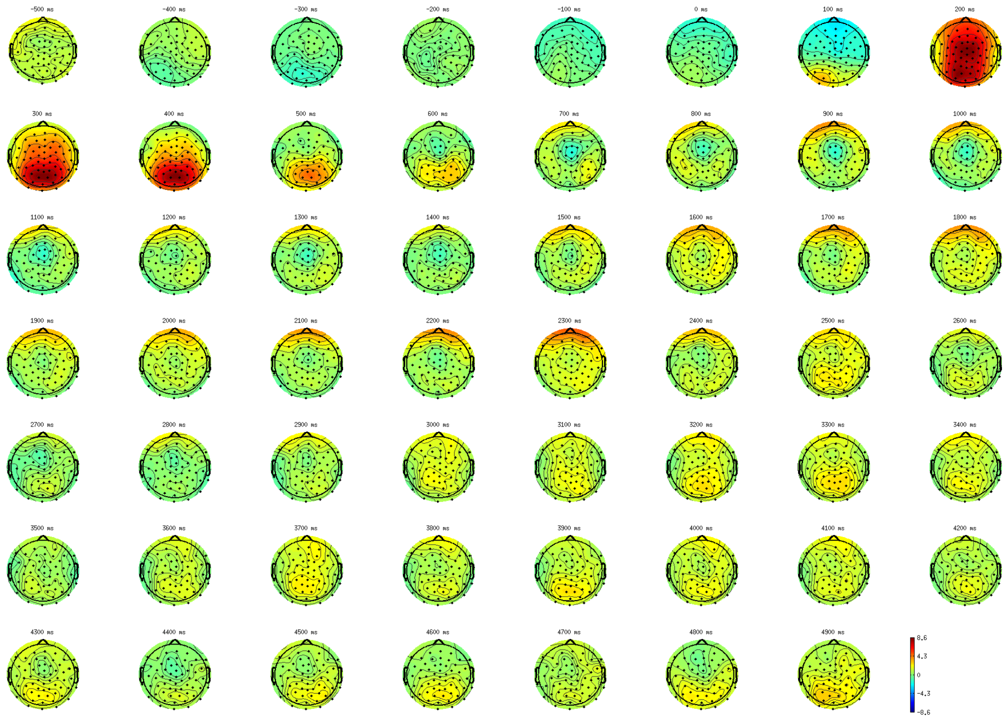

Figure 14. Grand Mean Average 2D-Plot for female subjects processing solvable tasks (time range: 500 ms pre-stimulus baseline and 5000 ms post-stimulus with a step-size of 500 ms).

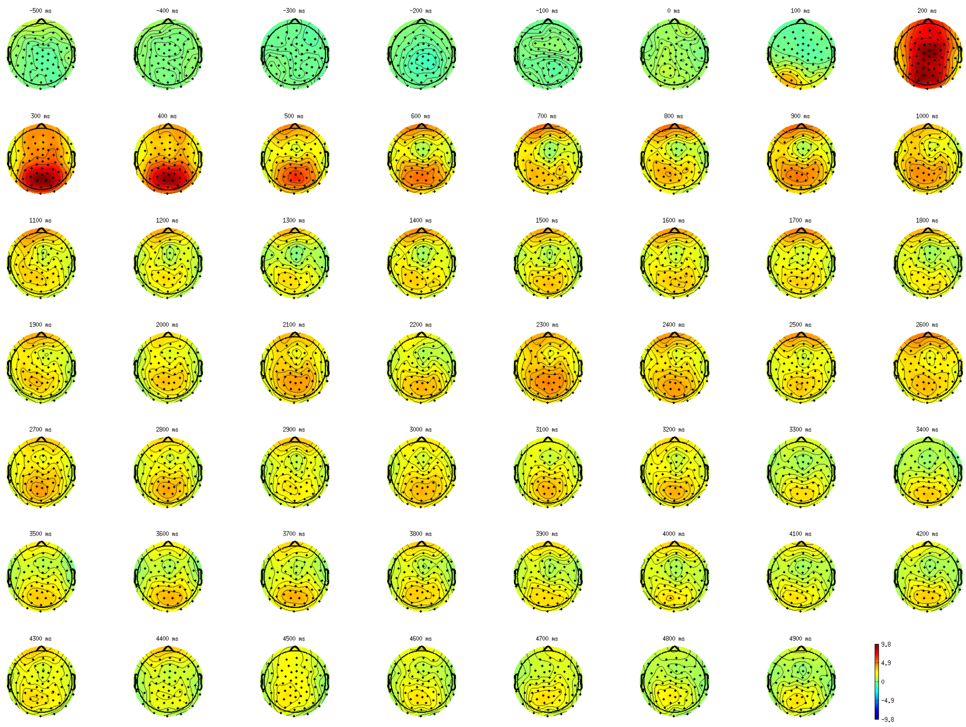

Figure 15. Grand Mean Average 2D-Plot for female subjects processing unsolvable tasks (time range: 500 ms pre-stimulus baseline and 5000 ms post-stimulus with a step-size of 500 ms).

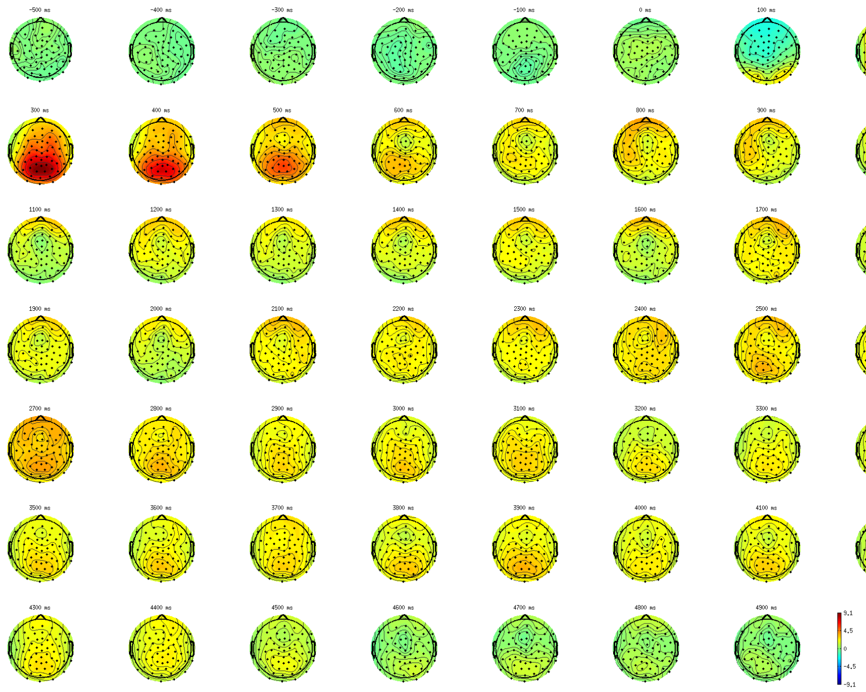

Figure 16. Grand Mean Average 2D-Plot for male subjects processing unsolvable tasks (time range: 500 ms pre-stimulus baseline and 5000 ms post-stimulus with a step-size of 500 ms).

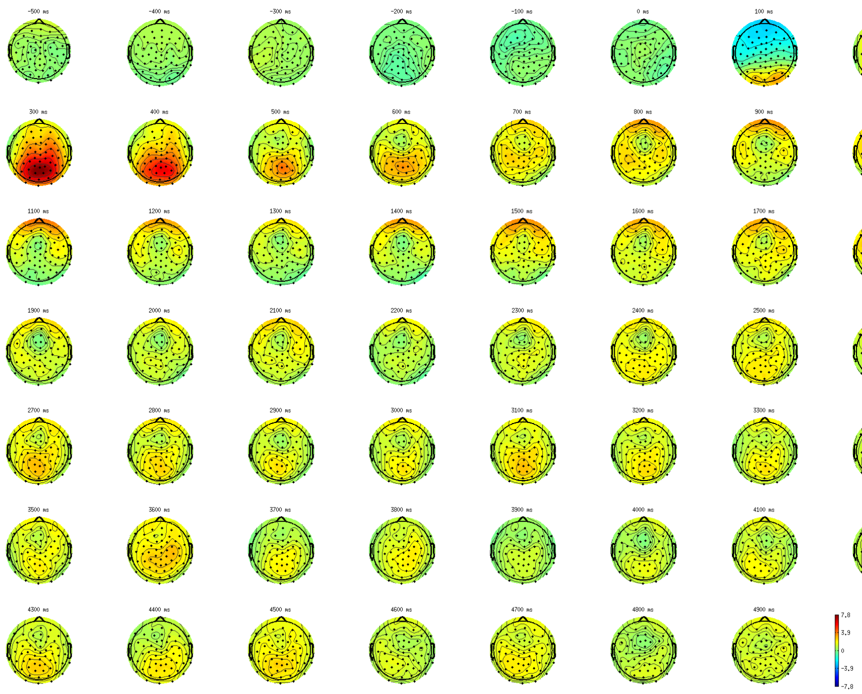

Figure 17. Grand Mean Average 2D-Plot for male subjects processing solvable tasks (time range: 500 ms pre-stimulus baseline and 5000 ms post-stimulus with a step-size of 500 ms).

Grand Mean Average Plots

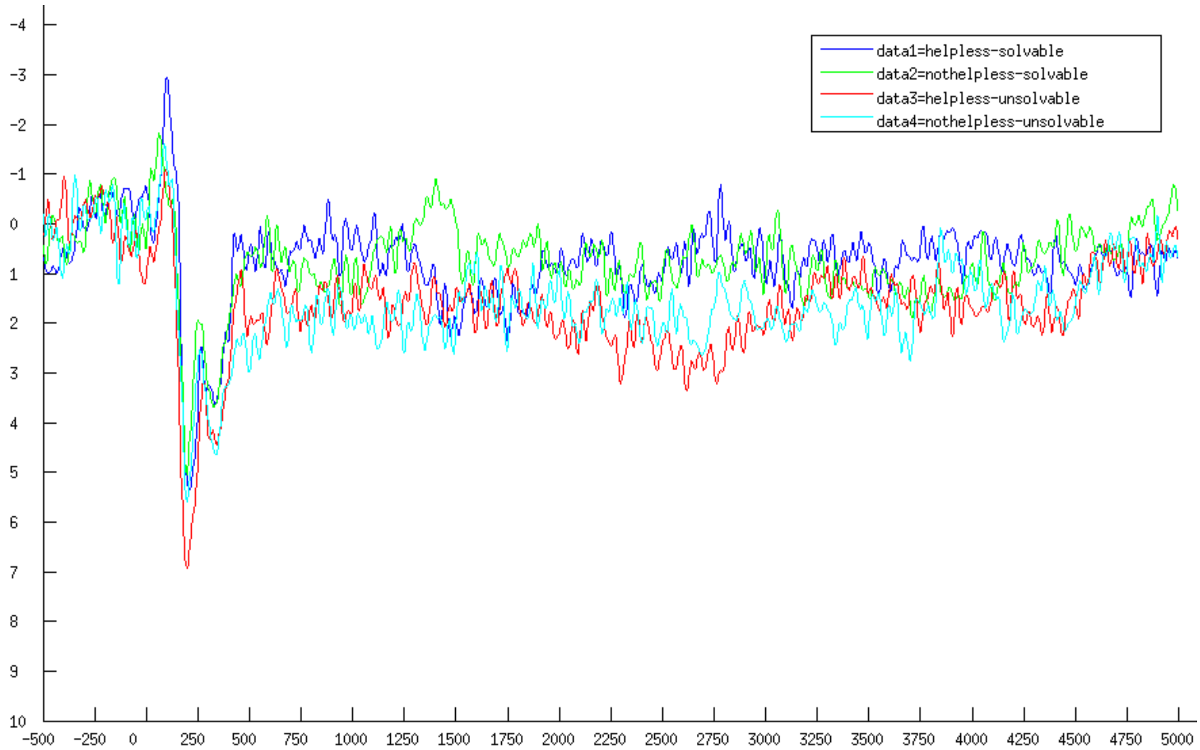

Figure 18. Grand Mean Plot for helpless vs. non-helpless subjects in the frontal-left

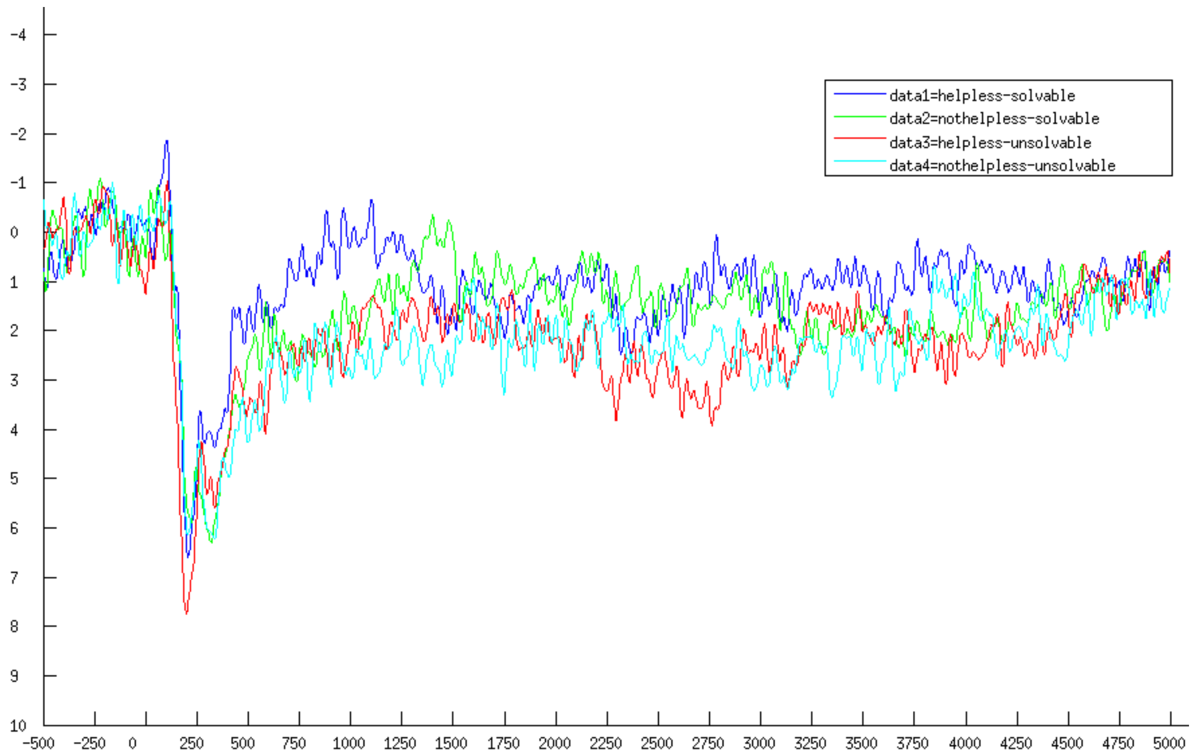

Figure 19. Grand Mean Plot for helpless vs. non-helpless subjects in the medial-left electrode cluster.

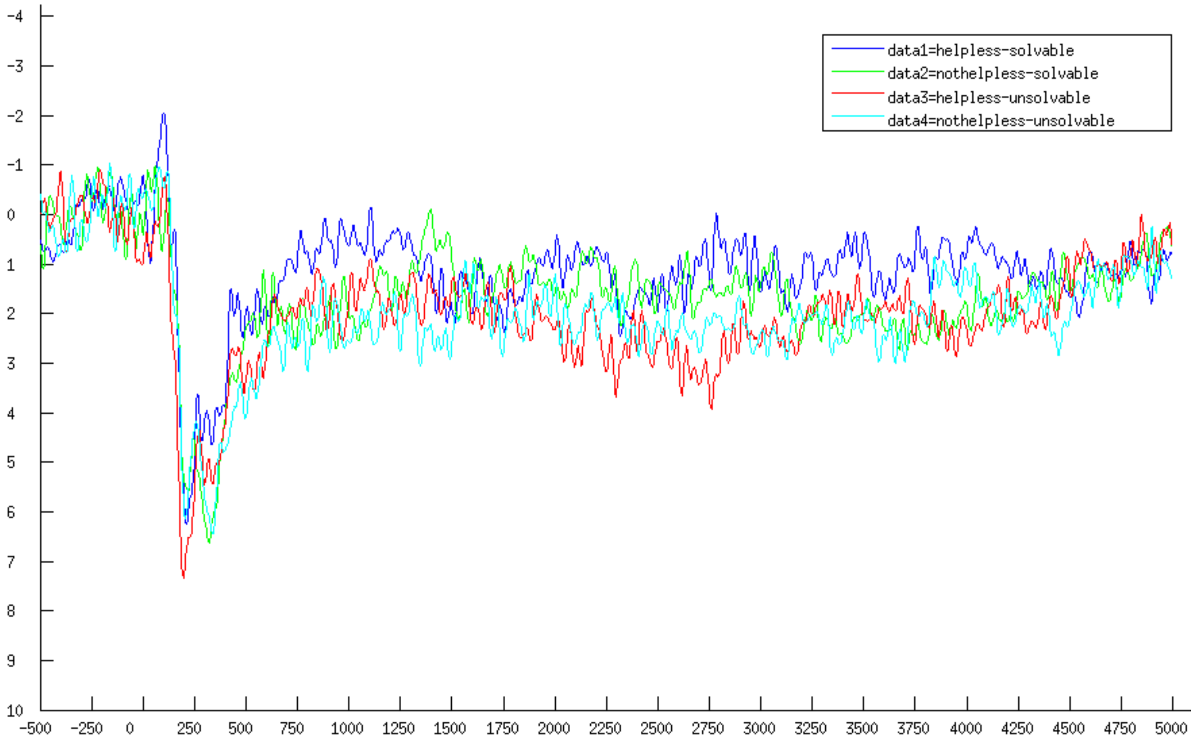

Figure 20. Grand Mean Plot for helpless vs. non-helpless subjects in the medial-right electrode cluster.

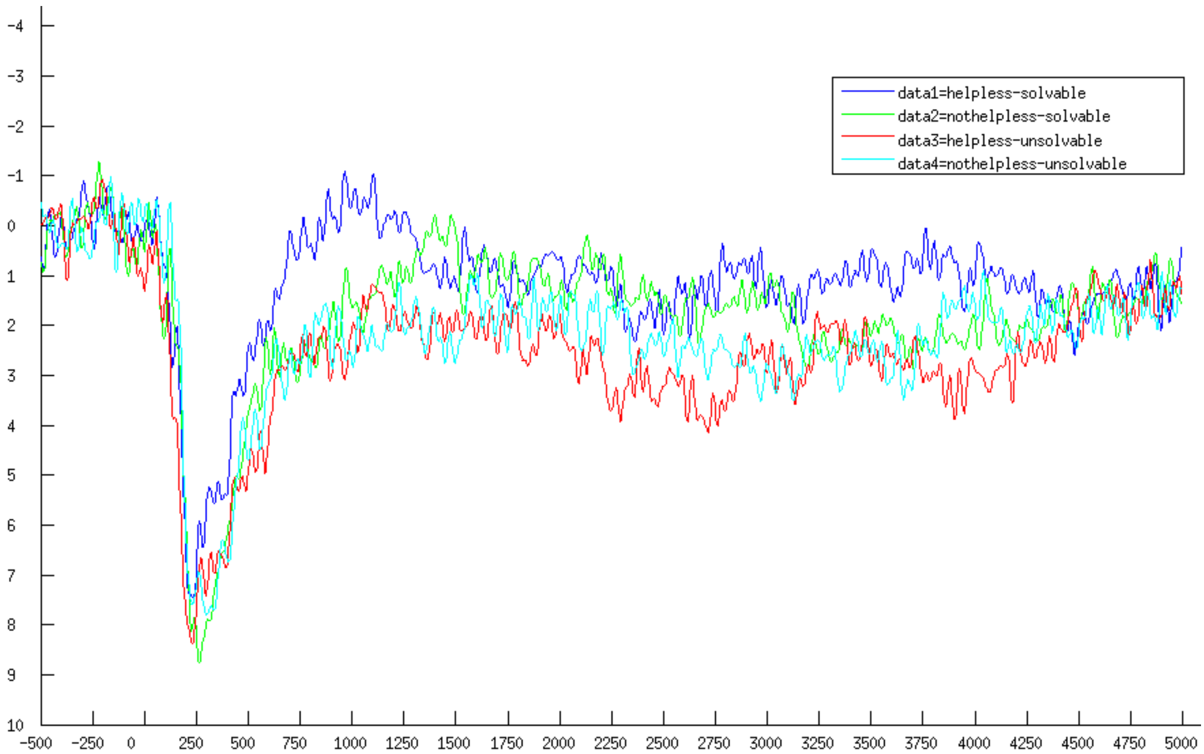

Figure 21. Grand Mean Plot for helpless vs. non-helpless subjects in the posterior-left electrode cluster.

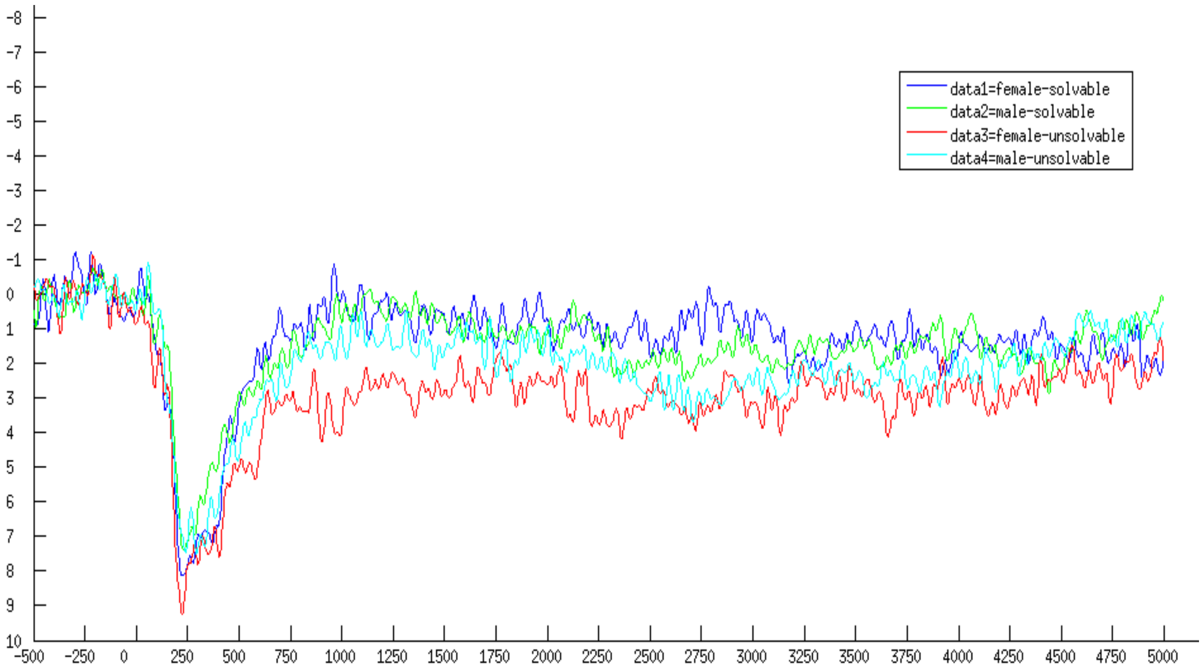

Figure 22. Grand Mean Plot for female vs. male subjects in the posterior-left electrode cluster.

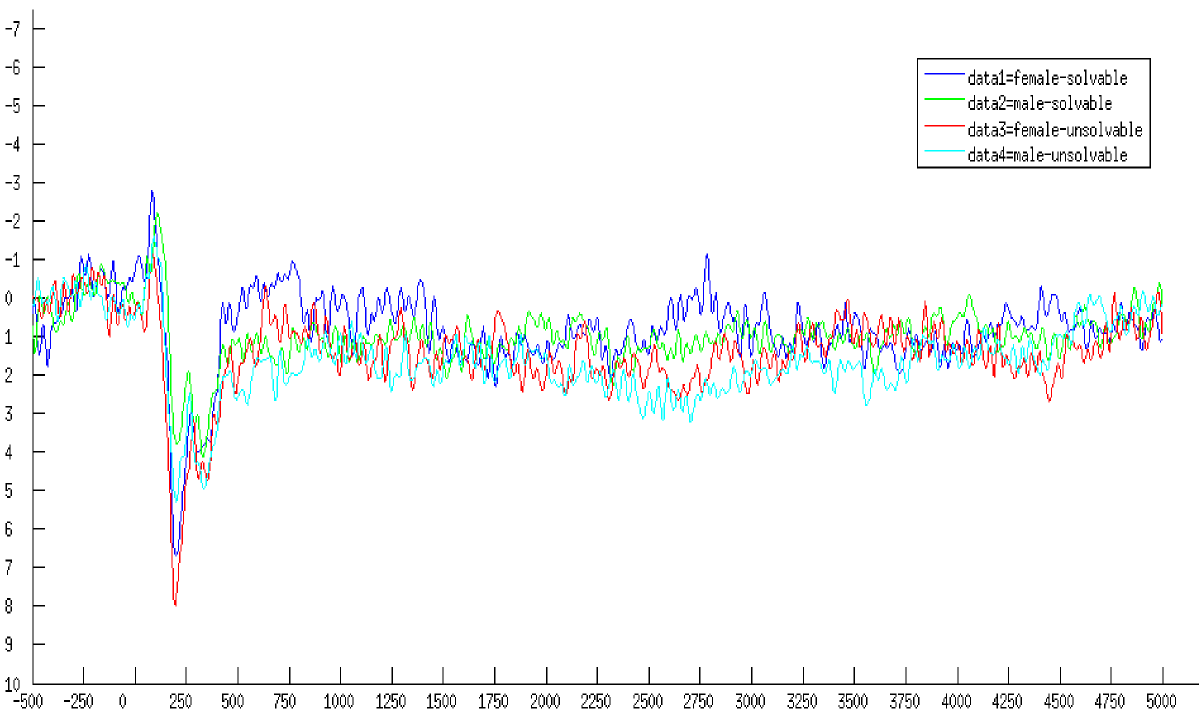

Figure 23. Grand Mean Plot for female vs. male subjects in the frontal-right electrode cluster.

T1=0-248 ms of baseline (pre-stimulus)	T12=2232-2480ms post-stimulus
T2=248-496 ms of baseline (pre-stimulus)	T13=2480-2728 ms post-stimulus
T3=0-248 ms post-stimulus	T14=2728-2976 ms post-stimulus
T4=248-496 ms post-stimulus	T15=2976-3224 ms post-stimulus
T5=496-744 ms post-stimulus	T16=3224-3472 ms post-stimulus
T6=744-992 ms post-stimulus	T17=3472-3720ms post-stimulus
T7=992-1240 ms post-stimulus	T18=3720-3968 ms post-stimulus
T8=1240-1488 ms post-stimulus	T19=3968-4216 ms post-stimulus
T9=1488-1736 ms post-stimulus	T20=4216-4464 ms post-stimulus
T10=1736-1984 ms post-stimulus	T21=4464-4712 ms post-stimulus
T11=1984-2232 ms post-stimulus	T22=4712-4960 ms post-stimulus

*Table 6.*Timeframes used in the statistical analysis.

Significant correlations

Correlations between questionnaire scales		
	Significance (p-value)	Pearson-correlation ®
Upset X NA after	0.003	0.450
Aggression X PA before	0.026	0.344
Aggression X PA after	0.046	0.310
Aggression X NA after	0.000	0.530
Depression X PA before	0.024	0.347
Depression X NA after	0.026	0.343
Demotivation X PA after	0.014	-0.378

Passivity X PA after	0.012	-0.386
Helplessness X NA after	0.022	0.351
Internality-positive situations X distress	0.008	-0.401
Internality-positive situations X overall score SPF	0.018	0.362
Stability-positive situations X perspective taking	0.007	0.413
Stability-positive situations X ability for empathy	0.044	0.312
Stability-positive situations X overall score SPF	0.004	0.439
Globality-positive situations X perspective taking	0.019	0.361
Globality-negative situations X NA before	0.017	0.366
Globality-negative situations X distress	0.031	0.333
Generality-positive situations X perspective taking	0.022	0.474
Generality-positive situations X ability for empathy	0.016	0.371
Generality-positive situations X overall score SPF	0.002	0.455
Overall score-positive situations X perspective taking	0.003	0.445
Overall score-positive situations X ability for empathy	0.037	0.323
Overall score-positive situations X overall score SPF	0.002	0.464
Generality-negative situations X NA before	0.045	0.311
Overall score-negative situations X NA before	0.046	0.310
Empathy X distress	0.020	0.357

Table 7. Significant correlations between questionnaire scores.

Correlations between questionnaire scales and SCP-amplitudes in the frontal-left cluster		
	Significance (p-value)	Pearson-correlation ®
PA after X t9_frontleft_cond2	0.046	-0.309
PA after X t10_frontleft_cond2	0.033	-0.330
PA after X t12_frontleft_cond2	0.034	-0.328
PA after X t13_frontleft_cond2	0.043	-0.313
PA after X t14_frontleft_cond2	0.037	-0.323
PA after X t15_frontleft_cond2	0.022	-0.352
PA after X t16_frontleft_cond2	0.015	-0.372
NA after X t3_frontleft_cond2	0.038	0.321
Fantasy X t14_frontleft_cond1	0.018	-0.362
Fantasy X t4_frontleft_cond2	0.010	-0.392
Fantasy X t5_frontleft_cond2	0.043	-0.313
Fantasy X t19_frontleft_cond2	0.008	-0.406
Fantasy X t20_frontleft_cond2	0.038	-0.321
Fantasy X t21_frontleft_cond2	0.030	-0.336
Empathy X t21_frontleft_cond2	0.030	0.336
Ability for empathy X t14_frontleft_cond1	0.032	-0.332
Overall score-SPF X t13_frontleft_cond1	0.048	-0.307

Table 8. Significant correlations between questionnaire scales and SCP-amplitudes in the frontal-left cluster.

Correlations between questionnaire scales and SCP-amplitudes in the frontal-right cluster		
	Significance (p-value)	Pearson-correlation ®
Empathy X t8_frontright_cond2	0.039	0.320
Empathy X t9_frontright_cond2	0.037	0.324
Empathy X t10_frontright_cond2	0.032	0.331
Empathy X t12_frontright_cond2	0.05	0.304
Empathy X t21_frontright_cond2	0.036	0.324

Table 9. Significant correlations between questionnaire scales and SCP-amplitudes in the frontal-right cluster.

Correlations between questionnaire scales and SCP-amplitudes in the medial-left cluster		
	Significance (p-value)	Pearson-correlation ®
PA before X t3_medialeft_cond1	0.012	-0.384
PA before X t22_medialeft_cond1	0.029	-0.337
PA after X t4_medialeft_cond1	0.038	-0.321
PA after X t13_medialeft_cond2	0.036	-0.325
PA after X t14_medialeft_cond2	0.036	-0.324
PA after X t15_medialeft_cond2	0.013	-0.379
PA after X t16_medialeft_cond2	0.021	-0.356
NA before X t3_medialeft_cond1	0.044	-0.313
NA before X t5_medialeft_cond2	0.042	0.316
NA after X t3medialeft_cond2	0.023	0.350

Fantasy X t14_medialeft_cond1	0.008	-0.407
Fantasy X t15_medialeft_cond1	0.045	-0.311
Fantasy X t4_medialeft_cond2	0.004	-0.440
Fantasy X t5_medialeft_cond2	0.049	-0.306
Fantasy X t7_medialeft_cond2	0.029	-0.336
Fantasy X t8_medialeft_cond2	0.023	-0.351
Fantasy X t18_medialeft_cond2	0.042	-0.315
Fantasy X t19_medialeft_cond2	0.003	-0.441
Fantasy X t20_medialeft_cond2	0.022	-0.352
Fantasy X t21_medialeft_cond2	0.033	-0.330
Ability for empathy X t13_medialeft_cond1	0.011	-0.388
Ability for empathy X t14_medialeft_cond1	0.009	-0.397
Ability for empathy X t15_medialeft_cond1	0.040	-0.318
Overall score-SPF X t13_medialeft_cond1	0.016	-0.368

Table 10. Significant correlations between questionnaire scales and SCP-amplitudes in the medial-left cluster.

Correlations between questionnaire scales and SCP-amplitudes in the medial-right cluster		
	Significance (p-value)	Pearson-correlation ®
PA before X t4_mediaright_cond2	0.048	-0.307
PA before X t10_mediaright_cond2	0.020	-0.358
PA before X t11_mediaright_cond2	0.017	-0.368
PA before X t13_mediaright_cond2	0.048	-0.307
PA before X t14_mediaright_cond2	0.017	-0.367

PA before X t15_mediaright_cond2	0.036	-0.325
PA after X t4_mediaright_cond2	0.040	-0.318
PA after X t10_mediaright_cond2	0.026	-0.342
PA after X t11_mediaright_cond2	0.029	-0.338
PA after X t12_mediaright_cond2	0.023	-0.351
PA after X t13_mediaright_cond2	0.007	-0.412
PA after X t14_mediaright_cond2	0.009	-0.397
PA after X t15_mediaright_cond2	0.005	-0.421
PA after X t16_mediaright_cond2	0.004	-0.433
PA after X t17_mediaright_cond2	0.043	-0.314
NA before X t3_mediaright_cond1	0.036	-0.325
NA before X t5_mediaright_cond2	0.045	0.311
NA after X t3_mediaright_cond2	0.021	0.355
Fantasy X t14_mediaright_cond1	0.012	-0.386
Fantasy X t4_mediaright_cond2	0.008	-0.406
Fantasy X t5_mediaright_cond2	0.040	-0.318
Fantasy X t19_mediaright_cond2	0.005	-0.424
Fantasy X t20_mediaright_cond2	0.036	-0.324
Perspective taking X t19_mediaright_cond1	0.044	0.312
Ability for empathy X t14_mediaright_cond1	0.029	-0.337

Table 11. Significant correlations between questionnaire scales and SCP-amplitudes in the medial-right cluster.

Correlations between questionnaire scales and SCP-amplitudes in the posterior-left cluster		
	Significance (p-value)	Pearson-correlation ®
Helplessness X t3_postleft_cond2	0.045	0.311
PA before X t22_postleft_cond1	0.038	-0.321
NA before X t5_postleft_cond2	0.043	0.314
NA after X t3_posteft_cond2	0.030	0.335
Fantasy X t14_postleft_cond1	0.027	-0.340
Fantasy X t4_postleft_cond2	0.020	-0.359
Ability for empathy X t13_postleft_cond1	0.032	-0.331
Ability for empathy X t14_postleft_cond1	0.011	-0.388
Overall score-SPF X t13_postleft_cond1	0.042	-0.315
Overall score-SPF X t14_postleft_cond1	0.049	-0.306

Table 12. Significant correlations between questionnaire scales and SCP-amplitudes in the posterior-left cluster.

Correlations between questionnaire scales and SCP-amplitudes in the posterior-right cluster		
	Significance (p-value)	Pearson-correlation ®
PA after X t15_postright_cond2	0.028	-0.340
NA before X t3_postright_cond2	0.022	0.352
NA before X t4_postright_cond2	0.012	0.384
NA before X t5_postright_cond2	0.008	0.407
NA before X t6_postright_cond2	0.045	0.311
NA before X t11_postright_cond2	0.019	0.360

NA before X t12_postright_cond2	0.021	0.356
NA before X t16_postright_cond2	0.014	0.375
NA before X t18_postright_cond2	0.042	0.315
NA before X t20_postright_cond2	0.038	0.322
NA after X t3_postright_cond2	0.004	0.430
Empathy X t21_postright_cond2	0.040	0.318
Empathy X t22_postright_cond2	0.032	0.332

Table 13. Significant correlations between questionnaire scales and SCP-amplitudes in the posterior-right cluster.

Significant effects of ANOVAs with repeated measurements for 20 timeframes

Timeframe 3				
factors	df	F-value	p-value	η^2
location X hemisphere	1.196/45.46	10.878	0.001	0.223
Hemisphere X condition X helplessness X gender	1/38	4.672	0.037	0.109

Table 14. Significant effects in the ANOVA with repeated measurements for timeframe 3.

Timeframe 4				
factors	df	F-value	p-value	η^2
location	1.40/57.50	10.573	0.001	0.218
hemisphere	1/41	25.471	0.000	0.401
Location X hemisphere	1.08/44.25	26.880	0.000	0.414
Location X condition	1.28/52.40	4.256	0.036	0.101

Table 15. Significant effects in the ANOVA with repeated measurements for timeframe 4.

Timeframe 5				
factors	df	F-value	p-value	η^2
location	1.39/53.06	12.046	0.000	0.241
Hemisphere	1/38	15.386	0.000	0.287
Location X hemisphere	1.09/41.67	31.950	0.000	0.457

Table 16. Significant effects in the ANOVA with repeated measurements for timeframe 5.

Timeframe 6				
factors	df	F-value	p-value	η^2
Location	1.40/53.43	23.996	0.000	0.387
Hemisphere	1/38	14.609	0.000	0.287
Location X hemisphere	1.12/42.69	42.877	0.000	0.530

Table 17. Significant effects in the ANOVA with repeated measurements for timeframe 6.

Timeframe 7				
factors	df	F-value	p-value	η^2
Location	1.35/55.62	26.362	0.000	0.410
hemisphere	1/41	20.188	0.000	0.347
Location X hemisphere	1.11/45.80	42.352	0.000	0.527

Table 18. Significant effects in the ANOVA with repeated measurements for timeframe 7.

Timeframe 8				
factors	df	F-value	p-value	η^2
Location	1.26/48.15	17.288	0.000	0.313
Hemisphere	1/38	14.814	0.000	0.281

Location X hemisphere	1.11/42.27	27.585	0.000	0.421

Table 19. Significant effects in the ANOVA with repeated measurements for timeframe 8.

Timeframe 9				
factors	df	F-value	p-value	η^2
Location	1.26/48.09	17.462	0.000	0.315
Hemisphere	1/38	12.946	0.001	0.254
Location X hemisphere	1.10/41.99	21.784	0.000	0.364

Table 20. Significant effects in the ANOVA with repeated measurements for timeframe 9.

Timeframe 10				
factors	df	F-value	p-value	η^2
Location	1.31/49.94	16.115	0.000	0.298
hemisphere	1/38	12.077	0.001	0.241
Location X hemisphere	1.11/42.40	23.196	0.000	0.379

Table 21. Significant effects in the ANOVA with repeated measurements for timeframe 10.

Timeframe 11				
factors	df	F-value	p-value	η^2
Location	1.33/50.53	14.414	0.000	0.275
hemisphere	1/38	10.131	0.003	0.210
Location X hemisphere	1.12/42.68	20.573	0.000	0.351

Table 22. Significant effects in the ANOVA with repeated measurements for timeframe 11.

Timeframe 12				
factors	df	F-value	p-value	η^2
location	1.35/51.41	14.573	0.000	0.277
hemisphere	1/38	11.528	0.002	0.233
Location X hemisphere	1.13/42.95	23.031	0.000	0.377

Table 23. Significant effects in the ANOVA with repeated measurements for timeframe 12.

Timeframe 13				
factors	df	F-value	p-value	η^2
location	1.35/51.49	11.138	0.001	0.227
hemisphere	1/38	14.501	0.000	0.276
Location X hemisphere	1.13/42.93	26.444	0.000	0.410
Condition	1/38	6.385	0.016	0.144

Table 24. Significant effects in the ANOVA with repeated measurements for timeframe 13.

Timeframe 14				
factors	df	F-value	p-value	η^2
Location	1.33/50.70	10.560	0.001	0.217
hemisphere	1/38	16.854	0.000	0.307
Location X hemisphere	1.12/42.67	24.354	0.000	0.391
Condition	1/38	5.005	0.031	0.116

Table 25. Significant effects in the ANOVA with repeated measurements for timeframe 14.

Timeframe 15				
factors	df	F-value	p-value	η^2
location	1.34/50.92	7.504	0.004	0.165
hemisphere	1/38	15.366	0.000	0.288
Location X hemisphere	1.08/41.33	23.947	0.000	0.387
Condition	1/38	4.293	0.045	0.102
Hemisphere X condition X gender X helplessness	1/38	5.302	0.027	0.122

Table 26. Significant effects in the ANOVA with repeated measurements for timeframe 15.

Timeframe 16				
factors	df	F-value	p-value	η^2
location	1.30/49.74	7.282	0.005	0.161
hemisphere	1/38	16.672	0.000	0.305
Location X hemisphere	1.07/40.78	24.430	0.000	0.391

Table 27. Significant effects in the ANOVA with repeated measurements for timeframe 16.

Timeframe 17				
factors	df	F-value	p-value	η^2
Location	1.31/49.94	9.535	0.001	0.201
Hemisphere	1/38	20.231	0.000	0.347
Location X hemisphere	1.09/41.53	29.730	0.000	0.439
Gender X helplessness	1/38	6.220	0.017	0.141

Table 28. Significant effects in the ANOVA with repeated measurements for timeframe 17.

Timeframe 18				
factors	df	F-value	p-value	η^2
Location	1.38/52.73	14.095	0.000	0.271
Hemisphere	1/38	23.780	0.000	0.385
Location X Hemisphere	1.10/41.99	37.261	0.000	0.495
Gender X Helplessness	1/38	4.231	0.047	0.100

Table 29. Significant effects in the ANOVA with repeated measurements for timeframe 18.

Timeframe 19				
factors	df	F-value	p-value	η^2
Location	1.17/44.64	12.976	0.000	0.255
Hemisphere	1/38	20.524	0.000	0.351
Location X Hemisphere	1.07/41.00	33.048	0.000	0.465
Hemisphere X condition X gender X helplessness	1/38	5.495	0.024	0.126

Table 30. Significant effects in the ANOVA with repeated measurements for timeframe 19.

Timeframe 20				
factors	df	F-value	p-value	η^2
Location	1.21/46.29	8.203	0.004	0.178
Hemisphere	1/38	17.164	0.,000	0.311
Location X Hemisphere	1.11/41.37	32.871	0.000	0.464

Table 31. Significant effects in the ANOVA with repeated measurements for timeframe 20.

Timeframe 21				
factors	df	F-value	p-value	η^2
Location	1.22/46.50	8.660	0.003	0186
Hemisphere	1/38	17.831	0.000	0.319
Location X Hemisphere	1.16/44.42	31.396	0.000	0.452

Table 32. Significant effects in the ANOVA with repeated measurements for timeframe 21.

Timeframe 22				
factors	df	F-value	p-value	η^2
Location	1.22/46.66	6.756	0.009	0.151
Hemisphere	1/38	14.062	0.001	0.270
Location X Hemisphere	1.17/44.81	25.792	0.000	0.404
Location X Hemisphere X Condition	1.191/45.270	6.590	0.010	0.148

Table 33. Significant effects in the ANOVA with repeated measurements for timeframe 22.

Post-hoc tests

Probabilities for Post-hoc tests for condition		
Timeframe 13		Unsolvable condition
	Solvable condition	0.328
Timeframe 14	Solvable condition	0.379
Timeframe 15	Solvable condition	0.429

Table 34. Probabilities for the post-hoc tests for condition in timeframes 13, 14 and 15.

Timeframe 17: Probabilities for Post-hoc test for gender X helplessness				
	Male-non-helpless	Male-helpless	Female-non-helpless	Female-helpless
Male-non-helpless		0.960	0.243	0.703
Male -helpless	0.960		0.445	0.385
Female-non helpless	0.243	0.445		0.031
Female -helpless	0.703	0.385	0.031	

Table 35. Probabilities for the post-hoc test for gender X helplessness in timeframe 17.

Timeframe 18: Probabilities for Post-hoc test for gender X helplessness				
	Male-non-helpless	Male-helpless	Female-non-helpless	Female-helpless
Male-non-helpless		0.880	0.131	0.997
Male -helpless	0.880		0.377	0.949
Female-non-helpless	0.131	0.377		0.176
Female -helpless	0.997	0.949	0.176	

Table 36. Probabilities for the post-hoc test for gender X helplessness in timeframe 18.

Significant effects in the ANCOVAs

Significant effects for the covariate 'performance'				
timeframes	df	F-value	p-value	η^2
t7	1/37	5.792	0.021	0.135
t8	1/37	10.255	0.003	0.217
t9	1/37	25.792	0.000	0.404
t10	1/37	17.548	0.000	0.322
t11	1/37	17.417	0.000	0.320
t12	1/37	18.278	0.000	0.331
t13	1/37	9.117	0.005	0.198
t16	1/37	4.419	0.042	0.107
t19	1/37	9.898	0.003	0.211
t20	1/37	7.528	0.009	0.169

Table 37. Significant effects for the covariate 'performance' in ten timeframes.

Significant effects for the interaction effect 'location X hemisphere'				
timeframes	df	F-value	p-value	η^2
t5	1.09/40.440	5.721	0.019	0.134
t6	1.115/41.253	8.444	0.005	0.186
t7	1.109/41.042	7.246	0.008	0.164
t8	1.107/40.964	4.298	0.041	0.104
t12	1.131/41.832	3.971	0.048	0.097
t13	1.129/41.775	5.152	0.025	0.122

t14	1.123/41.540	5.051	0.026	0.120
t18	1.089/40.289	4.655	0.034	0.122
t19	1.071/36.619	5.232	0.025	0.124
t20	1.090/40.332	7.880	0.006	0.176
t21	1.160/42.909	5.035	0.025	0.120
t22	1.175/43.481	5.645	0.018	0.132

Table 38. Significant interaction effects between location and hemisphere in ANCOVAs.

LEBENSLAUF

Persönliche Daten

Name:	Marta Czapla
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Schulbildung

1992-1996:	Grundschule Holzmaden (Deutschland)
1996-2005:	Schlossgymnasium in Kirchheim/Teck (Deutschland) Abschluss mit Abitur

Studium

Seit Oktober 2005:	Studium der Psychologie an der Universität Wien
Oktober 2007:	Abschluss des ersten Abschnittes: Vordiplom
2007-2009:	Mitbelegung an der Medizinischen Universität Wien
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Praktische Tätigkeiten

2008:	Assessorentätigkeit im Zuge einer Potentialanalyse bei den Wiener Linien (inkl. Schulung), Wien
2009 & 2010:	Testleiterin für die Validierung des englischen AID2 in Düsseldorf, Wien und London

Praktika

2003:	einwöchige Berufserkundung in einer Praxis für Pathologie in Nürtingen

2006:	dreiwöchiges Praktikum in der Drogen- und Suchtberatungsstelle in Kirchheim/Teck
2008:	dreimonatiges Praktikum Kolpinghaus „Gemeinsam Leben" im Bereich Psychologie, Wien

Sprachkenntnisse

Deutsch	Muttersprache
Englisch:	sehr gute Beherrschung in Wort und Schrift
	TOEFL-Test am 31.10.2008: 102 Punkte (von 120)
Polnisch:	fließend in Wort und gut in Schrift
Französisch:	Grundkenntnisse