Individual differences in affect rating of neutral stimuli preceded with subliminally presented emotional facial expressions

Masterthesis

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Foreword

This study has been conducted as part of my research internship which I followed from 1st February to 30th December 2010 during my Master program Neuropsychology at the Faculty of Psychology and Neuroscience of the Maastricht University in collaboration with the Department of Psychiatry and Psychotherapy at the Universitätsklinikum Aachen, Germany. This work should therefore be considered as a Master Thesis.

Acknowledgments

My gratitude goes to my supervisors Prof. Dr. Dr. Klaus Mathiak and Dr. Wijnand Raaijmakers. I further like to thank Krystyna A. Mathiak, M.D., Ph.D. and collaborating colleagues for their guidance, efforts and cooperation during my stay as a research intern.
Abstract

Every day people perceive different emotions, show different responses and react differently to specific stimuli in the environment. Short subliminal presentation of an affective picture (<40 ms) followed by an immediate presentation of a neutral stimulus (mask) leads to behavioral and physiological effects without conscious perception. Results of behavioral as well as neuroimaging studies using subliminal stimuli show discrepancies, possibly resulting from inter-individual differences and different methodology. In order to understand the mechanism of processing subliminal stimuli, we investigated the individual differences in behavioral and physiological response to short emotional stimuli. Subliminal fearful, angry, neutral and happy faces were presented for 17 ms and masked with neutral face of 183 ms duration. One angry face was earlier paired with an unconditional stimulus, white noise (100 dB). EDA was measured in order to control for successful conditioning. Participants were asked to judge how positive or negative they experience the emotional value of the mask. The emotion regulation questionnaire (ERQ) and the positive affect negative affect scale (PANAS) served as a control for inter-individual differences. The rating of the supraliminal mask was depended on individual differences in higher affect as measured with PANAS. Higher affect led to perceiving subliminally presented happy and angry faces as more similar which indicate that subjects with higher affect state seem to be less responsive to subliminal stimuli.

Keywords: subliminal stimuli; individual differences; backward masking; affective priming; emotional visual stimuli; electro-dermal activity.
Introduction

Every day people perceive different emotions, show different responses and react differently to specific stimuli in the environment. These stimuli can occur inside and outside our awareness. The influence of stimuli that occur outside our awareness can affect our emotional and behavioral responses in an automatic fashion (Ruys & Stapel, 2008; Kouider & Dehaene, 2007). The first studies to reveal if and to what extent non-conscious stimuli influence behavior go back to the nineteenth century when the word “subliminal” was introduced by Johann Friedrich Herbart (1776 – 1841) to refer to stimuli that are beneath the threshold of consciousness.

Nowadays, the influence of subliminal stimuli on behavior and emotions is widely accepted (Van Den Bussche, Van Den Noortgate & Reynvoet, 2009). Support for this comes from studies demonstrating behavioral, autonomic and neuroimaging responses to presentations of subliminal stimuli presentations. To study the influence of subliminal stimuli they are usually presented very briefly, below 40 ms, and masked with a quickly following stimulus which is believed to assure that no conscious processing can take place (Williams et al., 2004). This visual backward masking method is commonly used to manipulate the perception of the target and to prevent the participant from becoming aware of it. In this procedure the target, e.g. an emotional face, is immediately followed by a similar stimulus, e.g. a neutral face. The presentation of a mask interrupts the processing of the target stimulus before it is consciously perceived; an emotional stimulus is not processed consciously when masked with a neutral one. Studies applying backward masking procedure supported the hypothesis that autonomic responses to emotional stimuli are elicited even when the participants report not to be aware of the subliminally presented stimuli (Pessoa, Japee & Ungerleider, 2005; Dimberg & Öhman, 1996).

Backward masking of emotional facial expressions

A number of previous studies using the backward masking procedure demonstrated that autonomic responses to emotional stimuli are elicited even when the awareness of the presented stimuli is inhibited (Pessoa et al., 2005; Dimberg & Öhman, 1996). These studies examined how fast a physiological response occurred after a subliminal stimulus is presented. Esteves, Dimberg & Öhman (1994) showed an increase in SCR in healthy participants after a subliminal presentation of an angry face. It was presented for 30 ms and masked with a neutral face for 30 ms. A different study by Liddell, Williams, Rathjen, Shevrin & Gordon (2004) compared event related potentials (ERPs) generated by masked fearful and neutral faces that were presented subliminally for 10 ms or supraliminally for 170 ms. The mask, a neutral face, was presented directly following the
presentation of the target stimuli for 100 ms. They found an enhanced response to fearful faces
compared to blocks of neutral faces for the N2 component in the subliminal condition. This
enhanced response of the N2 component, which is believed to represent automatic processing and
orienting to novel stimuli, was not found in the supraliminal condition. This finding was interpreted
in the way that autonomic responses to emotional stimuli are elicited independently of the
awareness of the presented stimuli. Comparable observations in healthy participants were made in a
number of similar studies (Morris, Öhman & Dolan, 1999; Whalen et al., 1998). These studies made
observations supporting the idea of processing subliminally presented emotional stimuli in a
backward-masking paradigm to prevent the subject to become aware of the presented stimulus.

Modern brain imaging techniques, such as functional magnetic resonance imaging (fMRI)
and positron emission tomography (PET), help to identify the neural correlates of fear learning and
the processing of subliminal emotional stimuli in humans. It was shown that the amygdala is not
only activated during conscious detection of a stimulus but as well when a stimulus is presented
below the threshold of consciousness (Sabatin i et al., 2009; Morris, Öhman, & Dolan, 1999;
Whalen et al., 1998). In contrast, a few studies exist that question the processing of emotional
stimuli in the absence of conscious awareness. In an fMRI study by Phillips et al. (2004) no
activation in the amygdala was found when a subliminal fearful face (30 ms) was presented, but
only in response to supraliminal presentation of 170 ms duration. Pessoa, Japee and Ungerleider
(2005) used a similar paradigm but told the subjects to report explicitly whether they had seen a
fearful face. The results showed that 64% of the participants were able to detect fearful faces
presented for 33 ms and some subjects could even detect fearful faces that were shown for 17 ms
duration. The authors concluded that “no universal objective awareness threshold exists for
emotional perception”.

Ambiguities of previous findings

Those inter-individual differences in detection of subliminal stimuli (Pessoa, Japee and
Ungerleider, 2005) could contribute to the contradicting results in the above mentioned studies
(Morris, Öhman & Dolan, 1999; Whalen et al., 1998; Phillips et al., 2004). Alternatively,
differential response patterns could reflect different psychological properties of a stimulus.

Stapel, Koomen and Ruys (2002) showed that different exposure times of subliminal stimuli
lead to different perception. Short exposure of 4 ms led to diffuse and unspecific evaluation of the
stimuli which resulted in an assimilation effect, that is judging the prime and the target as being
similar; thus a neutral stimulus was judged more positive when preceded by a positive subliminal
stimulus and more negative when preceded by a negative one (Murphy and Zajonc, 1993). Longer
exposures of 16 ms activated more complex networks and led to distinct, specific evaluations which
were more likely to be followed by a contrast effect, where a Chinese ideograph used as target was judged more negatively when it was primed by a positive stimulus than by a negative one. (Kobylinska & Karwowska, 2007). A contrast effect is thus judging the prime and the target as being different. To control for individual differences in our study the participants filled in a German adaptation of the emotion regulation questionnaire (ERQ; Gross & John, 2003; for the German adaptation see Abler & Kessler, 2009) and the positive affect negative affect scale (PANAS-X; Watson & Clark, 1994; for the German adaptation see Röcke & Grühn, 2003). The ERQ is a questionnaire measuring the emotional coping strategies of the subjects. It consists of two subscales measuring tendencies to use suppression or reappraisal strategy to regulate emotions in different aspects of their daily life. PANAS-X is measuring the affective state of the subject the positive and negative affect.

Neuroimaging studies try to understand the neurobiological background of processing subliminal stimuli often without taking into account their complexity. It is difficult to make the direct comparison between the behavioral studies due to very different methodology used. For presenting the subliminal stimuli either a tachistoscope (Kobylinska & Karwowska, 2007; Murphy and Zajonc, 1993) or a computer monitor screen (Stapel, Koomen and Ruys, 2002) was used in these studies. The advantage of using a tachistoscope over a screen is the very precise control of the timing. However, one cannot use a tachistoscope together with fMRI. Since we plan the follow up fMRI studies to investigate the neural processing of subliminal stimuli, we decided to use a multimedia projector with 120Hz refresh rates to assure the precise timing of the affective subliminal stimuli.

Fear-learning and electro-dermal activity

Another factor leading to ambiguities in the studies of subliminal emotions is that some of them used conditioned angry faces (Sabatini et al., 2009; Morris, Öhman, & Dolan, 1999) whereas others used emotional stimuli without pairing them with an US (Pessoa, Japee & Ungerleider, 2005; Phillips et al., 2004). Classical Pavlovian conditioning is a commonly used method to study fear learning and its neural correlates. Conditioning is an associative process which links an initial neutral stimulus, the conditioned stimulus (CS) with an aversive unconditional stimulus (US). USs are for example a mild shock or white noise, that automatically lead to different physiological responses. After repeated paired presentations of the CS with the US an association is learned. This process leads to a conditioned reaction (CR), where physiological automatic responses characteristic for the US can be elicited when only the CS+ is presented.

Compared to other psycho-physiological methods the electro-dermal activity (EDA) has been shown to be most responsive to aversive stimulation (Dawson, Schell & Filion, 2007).
Measuring the EDA of participants after learning can be used as a control for the conditioning process. Previous studies showed that changes in the skin conductance level (SCL) corresponded to the automatic elicited CR; it was shown in particular that there is an increase in skin-conductance response (SCR) to the CS+ compared with the stimulus that is never paired with the US, the CS- (Eastwood & Smilek, 2005; Esteves, Dimberg & Öhman, 1994).

Aim of the thesis

In order to understand the mechanism of processing subliminal stimuli, we investigated the individual differences in perception of short emotional stimuli of 17 ms duration. We used pictures of facial expressions of four different emotions. Moreover some stimuli were earlier paired with an unconditional stimulus (white noise 100dB). To control for the success of conditioning, we measured an EDA response to presented stimuli. To determine the effect of subliminal stimuli, the participants were asked to judge the emotional value of the mask.

We expected to find different behavioral effects in judging the mask depending on the different emotions of the subliminal stimuli. Specifically, the mask will be more negatively rated when preceded by positive subliminal stimuli (happy faces) compared to those preceded by faces expressing negative emotions such as anger and fear. Thus, we expect the contrast effect to occur for subliminal affective presentations of 17 ms durations that are masked with neutral faces. Moreover, we assume that the CS+ will evoke greater EDA response than the CS- (based on Morris, Öhman, & Dolan, 1999).

To control for individual differences the participants fill in a German adaptation of the ERQ (Abler & Kessler, 2009) and the PANAS-X (Röcke & Grühn, 2003). The ERQ is a questionnaire measuring the emotional coping strategies of the subjects. It consists of two subscales measuring tendencies to use suppression or reappraisal strategy to regulate emotions in different aspects of their daily life. Using the reappraisal strategy occurs early in processing emotions and changes the behavioral response to an emotional event, especially controlling and down-regulating negative emotions (Gross & John, 2003), and the experience of the emotions is changed as well. The suppression strategy occurs later in affective processing after a response tendency is already generated. People more prone to use the suppression strategy can suppress and thereby change the behavioral response but it does not change the feeling of a negative emotion (Gross & John, 2003). We hypothesize, that individuals who tend to use the reappraisal strategy to control emotions will demonstrate a smaller behavioral effect of the subliminal stimuli on the mask as compared to individuals who tend to use the suppression strategy.

The PANAS-X is measuring the affective states of the subject; the two most dominant dimensions of this scale are the positive and negative affect. High positive affect refers to a state
characterized by positive emotions and extraversion whereas high negative affect is characterized by negative emotions (Watson & Clark, 1994). We hypothesize that individuals will differ in their behavioral response to the mask depending on their current state of affect and the subliminal emotion presented. A positive subliminal stimulus will have a stronger behavioral effect on the mask compared to a negative prime in individuals who tend to show more positive affect whereas in subjects with higher negative affect a positive subliminal stimulus will have a smaller effect compared to the negative one.
Methods

Participants and set-up

We examined 23 (mean age: 28.18 ± 7.713, 17 females, 6 males) healthy volunteers. Each participant was screened to rule out a history of neurological or psychiatric disorders (Appendix 1: Screening). During the study they viewed angry, fearful, happy and neutral facial expressions from the digitized Pictures of Facial Affect set (Ekman & Friesen, 1976).

For every emotion 10 different pictures of equally men and women were selected on a table from the brochure accompanying the Pictures of Facial Affect set illustrating the percentage of judgments of each emotion for each photograph based on a 10 second exposure time. Two pictures each showing a woman with an angry facial expression (MF-2-07 and SW-4-09; Ekman & Friesen, 1976) with 100% rating in representing the emotion anger were additionally selected as the CS+/CS- (see Appendix 2: Ekman faces). The same neutral pictures plus two additional ones were used as masking faces to assure that one face was never masked with the previous one used. All pictures were equalized regarding shape, brightness and color. Angry faces were selected as conditioned stimuli because they evoke more negative emotions in the subject.

The participants were tested individually and were seated in a comfortable armchair in a laboratory room with a screen in front of them on which the pictures were projected with 120Hz refresh rates. The purpose of the study was partly covered, the participants were only told that it is conducted to measure physiological reactions to different emotional facial expressions and that they have to rate how positively or negatively they experience the presented faces by pressing a button. They were not told about the exposure to subliminal presentation of the faces (Appendix 3: Instructions to test subjects). The study was approved by the ethical committee of the RWTH Aachen University, Germany.

Questionnaires

Before the first trial, the participants filled in a validated German adaptation of the PANAS-X scale (Röcke & Grühn, 2003) and the ERQ to control for inter-individual differences (Appendix 4: Questionnaires).

The ERQ questionnaire measures emotional coping strategies of the individuals. It investigates if a suppression or a reappraisal emotion regulation strategy is used by asking the participants how they control their emotions in two different aspects in their life. Some questions concern their emotional experience, the others their emotional expressions.

The PANAS-X scale is an extended version of the PANAS affect scale which consists of 60 names of different emotions. Participants are asked to indicate to what extent they are feeling this
emotion now or during some determined time episode. In addition to the traditional two dimensions, namely the positive and negative affect, more specific affective states correlated to them are measured as well.

Backward masking procedure

A visual backward masking method is commonly used to manipulate the processing of a target and to prevent the participant from identifying it and consciously becoming aware of it. In this procedure the target is immediately followed by a second similar stimulus. In this study an emotional face is directly followed and thereby masked by a neutral face. The presentation of a mask interrupts the processing of the emotional stimulus before it is consciously noticed.

Experimental procedure

In the conditioning phase two angry faces were presented subliminally (17 ms) and were masked by a neutral face which was presented for 183 ms to prevent conscious processing. The presented faces were followed by a fixation cross which was presented with a varying inter-stimulus interval (ISI) which lasted in average 3.2 sec. One of the angry faces (CS+) was paired in 50% of times with the US (white noise 100dB, 1 sec), the second one (CS-) was never paired with the US (see fig.1a). The choice of the face paired with US has been counterbalanced among subjects.

**Figure 1: Experimental design**

a, Conditioning procedure: the conditioned angry face (A+) was presented 12x and in 50% paired with white noise of 100 dB. The A- was presented 12x and was never paired with the unconditional stimulus.

b, subliminal fearful, angry, neutral and happy faces of 17 and 33 ms duration were masked with a neutral face of 183/167 ms duration respectively.
A testing phase consisted of four identical sessions of nine minutes duration. Here the angry, fearful, happy or neutral faces were presented for a duration of 17 ms and were immediately followed by a backward mask (neutral face) of 183 ms duration with an exposure time of 200 ms in total. The stimuli were presented with a varying ISI of two seconds in average and were presented in pseudo-randomized order, with each of the conditions occurring three times per session (see fig. 1b). Additionally, three conditioning reminders were presented as well in every session. During each ISI the grey fixation cross was shown, which participants were instructed to fixate. It appearance was a cue to signal the participants that they have a short response time to judge how positive or negative they have experienced the presented faces by pressing one out of five buttons, representing a five-point scale. The response buttons were also counterbalanced between subjects, half of the participants rated the picture as very positive by pressing button one and very negative by pressing button five or vice versa.

A modification of this experimental procedure was made after testing the first six subjects. Changes were made in the conditioning phase; faces were shown supraliminal (200 ms) and were not masked by a neutral face. Each face was presented 12 times, whereas the CS+ was paired with the sound in 50% of the trials like in the original experimental procedure. This procedure was introduced to compare conditioning to subliminal (17 ms) to supraliminal presentation of an angry face. The first two testing sessions were identical to the ones of the first experimental procedure; the emotional pictures were presented again subliminally and masked by a neutral face with the total exposure time of 200 ms and the same ISI of in average 4.8 sec. Another modification was made in the last two sessions the angry, fearful, happy or neutral faces were presented for 200 ms without masking them.

Conditioning procedure was at last adjusted after measuring the first 13 subjects. Each face, the CS- and the CS+, was presented 24 times. The CS+ was paired with white noise (100dB, 1sec) in 80% in this experimental procedure, thus for 20 times and it was just shown four times without being paired to the US. The ISI ranged from 8.2 to 10.7 sec (mean ISI 9.5 sec) in this session. The changes made in this procedure were meant to improve conditioning and the ISI range increased to better distinguish which EDA response correlates to which emotional presentation. After the last picture of the conditioning part was presented a short testing session followed in which the CS+ without sound and the CS- were presented 12 times. Three more regular testing sessions followed.

EDA recording

EDA is commonly used to measure psycho-physiological changes induced by the experimental protocol. These changes are consistently varying depending on the emotional intensity
and are most prominent during very arousing states (Bradley & Lang, 2007). Previous studies (Eastwood & Smilek, 2005; Esteves, Dimberg & Öhman, 1994; Critchley, 2002) showed that EDA response is closely linked to emotional processing without the conscious awareness of the participant. Thus, in this study this method is used to control for conditioning. In a non-invasive way the small tonic changes in skin conductance level (SCL) and the faster phasic changes of the skin conductance response (SCR) shortly following the onset of subliminally and the supraliminally presented angry faces were recorded at a sampling rate of 1000 Hz in constant voltage technique. Silver-silver chloride electrodes of the Brain Vision galvanic skin response-module (Brain Products GmbH, Germany) were placed at the palmar middle phalanges of the index and middle finger of the left hand. The function of the eccrine sweat glands at this location was shown to be more related to psychological stimulation than to thermoregulation (Dawson et al., 2007). The EDA signal was recorded in DC mode by means of a bipolar BrainAmp ExG MR amplifier and analyses was done using the Brain Vision Analyzer package and Ledalab, a Matlab-based software. The collected raw data was down-sampled to 100 Hz and analyzed in Ledalab by means of the continuous decomposition analysis (Benedek & Kaernbach, 2010) which divides the data into continuous tonic signals and phasic activity. SCRs were defined as the maximal SCR in the 1–5 s time window after the stimulus event.

Statistical analysis

The effect of the rating of the different presented subliminal stimuli is analyzed using repeated-measures analysis of variance (ANOVA), with mean ratings for each of the six emotional experimental conditions as the factor. A post-hoc paired-sample t-test is used for pairwise comparisons. Afterwards another ANOVA is used for the rating with four levels only, comparing the happy, fearful, neutral and the mean of the rating of the sum of all angry subliminal stimuli faces, and adding the mean PANAS score for positive and negative affect and the ERQ strategies, suppression and reappraisal, respectively as a co-variate. A post-hoc linear regression determined the direction of relations between PANAS score and the rating of emotions. Statistical significance is considered at a p-value < 0.05.

For analyzing the effects on the EDA response, the mean of the maximal SCR within the selected time window of 1 – 5 sec. after stimulus presentation was used with emotion as factor with six levels in the repeated-measures ANOVA. Post-hoc analysis was similar to the one of the rating, a paired-sample t-test was used for pairwise comparisons and another ANOVA was conducted with PANAS-X and ERQ values as between subject factors. Raw EDA data is first analyzed by Ledalab, then analysis for EDA and behavioral data is further analyzed and plotted with SPSS statistical software (version 17.0).
Results

Four subjects were excluded from the analysis resulting in a total of 19 subjects. Two resigned from participation during the first session due to the loud noise of 100 db; during the measurement of another subject, technical problems with the electrodes occurred and the fourth subject not included in the analysis did not perform the behavioral task as he was instructed to do. Assessment of response to subliminal emotions is described by two behavioral dependent variables: by means of behavioral rating on a five-point scale (1 = very positive; 5 = very negative) and the psycho-physiological EDA response.

Results for rating the mask

We found a significant main effect of the subliminal emotions (F(5,80) = 4.180, p = .002). Figure 2 shows the mean ratings of the supraliminal neutral mask for the subliminally (17 ms) presented faces expressing distinct emotions. Contrasts between the conditions were done to check the significance of mean differences and revealed that the mean rating of the CS- was significantly higher compared to ratings of the other subliminal emotions, also compared to the CS+ (F(1,16) = 5.921, P = .027).
Paired t-test revealed that ratings of positive subliminal emotions were significantly more positive compared to the mean of the rating of the sum of all angry subliminal stimuli (Angry Sum; \( t_{19} = -2.712, P = .015 \)). The mean of the rating of the sum of all angry subliminal faces included the mean ratings of the CS+, the CS- and angry faces. The mean rating of the Angry Sum was significantly more negative compared to fearful faces (\( t_{19} = -3.490, P = .003 \)). There was no significant difference between happy and neutral or neutral and fearful or happy and fearful faces (all \( p > .005 \)).

To check for individual differences in the rating PANAS-X scores of the positive and negative affect scale were included in the ANOVA as between subject covariate. The individual differences in positive affect interacted significantly with emotion condition for the judgment of emotion rating (\( F(1,14) = 5.611, P = .033 \)): subjects with higher positive affect rated the pictures followed by the angry and the happy faces as more similar than those with lower positive affect (\( \beta = -0.41 \)). Although individual differences in negative affect did not interact with emotion condition, there was a trend (\( F(1,14) = 4.510, P = .052 \)); similarly as for positive affect, higher negative affect led to rating faces as more similar (\( \beta = -0.34 \)). All other comparisons failed significance. Individual differences associated with the reappraisal strategy (ERQ) or the suppression strategy had no significant influence on the rating of the valence of the stimuli.

We found no significant interaction effect between the emotional rating of the mask and the Ekman face selected as CS+ or CS-.

Results for EDA response to subliminal emotions

The repeated-measures ANOVA revealed no significant EDA response to the different subliminal emotional expressions presented for 17 ms (\( F(5,80) = 1.096, P = .369 \)). To control if EDA is working at all post-hoc paired t-tests were conducted which revealed a significant EDA response to the US compared to the emotional facial stimuli (\( t_{19} = 6.452, P = .000 \)). In particular, there was no effect of conditioning reflected in EDA responses, which was further confirmed by the paired t-tests; the mean EDA response did not differ significantly between the different emotional conditions, no differences were found between happy and negative emotions. Including scores of the positive and negative affect scale of PANAS and individual differences measured with the ERQ as between subject factors did not interact with the electro-dermal response.
Discussion

Summary of aim of study

We studied individual differences in the effect of subliminal stimuli on emotional judgment. Differences in psychological meaning of short stimuli depending on associative learning were examined while controlling for inter-individual differences and very short exposure time of subliminal stimuli which were either earlier conditioned or never conditioned to a 100-db-noise. The hypotheses of the study were: 1) Different behavioral effects in judging the mask will depend on the different emotions of the subliminal stimuli. Neutral faces will be more positively rated when preceded by happy facial expressions compared to those preceded by negative emotions such as anger and fear. 2) Different emotions will evoke different EDA responses; especially the CS+ will evoke greater EDA response than the CS-. 3) Individuals who tend to use the reappraisal strategy (ERQ) to control emotions will demonstrate a smaller behavioral effect of the subliminal stimuli on the mask as compared to individuals who tend to use a suppression strategy (ERQ). 4) A positive subliminal stimulus will have a stronger effect in individuals who tend to show more positive affect (PANAS) whereas the negative subliminal stimulus has a bigger effect on the mask in subjects with higher negative affect (PANAS).

We studied the effect of different emotional stimuli presented subliminally for 17 ms on a rating of an immediately following neutral mask. As expected, the rating of the supraliminal mask was depended on the emotion of a preceding subliminal stimulus but in a different way than expected: happy faces were rated more positively than angry ones. Thus, instead of a contrast effect an assimilation effect occurred, that is judging the prime and the target as being similar. This difference to previous studies (Kobylińska & Karwowska, 2007) can be explained by our different methodology of using neutral facial expressions instead of Chinese characters. A follow-up study comparing subliminal emotional stimuli of different durations (e.g. 8, 17 and 23 ms) could be conducted to better understand the psychological properties of subliminal stimuli. Although the happy faces were evaluated the most positive, followed by fearful faces, then neutral and last by angry faces, the differences in rating among neutral, fearful and happy faces were not statistically significant. Indeed, a number of studies revealed, that neutral expressions tend to be judged as somehow negative (e.g. Williams et al., 2004; Phillips et al., 1997). Mobbs et al. (2006) demonstrated that ratings of a neutral face are context dependent; it is more negatively rated in a mainly negative valenced environment. In our study, the number of positive and negative facial expressions was not balanced; three negative emotions and one positive emotion were selected as the different experimental conditions, which may have led to more negative ratings of the neutral facial expressions. Moreover, we examined a relatively small group of 23 participants; the lack of
statistically significant difference between positive and neutral or fearful faces might have resulted from insufficient statistical power.

In contrast to the hypothesis that the CS+ will be rated more negatively than the CS- the data revealed exactly the opposite pattern: the stimulus that was paired with the aversive sound of 100 db evoked more positive ratings, than the one that was never paired. To rule out that the Ekman face chosen as CS+ or CS- influences the results, two faces with 100% rating in representing the emotion anger were selected, counterbalanced between the subjects and included into the analysis. No significant interaction effect of the emotional rating of the mask and the Ekman face selected as CS+ or CS- between subjects was found. The fact that conditioning turned out unsuccessful does not explain this result. The significant lower valence rating of the CS+ and the higher negative evaluation of the CS- can be explained by the expectancies of the subjects. After each presentation of the CS+ the subjects expected the sound to occur which rarely happened during the experimental conditions which in turn made them feel relieved resulting in more positive ratings. The finding that the CS+ is rated the most positive compared to all other subliminal angry faces, the CS- and the angry faces that were only presented during the testing sessions, supports the expectancy explanation. During the presentation of the CS- and the other angry faces the participants were only focused on their task of judging the valence of the mask and did not expect the aversive sound to occur.

The ERQ scale measures emotional coping strategies, especially if tendencies to use suppression or reappraisal strategies exist to regulate emotions. The hypothesis that individuals who tend to use the reappraisal strategy to control emotions will demonstrate a smaller behavioral effect of the subliminal stimuli on the mask as compared to individuals who tend to use a suppression strategy was not supported by the data. It might be that the sample was too small to see differences in using strategies to regulate emotions.

Our hypothesis that individual differences lead to different effect of the subliminal stimuli on the behavioral response in judging the mask was confirmed though not as expected. An individual with higher positive affect rate the mask primed with angry and happy subliminal stimuli significantly more similar than those with lower positive affect. Individuals with higher positive affect state show less pronounced responses to stimuli that are presented below the threshold of consciousness and masked with neutral faces. Though higher negative affect resulted in no significant difference in the rating of the mask preceded by either happy or angry faces a trend was seen in judging the masks more similar. Higher affect led to perceiving subliminally presented happy and angry faces as more similar which indicate that individuals with higher affect state seem to be less responsive to subliminal stimuli.

EDA has been shown to be the most responsive physiological response to aversive
stimulation compared to other psycho-physiological measures (Dawson, Schell & Filion, 2007) and it has been used as a control for the conditioning process in a number of studies (Eastwood & Smilek, 2005; Esteves, Dimberg & Öhman, 1994). The hypothesis that the subliminally presented CS+ would evoke a greater EDA response than the CS- was not confirmed. Conditioning was unsuccessful in both ways, when the CS+ was presented subliminally and supraliminally. This outcome can be a result of not enough repetitions of paired presentations of the CS+ with the US during the conditioning phase. The EDA response to the US alone was proof for the EDA to work properly. After modifying the conditioning procedure and increasing the repetitions of pairing the CS+ with white noise in 80% of the trial, thus presenting them paired for 20 times, the repetitions were not sufficient for conditioning.

We found no significant difference in EDA response to distinct subliminal emotional expressions. Thus, it was shown that there is no difference between any of the distinct emotional conditions; also no difference between positive and negative emotions was found. Kreiber (2010) reviewed 134 studies that investigated the role of the autonomic nervous system in processing emotions and found that EDA responses are highest in both happy and angry conditions. Thus, in a situation in which people respond to emotional stimuli EDA increases in pleasant and unpleasant contents (Bradley & Lang, 2007). There was also no significant physiological difference of emotional stimuli compared to neutral ones, which can be explained similarly as the result of rating, that the neutral face was perceived as more negative than neutral.

Methodological considerations and limitations

The methods used in this study for investigating the behavioral and psycho-physiological response to subliminal emotional stimuli are limited in revealing completely the psychological properties of different subliminal stimuli.

The aim of this study was to present subliminal stimuli which the participants were not aware of and the backward masking procedure seemed to be the best way to achieve this goal. During debriefing, after the subjects finished all sessions, no participant reported of having been aware of the presentation of two faces when the target was presented for 17 ms; the masking of emotional pictures can thus be taken as successful. To be completely sure beforehand that the participant does not become aware of the stimulus and because differences between subjects do exist (Pessoa, Japee & Ungerleider, 2005) a detection threshold-setting task would have been a solution to determine the individual threshold of each participant of the detection of the subliminal face. This, however, would have made subjects aware of the subliminal stimuli and could consequently interfere with their effect on the subject’s judgment.

A limitation of this study is the unsuccessful conditioning. Although the conditioning
procedure that we applied was reported successful in a number of studies, a higher number of pairing CS with US might have been necessary for the successful learning. Moreover the two selected faces as CS+/CS- might have been too similar to result in distinct behavioral or autonomic responses. The choice to select 10 different pictures of the Pictures of Facial Affect by Ekman and Friesen (1976) on basis of their original rating which were summarized in a table in the brochure accompanying the complete picture set saved valuable time and had the other advantage of having been used in a lot of different studies (Morris, Öhman & Dolan, 1999; Whalen et al., 1998). Two pictures of this set showing the emotion anger in two women (MF-2-07 and SW-4-09) that were rated 100% as representing this emotion in an American sample in 1976 were selected as the CS+/CS- (see Appendix 2: Ekman faces). Performing rating in German population prior to the study might have led to a different selection and even to more pronounced differences in the behavioral and psycho-physiological responses to the different conditions and might have led to successful conditioning. A rating of the Ekman faces prior to the study might have additionally removed bias from other angry faces.

The number of subjects was not balanced between male and female individuals, which could have influenced the outcome of the rating of the different facial expressions, especially of both pictures selected as CS+ and CS- which were exclusively female faces. This could have resulted in gender bias. Additionally, the number of positive and negative facial expressions chosen as the different experimental conditions were not balanced and led to more negative context-dependent ratings of neutral expressions.

Another limitation of this study is the relatively small group of 23 participants. This small group lacks enough statistical power to lead to statistically significant difference in positive and neutral or fearful faces. Furthermore, the paradigm has been modified twice to improve conditioning and the ISI range increased to better distinguish which EDA response correlates to which emotional presentation. Next to the improvements, these modifications made it difficult to compare the behavioral and autonomic response between the subjects under the different experimental conditions.

Follow-up studies could improve this by using a fixed experimental condition in a larger group of participants. The experimental set-up could be improved by choosing stimuli as CS+/CS- that were rated previously in a comparable sample to elicit more pronounced response differences. A post test after the measurement could be added to assess the individual thresholds of consciousness. To make the conditioning more successful the pictures should not be too similar and more repetitions of the paired CS+ with the US should be introduced.

It would also be interesting to combine the psycho-physiological method with a neuroimaging technique like fMRI to understand the neural correlates underlying the processing of
supraliminal and subliminal presentation of a stimulus. Especially, to get a better insight into the psychological meaning of these different stimuli, it is important to elucidate the precise role of the amygdala that was shown to be activated in previous studies during the presentation of different subliminal stimuli.

Conclusions

The results of our study suggest that the response to subliminal stimuli is better reflected in evaluation of the participants than by the physiological EDA response to emotional stimuli. It was shown that the rating of the supraliminal mask is influenced by inter-individual differences. Individual differences in positive affect lead to different effect of the subliminal stimuli on the behavioral response in judging the mask. This finding identified a key role for the state of an individual in judging emotional stimuli that occur outside our awareness, suggesting that individuals prone to higher affect perceive presented happy and angry faces as more similar and show less pronounced responses to stimuli that are presented below the threshold of consciousness and masked with neutral faces.
References


Appendix

Appendix 1: Screening

“Screeningfragen aus dem SKID-I: Psychiatrie und Psychotherapie”

1. Fragen

1. Gab es einmal eine Zeit in Ihrem Leben, in der Sie 5 oder mehr Gläser Alkohol (Bier, Wein oder Likör) auf einmal getrunken haben? Nein □  Unklar □  Ja □

2. Haben Sie jemals Drogen genommen? Nein □  Unklar □  Ja □

3. Fühlten Sie sich jemals von einem ärztlich verschriebenen Medikament abhängig oder nahmen Sie mehr davon ein, als Ihnen verschrieben wurde? Nein □  Unklar □  Ja □

4. Hatten Sie jemals in Ihrem Leben einen Angstanfall, bei dem Sie ganz plötzlich in panischen Schrecken gerieten oder starke Angst hatten? Nein □  Unklar □  Ja □

5. Hatten Sie jemals Angst, allein das Haus zu verlassen, sich in einer Menschenmenge zu befinden, in einer Schlange anzustehen oder mit dem Zug oder Bus zu fahren? Nein □  Unklar □  Ja □

6. Hatten Sie jemals unter Gedanken gelitten, die unsinnig waren und die immer wieder kamen, auch wenn Sie es gar nicht wollten? Nein □  Unklar □  Ja □

7. Gibt es noch andere Dinge, vor denen Sie besonders Angst haben, wie z.B. in einem Flugzeug zu sitzen, Blut zu sehen, sich in geschlossenen Räumen aufzuhalten, vor bestimmten Tieren oder vor Höhen? Nein □  Unklar □  Ja □

8. Haben Sie jemals unter Gedanken gelitten, die unsinnig waren und die immer wieder kamen, auch wenn Sie es gar nicht wollten? Nein □  Unklar □  Ja □

9. Ist es schon einmal vorgekommen, daß Sie bestimmte Dinge immer und immer wieder tun mußten, wie z.B. sich immer wieder die Hände zu waschen oder etwas mehrmals zu kontrollieren, um sicherzugehen, daß Sie es richtig gemacht haben? Nein □  Unklar □  Ja □

10. Waren Sie in den letzten 6 Monaten besonders nervös oder ängstlich? Nein □  Unklar □  Ja □

11. Kam es schon einmal vor, daß andere Menschen sagten, Sie seien zu dünn? Nein □  Unklar □  Ja □

12. Hatten Sie jemals Essanfälle, bei denen Sie das Gefühl hatten, Ihr Essverhalten nicht mehr kontrollieren zu können? Nein □  Unklar □  Ja □

13. Während der letzten 4 Wochen, gab es da eine Zeitspanne, in der Sie sich fast jeden Tag nahezu durchgängig niedergeschlagen oder traurig fühlten? Nein □  Unklar □  Ja □

14. Während der letzten 4 Wochen, haben Sie das Interesse oder die Freude an fast allen Aktivitäten verloren, die Ihnen gewöhnlich Freude machten? Nein □  Unklar □  Ja □

15. Hatten Sie jemals, d.h. irgendwann in Ihrem Leben, eine Phase, in der Sie sich fast jeden Tag durchgängig depressiv oder niedergeschlagen fühlten? Nein □  Unklar □  Ja □

16. Gab es schon einmal eine Zeitspanne, in der Sie das Interesse oder die Freude an fast allen Aktivitäten verloren haben, die Ihnen gewöhnlich Freude machten? Nein □  Unklar □  Ja □

17. Kam es Ihnen jemals so vor, als ob andere Leute über Sie geredet haben oder Sie mit besonderer Aufmerksamkeit betrachtet haben? Nein □  Unklar □  Ja □
<table>
<thead>
<tr>
<th>Frage</th>
<th>Antwort</th>
<th>Nein</th>
<th>Unklar</th>
<th>Ja</th>
</tr>
</thead>
<tbody>
<tr>
<td>18. Hatten Sie schon einmal das Gefühl, daß Ihnen jemand das Leben schwer machen wollte oder versuchte, Sie zu verletzen?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>19. Hatten Sie jemals das Gefühl, daß Sie in irgendeiner Weise besonders wichtig waren oder daß Sie über spezielle Kräfte verfügten, um Dinge zu tun, die andere Leute nicht tun konnten?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>20. Hatten Sie jemals das Gefühl, daß irgend etwas körperlich nicht mit Ihnen stimmte, obwohl Ihnen Ihr Arzt nach sorgfältiger Untersuchung versicherte, daß alles in Ordnung war?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>21. Machten Sie jemals irgendetwelchen ungewöhnlichen religiösen Erfahrungen?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>22. Haben Sie irgendwann einmal Dinge gehört, die andere Leute nicht hören konnten, wie z.B. Geräusche oder Stimmen von Menschen, die flüsterten oder sprachen?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>23. Hatten Sie irgendwann einmal Visionen oder sahen Dinge, die andere nicht sehen konnten?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>24. Hatten Sie schon einmal merkwürdige Empfindungen in Ihrem Körper oder auf Ihrer Haut?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>25. Haben Sie schon einmal Gerüche wahrgenommen, die andere Leute nicht riechen konnten? Oder Dinge geschmeckt, die andere nicht schmecken konnten?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>26. Machen Sie sich viele Sorgen um Ihre körperliche Gesundheit?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>27. Denkt Ihr Arzt, daß Sie sich zu viele Sorgen um Ihre Gesundheit machen?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
<tr>
<td>28. Einige Menschen machen sich viele Sorgen um Ihr Äußeres. Ist das auch ein Problem für Sie?</td>
<td></td>
<td>Nein</td>
<td>Unklar</td>
<td>Ja</td>
</tr>
</tbody>
</table>

“2. Info

Abgefragte Störungen:
1. Mißbrauch / Abhängigkeit von Alkohol
2. Mißbrauch / Abhängigkeit von Drogen
3. Mißbrauch / Abhängigkeit von Medikamenten
4. Panikstörung
5. Agoraphobie
6. Soziale Phobie
7. Spezifische Phobie
8. Zwangsgedanken
9. Zwangshandlungen
10. Generalisierte Angststörung
11. Anorexie
12. Bulimie
13-16. Depression
17-25. Psychosen
26-28. somatoforme Störungen

Quelle:
Appendix 2: Ekman faces

Two female pictures (MF-2-07 and SW-4-09; Ekman & Friesen, 1976) with 100% rating in representing the emotion anger were additionally selected as the CS+/CS-.

Appendix 3: Instructions to test subjects

“Hier geben wir Ihnen einen Überblick über den Untersuchungsablauf dieser Studie: Wir untersuchen emotionales Lernen und die Fähigkeit subtile Emotionen zu erkennen.

Im ersten Teil werden Ihnen Gesichter mit verschiedenen emotionalen Ausdrücken gezeigt, von denen manche mit einem lauten Ton begleitet werden. Im zweiten Teil der Untersuchung werden Ihnen erneut Gesichter von verschiedener Intensität präsentiert, die ab und zu von einem lauten Ton begleitet werden. Dabei sollen Sie angeben wie positiv oder negativ Sie das Gesicht empfinden. Auch wenn Ihnen das Gesicht neutral erscheint versuchen Sie bitte anzugeben ob Sie es eher als positiv oder negativ empfinden. Ihre Aufgabe ist es dies per Tastendruck anzugeben.

Appendix 4: Questionnaires

The original PANAS-X scale; the participants filled in a validated German adaptation of the PANAS-X scale (Röcke & Grühn, 2003).

“This scale consists of a number of words and phrases that describe different feelings and emotions. Read each item and then mark the appropriate answer in the space next to that word. Indicate to what extent you have felt this way during the past few weeks. Use the following scale to record your answers:”

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>very slightly or not at all</td>
<td>a little</td>
<td>moderately</td>
<td>quite a bit</td>
<td>extremely</td>
</tr>
</tbody>
</table>

____ cheerful ____ sad ______ active ______ angry at self
____ disgusted ____ calm ______ guilty ______ enthusiastic
____ attentive ______ afraid ______ joyful ______ downhearted
____ bashful ______ tired ______ nervous ______ sheepish
____ sluggish ______ amazed ______ lonely ______ distressed
____ daring ______ shaky ______ sleepy ______ blameworthy
____ surprised ______ happy ______ excited ______ determined
____ strong ______ timid ______ hostile ______ frightened
____ scornful ______ alone ______ proud ______ astonished
____ relaxed ______ alert ______ jittery ______ interested
____ irritable ______ upset ______ lively ______ loathing
____ delighted ______ angry ______ ashamed ______ confident
____ inspired ______ bold ______ at ease ______ energetic
____ fearless ______ blue ______ scared ______ concentrating
____ disgusted ______ shy ______ drowsy ______ dissatisfied
____ with self ______ very slightly or not at all ______ a little ______ moderately ______ quite a bit ______ extremely

The original ERQ scale:

“We would like to ask you some questions about your emotional life, in particular, how you control (that is, regulate and manage) your emotions. The questions below involve two distinct aspects of your emotional life. One is your emotional experience, or what you feel like inside. The other is your emotional expression, or how you show your emotions in the way you talk, gesture, or behave. Although some of the following questions may seem similar to one another, they differ in important ways. For each item, please answer using the following scale:

1. ____ When I want to feel more positive emotion (such as joy or amusement), I change what I’m thinking about.
2. ____ I keep my emotions to myself.
3. ____ When I want to feel less negative emotion (such as sadness or anger), I change what I’m thinking about.
4. ____ When I am feeling positive emotions, I am careful not to express them.
5. ____ When I’m faced with a stressful situation, I make myself think about it in a way that helps me stay calm.
6. ____ I control my emotions by not expressing them.
7. ____ When I want to feel more positive emotion, I change the way I’m thinking about the situation.
8. ____ I control my emotions by changing the way I think about the situation I’m in.
9. ____ When I am feeling negative emotions, I make sure not to express them.
10. ____ When I want to feel less negative emotion, I change the way I’m thinking about the situation.”