

Emotional Facial Expression Recognition in Depressed and Healthy Subjects

Theses

Dr. Gábor Csukly

Semmelweis University
Mental Health Sciences Doctoral School



Supervisor: Dr. Lajos Simon, associate professor, Ph.D.

Opponents: Dr. Ferenc Túry, professor, Ph.D.
Dr. Péter Molnár, professor, Ph.D.

President: Dr. Dániel Bereczki, professor, D.Sc.
Committee: Dr. Gábor Stefanics, research worker, Ph.D.
Dr. György H. Ostorharics, Ph.D.
Dr. Erzsébet Németh, assistant professor, Ph.D.

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1. Introduction

Emotional facial expressions are an important part of social communication and play a crucial role in interpersonal interaction. Universal recognition of facial expressions of basic emotions has been demonstrated by Ekman et al.'s research group in several cross-cultural studies.

In the past 20 years numerous studies have highlighted the role that recognition of facial expressions plays in various psychiatric conditions. Abnormal performance on facial emotion recognition tasks has been reported in autism, social phobia, borderline personality disorder and schizophrenia. Patients with depression have consistently been found to have a negative bias in the judgment of facial expressions. The majority of studies found a global deficit in facial judgment accuracy. However, these findings are somewhat contradictory, with some of the studies reporting no such deficit. There are various reasons for these discrepant findings which include inconsistent methodology across studies and the use of small samples in some of the investigations.

The phenomenon that the literature refers to as 'mood congruency' effect implies that subjects with depressed mood tend to judge positive emotions as neutral and neutral faces as negative. Correspondingly, patients with mania tend to judge sad facial expression less intensive or neutral. The finding that patients with depression were able to recognize both positive and negative stimuli, but could not recognize neutral emotions as neutral can also be interpreted as a reflection of mood congruency.

2. Objectives

We evaluated 3 clinical studies to analyze the associations between emotion recognition, depressive symptoms and psychological distress respectively.

While much attention has been given to the characteristics of the judgment of facial expressions by major depressives and schizophrenics, to our knowledge, no attention has been given to the relationship between the psychiatric symptom distress observed in a healthy population and their judgment of emotional facial expressions. In the first study, our objective was to further investigate the possibility of mood congruency effect in case of mild impairments among healthy subjects. We tried to find the possible relationship between the emotion recognition capabilities and psychological distress of healthy volunteers.

Subtle emotions are most common and closer to those experienced in everyday life, and therefore the investigation of such emotions in experimental studies may enhance ecological validity. Exposure to stimuli with different emotion intensities (both low and high) may offer a more powerful strategy for studying emotional facial expression processing deficits in psychiatric illnesses than the exposure to only one (typically high intensity) stimulus, resulting in increased test sensitivity. We decided to further investigate this possibility and applied a case-control design, where facial expression recognition (at different emotion intensities) of depressed subjects and matched healthy controls were compared. Furthermore, based on the literature our second objective was to test the hypothesis that a bias occurs towards the high arousal emotions in facial expression recognition of patients with depression. This hypothesis was formulated in the context of a dimensional model of affect, termed the circumplex model, which proposes that all affective states arise from two independent neuropsychological systems, one related to arousal or alertness (along a low-high continuum) and the other to valence (a pleasure-displeasure continuum). An emerging body of literature indicates a potential spatial separation of brain regions that respond to the arousal versus the emotional value of the stimuli.

During the first two studies we did not find any significant associations between symptoms of depression and positive emotion recognition, therefore in the third study I tried to shed light on this question recruiting 107 subjects with depression and measuring severity of depression and emotion recognition capabilities.

Study I.

- a.) The first hypothesis of this study was that healthy subjects with mild psychiatric symptom distress would have poorer performance in affective facial recognition in general.
- b.) The second hypothesis was that the same subjects would have poorer functioning especially in neutral face recognition and that they would be prone to attribute negative emotions for example sadness and fear to neutral faces. We also expected that such a negative bias would show the most pronounced association with symptoms of depression as compared to other symptom dimension.

Study II.

- c.) In this experiment our first objective was to investigate whether persons with depression, as compared to non-depressed control subjects, would perform more poorly in overall and neutral facial emotion perception tasks, and whether the difference would be more pronounced at lower intensities.

- d.) Furthermore we predicted that persons with depression would make more errors in the direction of high arousal facial expressions (fear, anger, surprise), and would recognize the low arousal facial expressions (neutral, disgust, sadness) with lower accuracy as compared to non-depressed control subjects.

Study III.

- e.) We expected an association between overall facial expression recognition and symptom severity measured by SCL-90 in depressed subjects
- f.) In this study the second hypothesis was that those depressed patients, who recognize positive emotions and neutral facial expressions at a lower rate, have the more severe symptoms of depressions indicated by the BDI.

3. Methods

Subjects included in the first study were healthy volunteers, including staff members and students at an approximately equal proportion (n=117). The mean age of the subjects was 25.3 (SD = 11.4), the sex ratio (f/m) was 68/49 and the mean years of education was 14.2 (SD = 2.3). The subjects were free of history of psychiatric illness, and none of them took any psychotropic medication. In the second experiment data were collected from a total of 46 depressed and control subjects distributing according to a 1:1 ratio (23 depressed and 23 control subjects). Patients in the depression group had to meet the DSM-IV criteria for depression and had to have a total score of >15 on the Beck Depression Inventory (BDI) for the inclusion in the study. The mean BDI score was 25.6 (SD 8.0) for the patient, and 3.6 (SD 2.6) for the control subjects. Control subjects were matched with the members of the clinical group for age, gender and level of education. They represented healthy volunteers who were free from a history of psychiatric illness, and were recruited from the office and medical staff at the University. The mean age was 48.1 (SD 13.0) and 48.5 (SD 11.9) for the patient and control subjects, respectively. The gender composition (female/male ratio=13/10, and the level of education (basic/intermediate/high=5/9/9) were identical in the two groups. The subjects (n = 106) in the third study were inpatients in a study of psychopathology of depression. The patients were diagnosed by an experienced investigator and clinical psychiatrist specialized in the psychotherapy of Mood Disorders using the DSM-IV criteria.

We used a virtual human – high-resolution digital copy of a living person – for presenting the basic emotions. During the first experiment we presented the six basic emotions in 2 alternative presentations (repetitions) to non-patient subjects, and found that the average recognition rate of the facial expressions were above 60%. In the second and third

study, we used the same facial images of the six basic emotions (happy, surprise, anger, disgust, fear, sadness) displayed at five different intensity levels (20, 40, 60, 80, 100%), and the same neutral facial expression 5 times. Thus, participants viewed 35 stimuli during the experiments (6 emotions times 5 intensity level, plus 5 displays of the same neutral stimulus). The Symptom Check List 90 (SCL-90) and was used as self-report measure of psychiatric symptoms in general and the Beck Depression Inventory (BDI) was applied in order to assess symptoms of depression.

In the first and third experiment associations between facial recognition and psychiatric symptoms were investigated by Generalized Linear Model Analysis (GENMOD) and Generalized Mixed Linear Models (GLIMMIX). In the analysis of the case-control study facial recognition in the 2 diagnostic groups (depressed, control) was investigated by GENMOD for categorical variables and Linear Mixed Model Analysis (MIXED) for continuous variables. The statistical analysis was conducted by using the Statistical Analysis System (SAS for Windows, version 9.1) and by the Statistical Package for Social Sciences (SPSS for Windows, version 13.0).

4. Results

Study I.

The Generalized Linear Model Analysis (GENMOD) yielded statistically significant associations between the total correct recognition and Global Severity Index (GSI) of the SCL-90 scale (Chi-square=5.87, $n=117$, $p=0.015$), the overall severity of obsessive-compulsive symptoms (Chi-square=7.02, $n=117$, $p=0.008$), depression symptoms (Chi-square=8.41, $n=117$, $p=0.004$), and phobic anxiety symptoms (Chi-square=11.51, $n=117$, $p<0.001$). Results indicated that a unit increase in GSI or any of the subscales was associated with a decreased likelihood of overall correct recognition.

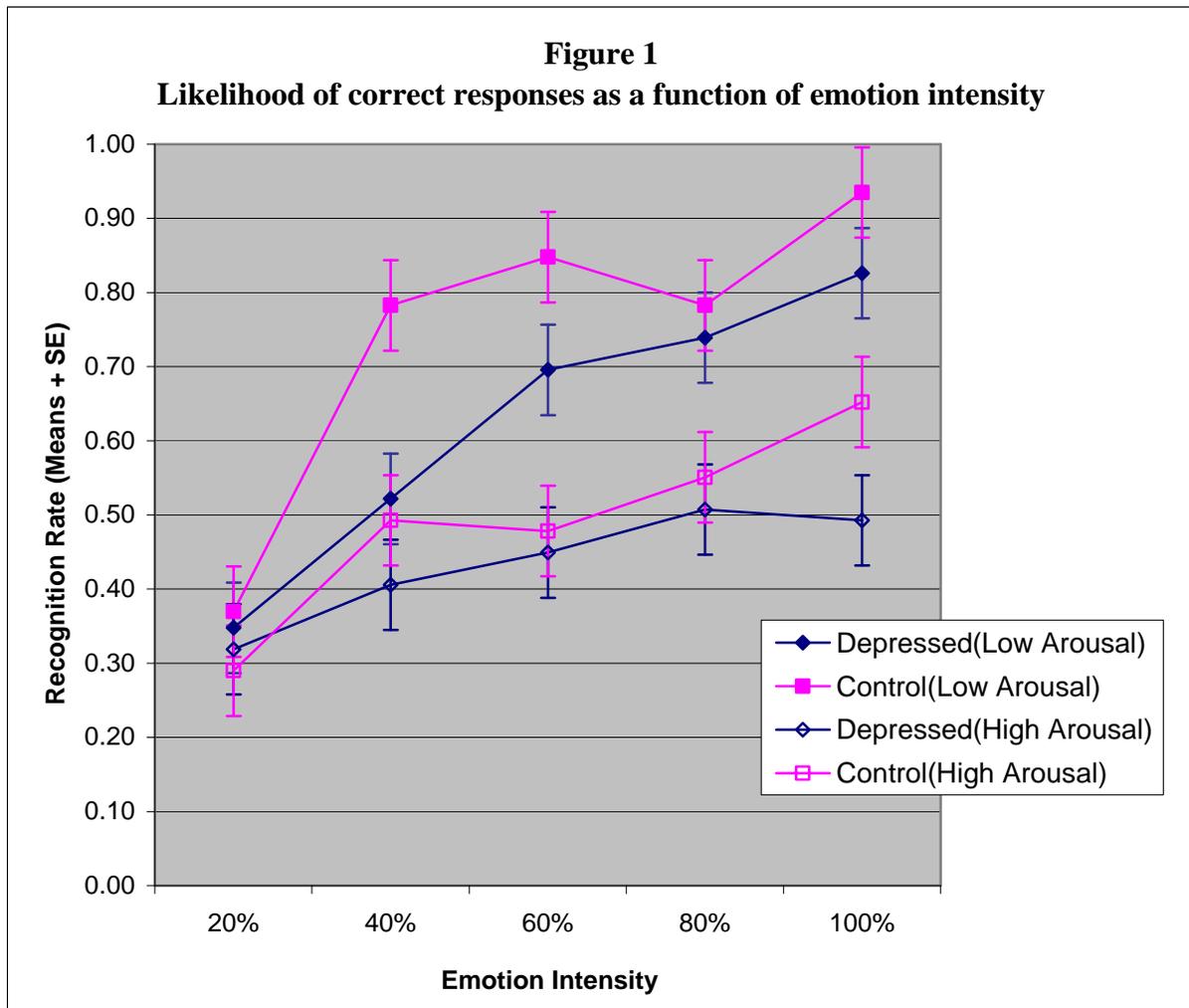
Similar relationship was found between neutral facial expression recognition and the overall severity of somatization symptoms (Chi-square=6.38, $n=117$, $p=0.012$), obsessive-compulsive symptoms (Chi-square=11.67, $n=117$, $p=0.0006$), depression symptoms (Chi-square=10.70, $n=117$, $p=0.001$), anxiety symptoms (Chi-square=9.64, $n=117$, $p=0.002$), hostility symptoms (Chi-square=6.35, $n=117$, $p=0.012$), phobic anxiety symptoms (Chi-square=5.50, $n=117$, $p=0.019$), and psychotic symptoms (Chi-square=7.09, $n=117$, $p=0.0078$).

Negative Bias was defined as judging the neutral facial expressions as angry, fear or sad. We found statistically significant associations between the negative bias and Global Severity Index (GSI) of the SCL-90 scale (Chi-square=7.50, n=117, p=0.006), the overall severity of obsessive-compulsive symptoms (Chi-square=8.85, n=117, p=0.003), and depression symptoms (Chi-square=7.21, n=117, p=0.007). Results indicated that a unit increase in GSI or any of the subscales was associated with an increased likelihood of negative bias (making errors towards sadness, fear and anger).

Study II.

Patients with depression displayed lower total recognition scores than their non-depressed counterparts. The Mixed Linear Model analysis (MIXED) indicated a statistically significant difference between the 2 groups in the total correct percent recognition rate (F = 6.76, n = 46, P = 0.02).

Facial recognition accuracy of high and low arousal emotions was investigated in the patient and control group by Linear Mixed Model analysis (MIXED), using Study Group, Arousal, and Intensity Level, and the interaction of these factors as independent variables. Results showed a significant main effect for Study Group (Control>Depressed; F=7.51, n=46, P = 0.008), Arousal (Low>High; F=45.7, n=46, P<0.0001) and Intensity Level (positive slope, higher>lower intensity; F=30.3, n=46, P<0.0001). In addition, the three-way interaction Study Group x Arousal x Intensity Level also reached significance (F=2.18, n=46, P=0.03), indicating that the lower accuracy in the depressed group compared to controls was a function of arousal level and stimulus intensity. Post-hoc analyses showed that at low arousal level a significant difference emerged at the 40% stimulus-intensity level (t=-3.14, n=46, P=0.002), and that this difference diminished at higher intensities (**Figure 1**). At high arousal level, depressed subjects showed a trend to perform more poorly than controls at high emotion intensity (100% level; t=-1.92, n=46, P=0.05; **Figure 1**).



The GENMOD analysis revealed that the 2 study groups differed significantly in the correct recognition rate of emotionally neutral facial expressions (Chi-Square = 5.22, $n = 46$, $P = 0.02$). Subjects in the depressed group showed a lower recognition rate for neutral facial expression than subjects in the control group (Depressed mean=55%, SD=26%; Control mean=71%, SD=31%). In addition to the emotionally neutral stimuli, as compared to controls, depressed subjects showed a marked decrease in accuracy in the recognition of low arousal stimuli including sadness (Chi-Square = 3.78, $n = 46$, $P = 0.05$) and disgust (Chi-Square = 3.67, $n = 46$, $P = 0.05$). For the rest of the individual emotions the difference was small, and did not obtain significance, although depressed group typically evidenced a poorer mean performance.

Significant difference was detected by using Linear Mixed Model analysis in the error pattern of the 2 groups ($F = 7.41$, $n = 46$, $P = 0.013$). Specifically, patients with depression made more errors in the direction of high arousal facial expressions (taken together) than subjects in the control group. The effect size in terms of Cohen's d was 0.75. The error pattern was calculated separately for the neutral facial expressions. The GENMOD analysis revealed

that patients with depression made more errors in the direction of high arousal emotions when interpreted the neutral facial expressions (Chi-Square = 6.64, $n = 46$, $P = 0.010$). As shown by the results, being in the patient group was associated with an increased likelihood of misattributing the neutral facial expressions in the direction of high arousal emotions (OR = 4.13 [95% CL: 1.40 to 12.17]).

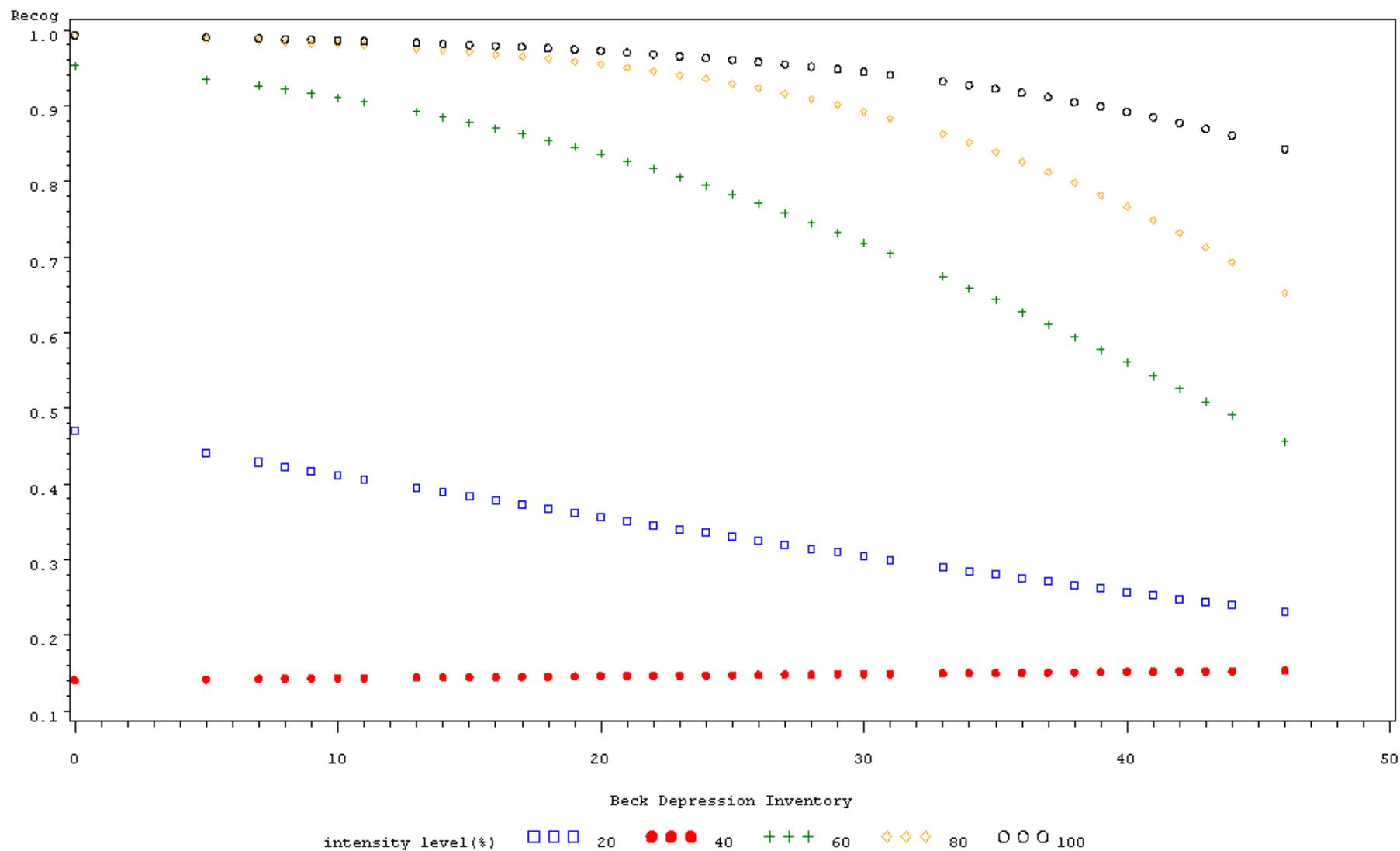
Study III.

The Generalized Linear Mixed Model analysis (GLIMMIX) yielded a statistically significant association between GSI and total correct recognition ($F=8.7$, $n=105$, $p=0.003$, $df = 1$). A unit increase in GSI was associated with a decreased likelihood of overall correct recognition.

Significant, positive association was found between emotion intensity and recognition rate ($p<0.001$ for all basic emotions). Furthermore, using the GLIMMIX procedure, significant negative association was found between recognition of happy facial expressions and BDI ($F=8.1$, $n=100$, $p=0.005$) and the depression subscale of SCL-90 ($F=6.22$, $n=104$, $p=0.01$). The interaction between BDI and emotion intensity was also significant ($F=2.38$, $p=0.05$), which means that the strength of the relationship between BDI and emotion recognition is a function of emotion intensity: the smaller is the odds ratio the stronger the decrease of likelihood of correct recognition by each unit of increase in BDI score. For this reason we present the odds ratios as a function of emotion intensity (OR₂₀=0.8[CI:0.49-1.16], OR₄₀=1[CI:0.59-1.8], OR₆₀=0.4[CI:0.25-0.75], OR₈₀=0.3[CI:0.14-0.77], OR₁₀₀=0.4[CI:0.14-1.24]). The odds ratios from these computations indicate the decrease of likelihood of correct recognition for a standard deviation unit increase in the BDI (**figure 2**). If the odds ratio is 1, as in case of emotion intensity 40%, that means the lack of association at this intensity level. The association is significant if the confidence interval does not include number 1, in our computations this means emotion intensity 60% and 80%.

Interaction was not significant between emotion intensity and the depression subscale of SCL-90, so we can characterize the association by one odds ratio (OR=0.7), which indicate the decrease of likelihood of correct recognition for a standard deviation unit increase of depression subscale.

Figure 2. Association between happy facial expression recognition and Beck Depression Inventory (BDI)



5. Conclusions

Our investigations demonstrated a significant negative association between overall recognition rate of facial expressions and global severity of psychological distress (GSI), and the depression, obsessive-compulsive, phobic anxiety, psychoticism subscales of SCL-90 in a healthy population, which is consistent with our first hypothesis, and is in agreement with results from the literature. Since poor overall recognition rate of facial expressions has been found to be associated with poor performance on cognitive tests in general, similar to other authors we think that the above negative associations may be a reflection of a poorer cognitive functioning.

We could find similar abnormalities and error patterns in facial affect recognition as previous studies did in patients with affective disorders. Consistent with our second hypothesis we found significant correlations between neutral facial expression recognition, the negative bias of neutral facial expressions and GSI, and SCL-90 subscales. In other words, our results provide empirical support for the hypothesis that subjects with higher severity on SCL-90 subscales and GSI would attribute emotional valence to non-emotional faces; furthermore, they show error patterns that would less often reflect a positive (happy) bias. Thus, the findings of this study suggest that general psychiatric distress (as indexed by the GSI) may bias emotion recognition in a negative direction, and that, expected on basis of hypothesis 2, the severity of depression symptoms shows a pronounced association with this negative bias.

Overall, our findings raise the possibility that difficulties in emotion processing contribute to the severity of psychiatric symptom distress, and that, as previous studies pointed out, neutral face recognition and a negative bias in neutral face recognition can be a sensitive sign of early psychiatric disorder.

Consistent with prior literature, in the second experiment we found that patients with depression performed significantly more poorly in overall and neutral facial emotion perception than healthy counterparts. To our knowledge this is the first study to investigate both the recognition rates and error patterns in the arousal dimension of facial expression recognition. We found that patients achieved lower scores than the control subjects in recognition accuracy at all intensity levels for the low arousal facial expressions. In particular, as we increased the stimulus intensity from 20%, a significant difference emerged at the 40% intensity level, which diminished gradually at higher intensities. The fact that such a trend was not observable at high arousal emotions may be attributable to a floor effect. Collectively, our findings are in agreement with the assumption that the use of subtle, but

clearly recognizable, emotional facial expressions offer a useful strategy to study emotion recognition in patient with depression. With regard to the low arousal emotions, our results are also consistent with the position that depressed patients are more likely to misinterpret the emotion if presented with less clear representations of the affect

In addition to comparing the two groups in their ability to correctly recognize facial expressions, we investigated their characteristic error pattern in the arousal dimension of emotions. Patients with depression were found to make more errors in the direction of high arousal facial expressions in general. In addition, compared to the control group, they were more commonly found to misattribute neutral facial expressions as emotionally high arousal ones. These results lend support to the notion that depressed patients misinterpret facial expression in the direction of high arousal emotions, and thereby detect stimuli that convey fear, anger, and surprise more commonly. As suggested by Beck more than three decades ago, difficulties in terms of interpretation and regulation of emotion may co-exist, either with one causing the other, or by operating through similar brain regions. Based on more recent literature, it is conceivable that greater amygdale activation by aversive stimuli in patients with depression in conjunction with tonic levels of activity in the amygdale in such patients may constitute a potential pathophysiological underpinning of the above misattribution.

Thus, we can conclude that the disability to accurately recognize non-emotional and emotional facial expressions along with the tendency to make more errors in facial expression recognition to the high arousal emotions, can be two important contributing factors for the well documented social problems of patients with depression.

Our third investigation demonstrated a significant negative association between overall recognition rate of facial expressions and global severity of psychological distress (GSI) of SCL-90 in a depressed population

Many behavioral models of depression focus on the anhedonic element of depression. Anhedonic depressed people are viewed as less responsive to rewards, and it is conceptualized as to arise from an underactivated approach system, low positive affectivity or reduced brain dopamine activity. Abnormalities in reward sensitivity may clarify the association between happy face recognition difficulties and the severity of depressive symptoms among depressive patients. Consistent with these models of depression we found that patients, who archived higher scores on BDI, could recognize happy facial expressions at a lower rate. We assume that this can be the part of mood-congruent bias in the recognition of emotions by depressed subjects.

These findings, taken together, are consistent with the notion that deficits in reading nonverbal cues may constitute a contributing factor in the well documented social problems of patients with depression.

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