Reading Simple and Complex Facial Expressions in Patients with Major Depressive Disorder and Anxiety Disorders

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Running title: Facial emotionin anxiety and depression

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Abstract

Aim: Decoding facial expression is important for psychological well-being. This study examined facial emotion recognition of simple/complex and pleasant/unpleasant emotions in patients with major depressive disorder (MDD) and anxiety disorders (AnDs). **Methods:** MDD (n = 37), AnDs (n = 36) and healthy controls (HC) (n = 40) participated in this study. The recognition accuracy of emotional faces was calculated. **Results:** MDD had significantly lower recognition accuracy compared to HC. MDD exhibited lower recognition accuracy for simple emotions compared to AnDs and HC, and lower accuracy for complex emotions compared only to HC. AnDs and HC showed comparable recognition accuracy for simple emotions, which were lower than that of MDD. However, in recognition accuracy of complex emotions, AnDs was not significantly different from both MDD and HC. **Conclusions:** MDD and AnDs have a distinctive difficulty at the recognition of facial expressions. The recognition of the complex emotions in MDD and AnDs should be studied further.

Keywords: anxiety, depression, emotions, facial expression, reading facial expression

1. Introduction

Previous studies have consistently demonstrated that facial expressions reflect the actual experience of emotion[1], and convey interpersonal information[2]. An accurate appraisal of facial expressions is critical for social functioning[3, 4].The recognition of facial expressions has been studied in major depressive disorder (MDD) andvarious anxiety disorders (AnDs).

Decoding facial expressions in MDD has been studied using different paradigms. Patients with MDD showed reduced accuracy of recognizing facial expressions of six basic emotions[5] including neutral facial expression[6]. Also, Gollan et al. [7] reported that MDD group required more intense facial expressions to recognize harsh and surprise expressions compared to healthy controls (HC). Other studies demonstrated that individuals at the current depressive state[8-11] and remission state[10] needed more intensity to recognize happiness[8, 12]. In addition, depressed individuals showed more negative response and interpretational bias toward happy face[11,13].

Facial emotion recognition in AnDs is not comprehensively investigated. Surcinelli et al.[13] found higher recognition accuracy for fearful faces in individuals with high trait anxiety compared to low trait anxiety. However, this was not observed in another study which employed the same task for a shorter duration[14]. Studies involving clinical samples indicated lower recognition accuracy for sad and angry faces in panic disorder[15], and for angry, fearful, surprised, contemptuous, and happy faces in post-traumatic stress disorder (PTSD)[16]. There are consistent evidences of attentional bias towards threatening information[17-19] and of negative interpretational bias[20, 21]. Also, Bell et al. [22] found that socially anxious individuals did not show impaired recognition, but tended to misclassify facial expressions as angry.

To our knowledge, there is only one meta-analytic study that compared facial emotion recognition among MDD, AnDs and HC. Demenescu et al. [23] reviewed 10 studies in AnDs and 8 studies in MDD, and found that both the MDD and AnDs had worse recognition accuracy with moderate effect size than HC. Depressed individuals appeared to have more impairment than anxious individuals. Although this study suggested that facial emotion recognition may differ between MDD and AnDs, no study h**as** yet investigated the idea in both disorders.

Moreover, most studies have focused on only a few number of emotions (such as Ekman's basic emotions) overlooking complex mental states which could appear more frequently in real life [24]. Also, people could read not only feelings but also thoughts from facial expressions[25]. The current study investigated recognition

accuracy of simple (affective mental states) and complex emotions (complex mental states). Complex emotion reflects one's wish and belief, and always involves cognitive appraisal of the situation. Simple emotion only reflects affective states and does not necessarily involve cognitive appraisal[25-27]. For example, if a person is frustrated (complex emotion), he/she may think something is not going as he/she desires. Then he/she would express the frustrated emotion with angry and sad facial expressions (simple emotions). Accordingly, an observer would recognize his/her complex mental state: the thoughts of frustration and the affective state of anger and sadness.

Nam et al.[28] reported reduced recognition accuracy of complex facial expressions in depressed individuals compared to HC.The findings from studies using "Reading the mind in the eyes task" (referred to as "Eye task"; [29]) are inconsistent. Some studies reported higher accuracy of recognizing complex mental states in depressed participants[30, 31]; others reported poorer performance in the eye task in depression group compared to HC[32-34]. However, no study has investigated the ability to recognize complex as well as simple emotions in AnDs and MDD.

Furthermore, it was reported that certain emotions could be recognized easily by looking at particular facial regions [35, 36].Baron-Cohen et al. [25] found that the eye was as informative as the whole face. Another study showed that people tended to rely on particular facial region to decode certain facial expressions (e.g., the eye for happiness and the mouth for fear) [37]. Also, socially anxious individuals are known to avoid eye contact[38]. In sum, previous studies seem to suggest that even partial facial regions are effective cues for reading emotions. The current study investigated decoding emotions from the eye, the mouth and the whole face.

In this study, we aimed to examine recognition accuracy for facial expressions in patients with MDD, AnDs, and HC. We hypothesized that 1)MDD and AnDs would show lower recognition accuracy for complex emotions compared to HC, 2) MDD would show more difficulties in recognizing pleasant emotions compared to unpleasant emotions, 3) MDD would display lower recognition accuracy compared to AnDs and HC.

2. Methods

2.1. Participants

Thirty-seven patients with MDD(11 male) and 36 AnDs(12 male) participated. The mean ages were 44.76 (SD, 16.28) and 42.97 (13.70) years for MDD and AnDs, respectively. Patients were divided into MDD and AnDs based on diagnosis, according to the DSM-IV[39], made by a board certified psychiatrist of Ilsan Paik hospital. AnDs included panic disorder (n=16), general anxiety disorder (n=9), PTSD (n=7), unspecified anxiety disorder(n=2), and social phobia (n=2).Patients with a history of psychotic disorder, mental retardation, or head injury were excluded. No patient was diagnosed with both MDD and AnDs at the same time, or with mixed anxiety and depressive disorder. All except one patient were receiving medications. 40 age- and gender-matched HC (10 male) were recruited through local community flyers. HC was selected following a semi-structured interview with a specialist to ensure no personal history of neurological or psychiatric disorder. The mean age was 40.23(9.56) years. All participants gave informed consents.

2.2 Clinical measures

The Hamilton Rating Scale for Depression (HAMD) [40]and the Hamilton Rating Scale for Anxiety (HAMA) [41], Beck Depression Inventory (BDI) [42] and Beck Anxiety Inventory (BAI) [43]were employed to assess clinical symptoms. HAMD/A was rated by a licensed clinical psychologist and a trained research assistant.

2.3. Stimuli and Procedure

A mental state decoding task of facial expressions[26] was used to assess facial expression recognition. Cho et al. [26] extracted 221 emotional words which reflected belief, intention and desire by reviewing previous literatures[25, 29, 35, 44]. Then, the words were presented to 28 naïve people and experts who were asked to judge if these lexicons expressed belief and desire, and if they were congruent with the facial expression. Consequently, a total of 32 emotional words (17 basic emotions and 15 complex emotions) were determined. The task was conducted by the computer-based program consisting of 64 black and white photographs of emotional faces by middle-aged one male and one female Korean actors.

During the each trial, the participants viewed four different photographs and one emotion word. They were asked to select a photograph that corresponds to the emotion word most closely (Figure 1). The correct and incorrect photographs used in the experiment were selected by plotting the 32 emotional words in two axial planes with valence and arousal. Three incorrect photographs were selected in axial planes according to the

following order: one photograph allocated farthest and the other two photographs allocated in distance of 2/3 and 1/3 away from the correct word. The total number of trials was 192(3facial regions× 2 genders of actors×32 emotion words). The test duration was approximately 40 minutes. The emotion words were randomly presented. The positions of the correct photograph were counterbalanced. The presentation of facial regions was blocked in the order of the eye, mouth, and the whole face. This study protocol has been approved by the institutional review board of Ilsan-Paik hospital, Korea.

The emotions were sorted by valence × complexity. The six simple pleasant emotions included interest, happiness, surprise, feeling pleased, serenity(or relaxation), and delight. The five complex pleasant emotions included relief, enthusiasm, confidence, contentedness, and desire. The 11 simple unpleasant emotions were distress, fear, shame, anger, depression, anxiousness, sadness, feeling unpleased, dazedness, lethargy, and contempt, while the 10 complex unpleasant emotions were worry, envy, fretting, frustration, cold-heartedness, remorse, embarrassment, desperation, pity and despair.

In order to check the reliability of the task, we compared our results from HC with previous studies that used the same task. The overall recognition accuracy of HC was 76% in the current study. This is quite compatible with the previous studies (75%[26], 77%[45], and79%[46]), which can imply a good reliability of the task.

2.4. Statistical analysis

The recognition accuracy was calculated by averaging the percentage of correct answers. A repeated measures ANOVA was conducted with group as a between-subject factor, and valence, complexity and facial regions as within-subject factors. Mauchley's test was used to evaluate the sphericity assumption. The correction of the degrees of freedom was made using the Greenhouse–Geisser procedure (for simplicity, the uncorrected degrees of freedom are presented). Post-hoc comparisons were made using Bonferroni corrected t-test. The significance level was set at $p < 0.05$.

3. Results

There was no significant group difference in age (F= 1.13, df = 2, 110, p=n.s.) or gender (χ^2=0.64, df = 2, p=n.s.). However, symptom severities were significantly different among groups: HAMA (F = 108.12,df = 2, 110, p <0.001), HAMD (F = 81.90,df = 2, 110,p <0.001), BDI (F=29.64, df = 2, 110, p<0.001) and BAI (F=21.70, df

= 2, 110, p<0.001). In post-hoc comparison, MDD had the highest depressive symptom score, followed by AnDs and then HC. Anxiety symptom scores were significantly different between the patient groups and HC. However, there was no difference between MDD and AnDs in either BAI or HAMA (Table 1).

A repeated measures ANOVA revealed significant main effect of valence (F = 643.67, df = 1, 110, p <0.001), complexity (F = 665.77, df = 1, 110, p <0.001), and facial region (F = 201.67, df = 2, 220, p <0.001). Bonferroni-corrected post-hoc showed that pleasant emotions were recognized significantly better than unpleasant emotions. Simple emotions were recognized better than complex emotions. Also, the whole face was recognized the most easily, the mouth was the most difficult, and the eye was intermediately difficult (Figure 2).

Furthermore, there was a significant main effect of group (F = 5.36, df = 2, 110, p = 0.006). MDD performed worse than AnDs and HC in overall recognition accuracy across emotions (Figure 2), while there were no group differences between MDD and AnDs (p = 0.29), and between AnDs and HC (p = 0.38). In addition, there was a significant interaction of complexity by group (F = 4.92, df = 2, 110,p = 0.01). For simple emotion, MDD displayed significantly lower recognition accuracy compared to both AnDs (p = 0.051) and HC (p = 0.004). There was no significant difference between AnDs and HC (p = 1.000). However, for complex emotion, recognition accuracy was lower in MDD compared to HC (p = 0.011) whereas there was no significant group difference between MDD and AnDs (p = 1.000), and between AnDs and HC (p = 0.082) (Table 2). This interaction remained significant even after controlling BAI scores (F = 5.06, df = 2, 109, p = 0.008) and BDI scores (F = 4.69, df = 2, 109, p = 0.011).

4. Discussion

In this study, we observed the following points: (1) simple and pleasant emotions were recognized better than complex and unpleasant emotions respectively. Furthermore, the whole face was easier to be recognized than the partial facial regions; Moreover, (2) MDD showed significant lower accuracy in recognizing simple emotions compared to AnDs and HC. The recognition accuracy of complex emotions was significantly lower in MDD compared to HC. (3) AnDs showed the comparable performance in recognizing simple emotions compared to HC. In addition, AnDs showed no significant differences in recognizing complex emotions either from MDD or HC.

The higher accuracy for simple, pleasant emotions and the whole face is consistent with the previous studies. Healthy people generally recognize pleasant emotions better than unpleasant emotions [11, 13], and the current study showed that this phenomenon is also consistently found in MDD and AnDs. The complexity and the limited sources of facial information may have made recognition of the emotions difficult for the patients. Although the eyes proved to be less informative than the whole face, they were more informative than the mouth. This result supports that the eyes are important parts to read others' mental states [47, 48]. Furthermore, the finding that reading the complex emotions produced more errors than the simple emotions indicates that they could be distinct emotions.

MDD and AnDs showed different level of the performance; the accuracy by MDD was the worst, HC was the best, and AnDs was somewhere between the two groups. This result seems to be consistent with a meta-analysis [23], where depressed individuals' recognition accuracy was worse than anxious individuals, and anxious individuals were also worse than HC. In addition, our results indicated that AnDs showed the tendency of reduced accuracy only in complex emotions whereas MDD showed in both simple and complex emotions. Since the interaction remained significant even after controlling BAI and BDI scores, thedistinctive ability of facial emotion recognition between the two patients groups may not have been driven by subjective symptoms, but rather by the pathognomic features of each disorder.

MDD has shown lower accuracy in facial emotion recognition[5, 6]. However, Harkness et al. [30, 31] found higher accuracy in reading complex emotions in dysphoric and previously depressed people, compared to HC. The researchers argued that the higher accuracy may be due to their enhanced sensitivity to subtle social information in mild depression. However, other studies using the same task to clinical depression showed poorer performance in MDD compared to HC [32, 33]. Our study also demonstrated that people with MDD are less accurate in decoding facial expressions, implying that clinical depression may be associated with deteriorated ability to recognize facial expressions.

In addition, previous studies showed that depressed individuals have a difficulty to read pleasant emotions in particular[8-11]. However, the current study could not find any significant valence effect. This discrepancy could be explained in terms of the task. The current task involves an intricate process of emotion discrimination. The participants were required to not only recognize, but also discriminate a target facial expression from other facial expressions from the same face. This may have interfered with the ability to recognize unpleasant emotions as well as the pleasant emotions. Also, the current task included more numbers of unpleasant (*n*=21)

words than pleasant (*n*=11) words. Although, the participants in the process of creating the task naturally recognized negative emotions more in either words or faces, the different number may have influenced our findings. In addition, the recent meta-analytic study found that depressed people showed impaired recognition of all the Ekman's basic emotions except the sadness [49], which seems consistent with our results.

AnDs seemed to have a difficulty only in the recognition of complex emotions. Although AnDs did not show significant difference compared to both MDD and HC in recognizing complex emotions, they had the accuracy level close to MDD, and the accuracy between AnDs and HC showed marginal significance ($p = 0.082$). Unlike simple emotions, understanding complex emotions always involves the cognitive appraisal. Although inconsistent findings exist regarding facial emotion recognition of AnDs[13-15, 50]_ENREF_14, many previous studies consistently demonstrate that AnDs exhibit interpretational bias not only for the facial expressions[51, 52]_ENREF_54, also for other stimuli[53-57]_ENREF_55_ENREF_55_ENREF_56. Because recognizing complex emotions can be influenced particularly by cognition, AnDs may have difficulties in recognizing complex emotions due to their cognitive bias[52, 58, 59]. Further studies are needed to identify the underlying mechanisms.

Regarding study limitations, most patients were taking psychotropic medication, and the difference of the medication combination could not be controlled between MDD and AnDs. The possible effect of benzodiazepine derivatives of 29 (78.3%) patients from 37 MDD patients, and 31 (86.1%) patients from 36 AnDs patients should also be noted, as benzodiazepines were found to impair facial emotion recognition[60]. In addition, MDD and AnDs seem to have mixed depression and anxiety symptoms. However, depressed patients tended to report higher scores in both anxiety and depression score[61], and two thirds of the depressed patients were clinically anxious and one thirds of anxious patients are depressed [62-65]. In this regard, the comorbid symptoms seem rather natural. The current study included diverse sub-disorders of AnDs. In this way, we were able to investigate the general characteristic of clinical anxiety. However, the diverse sub-disorders of AnDs may have influenced the findings. Future study can investigate each sub anxiety disorder in order to promote better understanding. As for the task, posed facial expression could be recognized differently from natural facial expressions in everyday life[66]. Another issue regarding the task is cultural effect. Translated words may not be able to convey exact same meaning of the original words[67]. The current study findings should also be cautiously interpreted in this regard.

Nevertheless, this is the first study to investigate decoding of simple and complex emotions in MDD and AnDs.

The present study revealed differences in facial emotion recognition among MDD, AnDs and HC. These results showed distinct features of MDD and AnDs in facial emotion recognition.

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Disclosure Statement

We declare no conflict of interest.

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Figure legend

Figure 1: Examples of the mental state decoding task of facial expressions.

Figure 2: (a) Overall recognition accuracy of facial expressions per facial region; (b) per group. Note: *, $p<0.05$; MDD denotes major depressive disorder, AnD denotes anxiety disorders, and HC denotes healthy controls.

Table 1. Demographic and clinical characteristics

	MDD (*n* =37)	AnD (*n*=36)	HC (*n*=40)				
	Mean (SD)	Mean (SD)	Mean (SD)	*F*	*df*	*p*	Comparison
Age (years)	44.76(16.28)	42.97(13.70)	40.23(9.56)	1.13	2	0.33	
Sex (male:female)	11:26	12:24	10:30	0.64(χ^2)	2	0.73	
HAMD	26.06(7.89)	16.80(9.46)	2.47(2.33)	81.90	2	<0.001	3<2<1
HAMA	21.94(6.19)	20.40(7.51)	2.17(2.52)	108.12	2	<0.001	3<1,2
BDI	22.14(10.66)	14.19(11.34)	5.75(5.05)	29.64	2	<0.001	3<2<1
BAI	22.68(12.83)	20.69(13.58)	6.70(8.07)	21.70	2	<0.001	3<1,2

Note:HAM-D, Hamilton Depression Rating Scale; HAM-A, Hamilton Anxiety Rating Scale; BDI, Beck Depression Inventory; BAI, Beck Anxiety Inventory; MDD denotes major depressive disorder, AnD denotes anxiety disorders, and HC denotes healthy control; In the post-hoc test, 1 denotes MDDs, 2 denotes AnDs, and 3 denotes HC.

Table 2. Recognition accuracy of facial expressions per complexity

	MDD[1]	AnD[2]	HC[3]				
	Mean (SD)	Mean (SD)	Mean (SD)	*F*	*df*	*p*	Comparison (*p*)
Simple Emotion	0.75(0.12)	0.81 (0.12)	0.82(0.13)	5.71	2/110	0.004	1<3 (0.004) 1<2 (0.051)
Complex emotion	0.63(0.12)	0.64(0.12)	0.69(0.06)	4.85	2/110	0.010	1<3 (0.011)

Note: *, *p<0.05*;MDD denotes major depressive disorder, AnD denotes anxiety disorders, and HC denotes healthy controls;In the post-hoc test, 1 denotes MDDs, 2 denotes AnDs, and 3 denotes HC.

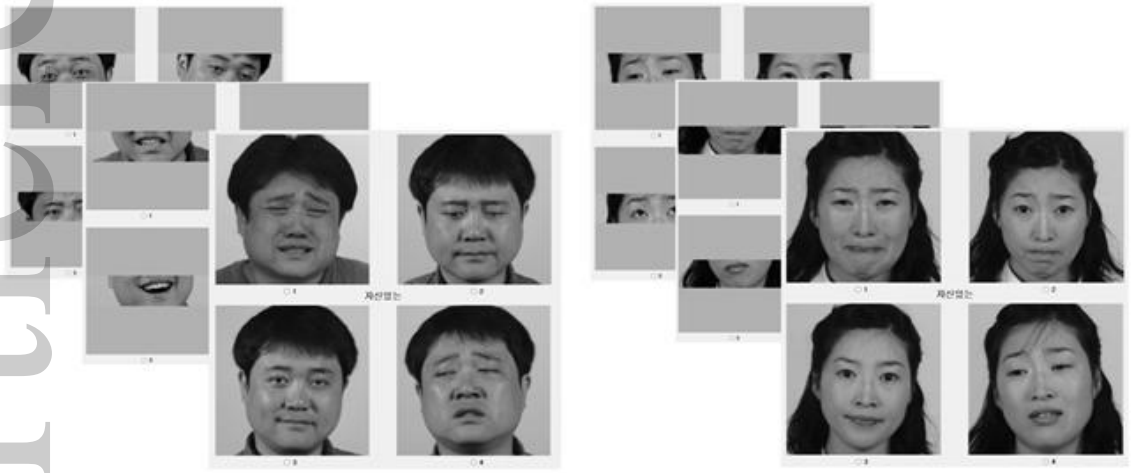

fig1

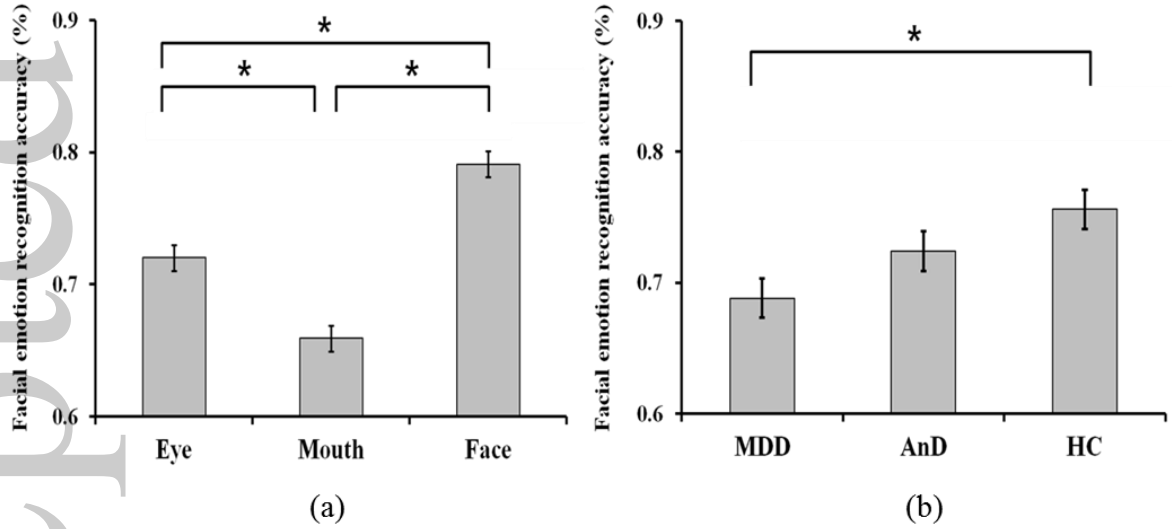

fig2