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ORIGINAL PAPER

Facial expression in male and female schizophrenia patients

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Abstract This study investigated gender differences in facial expression as a reaction to various emotional stimuli in two groups of schizophrenia patients. The first group consisted of hospitalized patients (22 men and 13 women) who were tested at three points in time. The second group consisted of outpatients (21 men, 8 women) who were tested at two points in time. In addition, the facial behaviour of two control groups was investigated (17 men and 12 women; 18 men and 14 women, respectively). Facial activity was videotaped, whilst participants watched emotion-eliciting video clips and participated in an emotion-inducing interview, and measured using the Facial Action Coding System. In agreement with our expectations, schizophrenia patients showed significantly less facial activity overall than healthy control participants. Contrary to expectations, however, female patients did not display more facial activity compared to male schizophrenia patients. This finding contrasts with those of healthy participants in previous studies where women tended to show more facial activity than men. It was further expected that in non-psychotic patients (i.e. outpatients), gender differences would be more clearly apparent and female schizophrenia patients would show considerably more facial activity than male patients, with findings more or less comparable to the gender differences found in healthy controls. However, no significant interaction was found between patient group (in- vs. outpatients) and gender. The different explanations for these findings are considered in this study.

Keywords Facial expression · Flat affect · Gender differences · Schizophrenia

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Introduction

Gender differences in the facial expression of emotions are generally observed in studies with healthy participants. Women have been found to be significantly more facially expressive than men in reaction to a wide variety of emotional stimuli [e.g. 20, 24]. However, little is known about the gender differences in facial expressivity of schizophrenia patients, the question addressed in this investigation.

It has been repeatedly reported that psychiatric patients and especially schizophrenia patients show characteristic facial activities [21, 26, 29], such as reduced levels of facial expressivity compared to healthy controls in reaction to emotional stimuli [e.g. 14, 15, 18, 32] and during social interactions [1]. This reduction could be regarded as a

behavioural indicator of 'affective flattening' reported in the psychiatric literature [13] and/or as a result of medication [8, 35]. On the one hand, neuroleptic medication can reduce facial activity, but on the other hand it can improve the patient's psychological state, which in turn can increase facial activity.

Participants in previous studies looking at facial expression in schizophrenia were mostly male patients [e.g. 19, 22]. When both genders were included, possible gender differences were rarely considered [e.g. 4]. The few studies that did consider the possible effect of gender on facial expression and other nonverbal behaviour in schizophrenia [e.g. 6] yielded either no significant gender differences or found that the female patients were significantly more expressive compared to male participants [see 23 for a review].

There are, however, aspects of schizophrenia in which male and female patients do differ. Schizophrenia usually starts at a later age for women than for men (25 to mid-30s for women vs. 18–25 for men) [2]. Female schizophrenia patients have more prominent mood symptoms, paranoid delusions and hallucinations, but also generally have a better prognosis than male patients [2] and function better socially [e.g. 33]. Male schizophrenia patients, on the other hand, show more negative symptoms (affective flattening is one of those symptoms) than female schizophrenia patients [2, 3]. Affective flattening, in turn, is usually associated with reduced facial expression. Thus, on the basis of these gender differences in symptoms and the general finding that in healthy populations men and women differ in levels of facial expressivity, it might be expected that male patients show less facial activity and fewer different facial movements (i.e. a smaller facial repertoire) than female patients even with an overall reduced level of facial expressivity in schizophrenia patients. Similarly, for schizophrenia patients in remission, the same gender differences might be expected albeit more prominent than for hospitalized patients and more similar to those found within the healthy population. To be able to explore whether these gender differences can indeed be found amongst schizophrenia patients and to make comparisons with a sample from a healthy population, we included samples of both hospitalized (i.e. inpatients) and outpatients in our study as well as healthy controls.

Additionally, it was expected that greater gender differences in the extent of facial activity would be found when participants were shown positive stimuli compared to negative stimuli, as was found with healthy participants [25]. Facial activity in the current study was therefore elicited by exposing participants to video clips with positive and negative valence. In addition, participants took part in an emotion interview, which was designed to induce emotions with either a positive or a negative valence and hence facial expressions. We expected the positive stimuli to elicit more facial activity than the negative stimuli and the gender differences to be more pronounced for the positive stimuli than for those of a negative valence. Further, since neuroleptic medication has been shown to influence facial activity [28], drug effects have been taken into account in explorative comparisons in this study.

This study focused on facial movements (the amount of movement and the repertoire) without inferring specific emotions. By remaining on a descriptive level, this study did not aim to address questions on the specific meaning of facial behaviour. Rather, facial behaviour, as analysed here, was regarded as reflecting non-verbal reactions or "comments" during an ongoing emotional situation, which may be expressions of affect or directed communication.

Method

Participants

Two samples of schizophrenia patients and healthy controls participated in this study. One group comprised patients who were hospitalized at the time of the research and the other group comprised of outpatients. Because of the risks of dropouts and organizational problems, the study was not extended to include more measurements during the hospital stay and afterwards when patients became outpatients. The two groups of patients came from two different clinics (Berlin and Düsseldorf) because of their availability. The Berlin sample included 35 schizophrenia inpatients (22 men, 13 women) from the Department of Psychiatry (W.G. and W.W. were formerly affiliated with the Free University of Berlin) and 29 healthy control participants (17 men, 12 women). Using ICD-10 criteria [37, 38], the schizophrenia inpatients were classified as follows:[1] simple schizophrenia (F20.6; $n = 1$); continuous paranoid schizophrenia (F20.0; $n = 21$); acute schizophrenia-like psychotic disorder (F23.2; $n = 2$); residual schizophrenia (F20.5; $n = 6$); and schizoaffective disorder (F25; 295.7 in ICD-9 [36]; $n = 3$). One patient received the diagnosis "other persistent delusional disorders" (F22.8) and despite a diagnosis of schizophrenia, the exact ICD classification for another outpatient was not available at the time of the study.

The Düsseldorf sample included 29 schizophrenia outpatients (21 men, 8 women) who had finished their clinical treatment at the Department of Psychiatry of the University

[1] ICD-9 criteria were used for the diagnoses of the inpatients. The ICD-9 codes have been translated into ICD-10 codes for consistency reasons. Where an accurate translation was not possible, the original ICD-9 code is also given.

of Düsseldorf, and 32 healthy control participants (18 men, 14 women). Using ICD-10 criteria [37, 38], the outpatients were classified as follows: continuous paranoid schizophrenia (F20.00; $n = 10$); episodic remittent paranoid schizophrenia (F20.03; $n = 1$); complete remission paranoid schizophrenia (F20.05; $n = 12$); continuous hebephrenic schizophrenia (F20.10; $n = 2$) and complete remission catatonic schizophrenia (F20.25; $n = 1$). For three outpatients there was no precise ICD-10 classification available.

The two groups of healthy control participants were from the same demographic area as the schizophrenia patients. They were recruited through the local radio, television, and newspaper and received 30 DM (€15/£10.00) for taking part in the study.

The samples of schizophrenia patients and healthy controls were approximately equal in professional background. In the Berlin sample, the men in the control group were significantly older than those in the schizophrenia group [$t(37) = -2.95$, $P = 0.005$] and in both the Berlin and the Düsseldorf samples the male patients were significantly younger than the female patients [$t(26) = -2.41$, $P = 0.023$].

Both samples contained more male than female schizophrenia patients, reflecting the different base rates for this clinical population [e.g. 33]. Table 1 gives an overview of the participants in each sample, the number for each gender and their mean age. Table 1 further gives information about the medication of the schizophrenia patients in both samples. About a third of inpatients did not receive any medication at the study baseline, all others received first and/or second generation antipsychotics either in either oral form ($n = 22$), depot form ($n = 1$) or a combination of both ($n = 2$). Most outpatients did receive some form of antipsychotics either in oral form ($n = 13$), depot form ($n = 11$) or a combination of both ($n = 3$). For two further outpatients, these data were missing (cf. Table 1).

Not all participants took part at each measurement point, or if they did their facial behaviours were not always coded for various reasons, resulting in missing data. Table 1 gives the number of participants in each sample for whom facial activity data are available for at least the first two measurement points. The data from those participants, for whom the facial activity data at one or more of the measurement points were missing, were automatically excluded from all analyses. For several participants, only the facial activity data for a particular task were missing (e.g. as a result of poor quality video recordings), and the remaining data for these participants was used where possible.

Table 1 Demographic data for schizophrenia patients (in- and outpatients) and healthy controls

	Berlin sample (inpatients)			Düsseldorf sample (outpatients)		
	Age *M* (SD)	*n*	*n* FA	Age *M* (SD)	*n*	*n* FA
Schizophrenia						
Men	30.18 (8.73)	22	13	34.70 (6.55)	21[a]	13
Women	39.54 (11.17)	13	9	43.00 (11.64)	8	6
Total	33.66 (10.59)	35	22	37.07 (8.94)	29	19
Control						
Men	39.18 (10.27)	17	17	38.11 (10.03)	18	12
Women	40.33 (12.98)	12	11	33.43 (12.83)	14	7
Total	39.66 (11.26)	29	28	36.42 (11.41)	32	19

Medication of schizophrenia patients	Berlin sample (inpatients)		Düsseldorf sample (outpatients)	
	T0 *n*	T1 *n*	T0 *n*	T1 *n*
Unmedicated	10	2	0	0
First-generation antipsychotics	18	20	14	12
Second-generation antipsychotics	6	8	9	7
Combination of first and second	1	3	4	4
Missing	0	2	2	6
Antidepressants	1	3	4	3
Tranquilisers	3	0	4	2
Anticholinergics	2	3	7	6

n FA: Number of participants for whom facial activity data is available for a minimum of two measurement points. Analyses were conducted with these reduced samples

Missing: either there was no information on these patients' antipsychotic medication or they were registered as dropouts (T1 only)

FA facial activity

[a] The exact age for one male patient was unknown, so mean age was computed for 20 male participants

Stimuli and experimental procedure

The schizophrenia inpatients from the Berlin sample were tested repeatedly during their clinical stay: on hospitalization (T0), after 4 weeks (T1), and on leaving the clinic (T2). The healthy control participants in this sample were tested twice at T0 and 4 weeks later at T1. The schizophrenia outpatients and the healthy control participants from the Düsseldorf sample were tested twice, 12 weeks apart (T0 and T1).

During the experiment, participants sat in a room on their own in front of a video monitor, whilst the experimenter was located in an adjacent room. Contact with the participant was made through a video intercom. The interview was conducted via a closed circuit TV; thus, participants watched the same monitor during the interview and the video clips shown later. The video camera recording the patient's behaviour was located next to the video monitor at an angle of 30°. It was covered by a black cloth, but was not concealed.

Facial activity was measured during two experimental situations: an emotion interview (happiness and anger) and video clips with an affective content (happy or sad). The whole experimental procedures lasted approximately 1 h, and included three further experimental tasks, which are described elsewhere [13, 34]. Further information can also be obtained form the authors.

Emotion interview

In a semi-standardized interview lasting approximately 20 min, participants were asked to close their eyes and in turn think about a situation in which they experienced a specific emotion (happy, angry, sad or fearful). After 1 min, they were requested to open their eyes and to describe the situation they had just thought about (e.g. "Please describe now a situation in which you were happy or in which something funny happened"[2]). For the current analyses of facial behaviour, we restricted ourselves to the anger and happy situations. We further only used the first 2.5 min after the imagination of a specific emotion, to assure that we had the same amount of video material for each of our participants.

Video clips

A second set of stimuli consisted of video clips taken from videotaped movies. All participants watched a video recording of one funny sketch performed by the well-known German comedian Vicco von Bülow performing as Loriot [either 'Die Nudel' (the noodle), 'Schiefes Bild' (crooked picture), or 'Tee und Hefetopf' (literal translation: tea and yeast pot)] and one negative video clip eliciting sadness (clip from either 'Gone with the Wind', 'Love Story' or 'Terms of Endearment'). The total viewing time for each video clip was 7.5 min. Participants never saw the same video clip twice. The video clips had been pre-tested on a German sample, to ensure a comparable affective content (either happy or sad). To separate personal experience from the video-induced one, all participants were interviewed first and then watched the video clips.

Participants were videotaped throughout the whole experiment, with their prior written consent. Participants were not given any explanation about the specifics of the research itself or that their facial expression was of special interest before the start of the study, because this would have influenced their performance during the study. Post hoc questions revealed that participants did not attend to the camera, but rather more to the tasks. The research was approved by the Ethical Committee of the Free University of Berlin.

Analysis of facial activity

Facial behaviour was coded from the videotapes using the Facial Action Coding System (FACS). FACS [10, 12] was taken as an objective measure and description of facial activity instead of other (related) coding systems such as EMFACS [16], which are based on emotional interpretations for specific facial expressions. Coding was undertaken by several certified FACS-coders. All coders achieved an inter-coder reliability of at least 75%, which is deemed to be satisfactory [11].

For each stimulus situation (positive and negative video clip, anger and happiness in interview), 2.5-min intervals were selected around pre-defined trigger points and facial activity was coded according to FACS. For the interview, the FACS coding started at the point when participants were asked to open their eyes and describe the situation they had just thought of. For the video clips, trigger points were identified by the experimenters as being especially funny or sad.

For every participant, the frequencies of each action unit (AU) and some AU combinations were determined. The total of all AUs displayed within the interval was used as a measure of general facial activity (GFA). GFA was divided into facial activity in the upper face (FAU) and in the lower face (FAL). In addition to that, the repertoire of AUs (REP) was defined as the number of different AUs that occurred at least once during the assessment period. Table 2 gives an overview of these measures.

Analyses were also performed for the occurrence of single AUs and AU combinations from three groups of AUs, i.e. 'positive AUs', 'negative AUs' and 'other frequently used AUs'. Positive AUs are those which are most often used in the expression of positive emotions, while negative AUs are most often used in the expression of negative emotions [10]. Frequent AUs were those that did not belong to the positive or negative group of AUs, but had been displayed frequently by the participants in this study. These groups of AUs and their description can be found in Table 2. Table 2 also gives an overview of the infrequent AUs; these AUs were taken into account for the calculation of GFA but were not analysed separately.

Results

Facial activity in schizophrenia patients

Because there were only two measurement points for the outpatients group and a fair amount of dropouts at T2 for

[2] The complete German version of the interview is available from the authors.

Table 2 Description of parameters

Name		Description	
GFA		General facial activity (=sum of AUs)	
FAU		GFA in the upper face	
FAL		GFA in the lower face	
REP		Number of different AUs used	
Positive AUs		Negative AUs	
6 (UF)	Cheek raise	4 (UF)	Brow lower
12 (LF)	Lip corner pull	14 (LF)	Dimple
1 + 2	Brow raiser	15 (LF)	Lip corner depress
6 + 12	Cheek raise + lip	17 (LF)	Chin raise
Frequent AUs		Infrequent AUs	
1 (UF)	Inner brow raiser	5 (UF)	Upper lid raise
2 (UF)	Outer brow raiser	7 (UF)	Lids tight
23 (LF)	Lip tight	9 (LF)	Nose wrinkle
24 (LF)	Lip press	10 (LF)	Upper lip raise
25 (LF)	Lips part	11 (LF)	Nasolabial deepen
26 (LF)	Jaw drop	20 (LF)	Lip stretch
37 (LF)	Lip wipe	22 (LF)	Lip funnel

AU Action unit according to the Facial Action Coding System [10, 12], *UF* AUs in the upper face, *LF* AUs in the lower face

the inpatient group (see also Table 1), we decided to use only the facial activity data for the first two measurement points (T0 and T1) in the following analyses.

General facial activity

We subjected the GFA scores to a 2 × 2 × 2 × 2 × 2 mixed design ANOVA[3] with time (T0 vs. T1), stimulus valence (positive vs. negative) and nature of stimulus (interview vs. video) as within subject factors and gender and patient group (inpatient vs. outpatient) as between-subject factors. A significant main effect for stimulus valence was found [F (1, 33) = 19.62, $P < 0.001$, $\eta_p^2 = 0.37$]. Patients displayed more facial activity in reaction to the positive stimuli ($M = 22.31$, SE = 2.62) compared to the negative stimuli ($M = 13.50$, SE = 1.71).[4] We also found a near significant main effect for the nature of the stimulus [F (1, 33) = 4.06, $P = 0.052$, $\eta_p^2 = 0.11$]. These effects were qualified by a significant interaction between stimulus valence and nature of the stimulus [F (1, 33) = 8.05, $P = 0.008$, $\eta_p^2 = 0.20$]. Whilst there was no significant difference due to stimulus valence for the interviews, patients displayed significantly less GFA whilst watching the negative video clip ($M = 7.55$, SE = 1.67) compared to the positive video clip ($M = 23.11$, SE = 3.93), F (1, 33) = 17.61, $P < 0.001$, $\eta_p^2 = 0.35$. Gender did not have the expected main effect on facial activity and did not interact with stimuli valence as expected.

We repeated these analyses with the GFA scores for the upper and lower face separately. For FAU, there was once more a significant main effect of stimulus valence [F (1, 34) = 8.87, $P = 0.005$, $\eta_p^2 = 0.21$) with patients displaying more expressivity in the upper face when the stimulus was positive ($M = 5.51$, SE = 0.86) compared to when the valence of the stimulus was negative ($M = 3.89$, SE = 0.67) and a significant effect of the type of stimulus [F (1, 34) = 8.82, $P = 0.007$, $\eta_p^2 = 0.19$] with the interviews eliciting significantly more upper face activity ($M = 6.08$, SE = 1.11) than the video clips ($M = 3.32$, SE = 0.52).

For facial activity in the lower face (FAL), we found a significant main effect of time [F (1, 33) = 6.18, $P = 0.018$, $\eta_p^2 = 0.16$] with patients displaying more FAL at T0 ($M = 14.24$, SE = 1.58) compared to T1 ($M = 12.14$, SE = 1.54). A significant interaction with patient group showed that this effect was only significant for the outpatient group [F (1, 33) = 9.71, $P = 0.004$, $\eta_p^2 = 0.23$] and not for the inpatient group. There was further a significant effect of stimulus valence [F (1, 33) = 17.57, $P < 0.001$, $\eta_p^2 = 0.35$] further qualified by an interaction with the type of stimulus [F (1, 33) = 9.99, $P = 0.003$, $\eta_p^2 = 0.23$]. There was no significant difference in lower face activity elicited by the happiness interview compared to the anger interview, whereas the positive video clip elicited significantly more lower face activity ($M = 18.26$, SE = 3.20) than the negative video clip ($M = 5.81$, SE = 1.44), F (1, 33) = 18.35, $P < 0.001$, $\eta_p^2 = 0.36$. No effects of gender were found.

Repertoire of AUs

We subjected the repertoire of different AUs that each participant displayed to a 2 × 2 × 2 × 2 × 2 mixed design ANOVA (see Footnote 3) with time, valence and nature of the stimuli as within-participant factors and gender and patient group as between-subject factors. We found a significant main effect of gender [F (1, 33) = 5.14, $P = 0.03$, $\eta_p^2 = 0.13$], but not in the expected direction. Contrary to predictions, male patients displayed a significantly greater repertoire of different AUs ($M = 6.09$, SE = 0.41) than female patients ($M = 4.58$, SE = 0.52).

We also found a significant main effect of valence [F (1, 33) = 15.51, $P < 0.001$, $\eta_p^2 = 0.32$] with a greater number of different AUs displayed when exposed to a positive stimulus ($M = 5.95$, SE = 0.38) compared to a negative

[3] Participant numbers were marginal for a five-factor MANOVA. We therefore repeated the analyses with only gender or patient group as between-subject variable. The results were comparable.

[4] As the cell size varied, all means reported in the text were the estimated marginal mean and standard errors.

one ($M = 4.72$, SE = 0.35). We further found a main effect of stimulus type [F (1, 33) = 28.28, $P < 0.001$, $\eta_p^2 = 0.46$], with the interview eliciting a greater repertoire of AUs ($M = 6.55$, SE = 0.43) compared to the videos ($M = 4.12$, SE = 0.37) and a significant interaction between valence of the stimulus and the type of stimulus [F (1, 33) = 10.27, $P = 0.003$, $\eta_p^2 = 0.24$]. There was no difference in repertoire due to stimulus valence when the participants participated in the emotion interview, but the positive video clip elicited a significantly greater repertoire of different AUs ($M = 5.27$, SE = 0.49) than the negative video ($M = 2.97$, SE = 0.38).

Single AUs and AU combinations

As an exploratory analysis, we submitted the frequency scores for the single AUs and AU combinations to a five-factor mixed design ANOVA (see Footnote 3) with time, valence and nature of the stimuli as within participant factor and gender and patient group as between-subject factors. Significant gender differences at the level of single AUs occurred primarily for AUs in the forehead area. Male patients displayed significantly more AU 1 [$M = 1.28$, SE = 0.24 vs. $M = 0.39$, SE = 0.32; F (1, 34) = 4.96, $P = 0.033$, $\eta_p^2 = 0.13$]; more AU 2 [$M = 1.37$, SE = 0.24 vs. $M = 0.47$, SE = 0.32; F (1, 34) = 4.98, $P = 0.032$, $\eta_p^2 = 0.13$] and combined AUs 1 and 2 significantly more often [$M = 1.07$, SE = 0.21 vs. $M = 0.30$, SE = 0.28; F (1, 34) = 4.99, $P = 0.032$, $\eta_p^2 = 0.13$]. Male patients further displayed AU 37 (a lower face AU) significantly more often ($M = 0.87$, SE = 0.17) than female patients ($M = 0.23$, SE = 0.22), F (1, 34) = 5.37, $P = 0.027$, $\eta_p^2 = 0.14$. Figure 1 illustrates these gender differences.

There was a significant main effect of valence for AUs 6 [F (1, 34) = 23.58, $P < 0.001$, $\eta_p^2 = 0.38$] and 12 [F (1, 34) = 34.58, $P < 0.001$, $\eta_p^2 = 0.50$] and for AU combination 6 + 12 [F (1, 34) = 38.51, $P < 0.001$, $\eta_p^2 = 0.53$], which were displayed more frequently as reaction to positive stimuli compared to negative stimuli (AU 6 $M = 2.62$, SE = 0.45 vs. $M = 0.47$, SE = 0.11; AU 12 $M = 5.46$, SE = 0.79 vs. $M = 1.25$, SE = 0.24; AU 6 + 12 $M = 2.50$, SE = 0.36 vs. $M = 0.42$, SE = 0.10).

In addition, there was a significant main effect in the patient group for AU 12, with the hospitalized sample ($M = 4.42$, SE = 0.64) displaying significantly more smiles compared to the outpatient sample ($M = 2.29$, SE = 0.68), F (1, 34) = 5.23, $P = 0.029$, $\eta_p^2 = 0.13$. There was a near significant interaction between patient group and valence [F (1, 34) = 4.00, $P = 0.053$, $\eta_p^2 = 0.10$). Inpatients only smiled significantly more often than outpatients in reaction to the positive stimuli ($M = 7.24$, SE = 1.09 vs. $M = 3.68$, SE = 1.09), F (1, 34) = 5.04, $P = 0.031$, $\eta_p^2 = 0.13$.

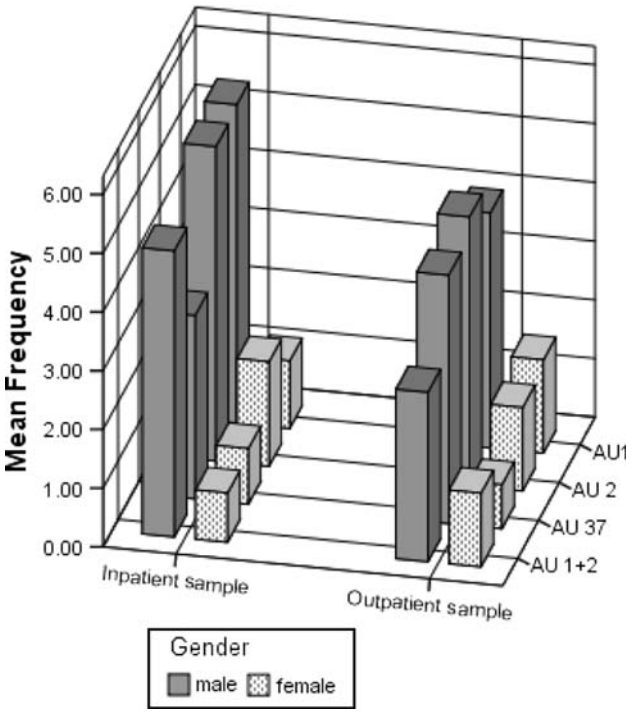

Fig. 1 Significant gender differences in the frequency of single AUs and AU combination in schizophrenia samples

We also found a significant main effect of time for AUs 25 and 26, with both AUs being displayed more frequently at T0 compared to T1. Finally, in line with our finding that the interviews elicited far more facial activity than the video clips, we found a significant main effect of stimulus type for AUs 1, 2, 4, 6, 14, 23, 24, 25, 26, 37 and AU combinations 1 + 2 and 6 + 12, with the interviews eliciting a significantly higher mean frequency for each of these AUs.

Differences between schizophrenia patients and control participants

We entered the GFA data (mean across four stimuli situations) from both the patient groups and the control groups into a 2 (patient vs. control) by 2 (inpatient vs. outpatient) by 2 (T0 vs. T1) mixed design ANOVA. As expected, healthy controls displayed significantly more facial activity ($M = 16.63$, SE = 1.13) compared to the schizophrenia patients ($M = 9.18$, SE = 1.19), F (1, 75) = 20.50, $P < 0.001$, $\eta_p^2 = 0.21$. This was further qualified by a significant interaction with patient group, F (1, 75) = 10.66, $P = 0.002$, $\eta_p^2 = 0.12$. Healthy controls for the inpatient group (i.e. Berlin sample) displayed significantly more facial activity ($M = 21.78$, SE = 1.48) in comparison with the schizophrenia inpatients ($M = 8.95$, SE = 1.66) [F (1, 75) = 33.06, $P < 0.001$, $\eta_p^2 = 0.31$], whereas the levels of facial activity for schizophrenia

outpatients ($M = 9.42$, SE = 1.71) and healthy controls ($M = 11.49$, SE = 1.71) did not differ significantly. As one can see from the group mean, this latter lack of effect seems to be (partly) due to reduced levels of expressivity in the healthy controls for the outpatients (i.e. the Düsseldorf sample) in comparison to the healthy controls for the inpatients (Berlin sample), and not because the outpatients showed improved expressivity in comparison to the inpatients. We further compared the patient and control groups on upper and lower face activity separately, with similar results as described above with the patients showing less upper and lower facial activity compared to the controls. The one exception was the interaction with the patient group (inpatients vs. outpatients) for upper face activity (FAU). For FAU, despite the generalized reduced facial expressivity of the Düsseldorf controls, the schizophrenia outpatients still tended to show less upper face activity than the controls [F (1, 75) = 3.91, $P = 0.052$, $\eta_p^2 = 0.26$], whereas there was no difference for the lower face activity.

Differences between male and female control participants

Because of the unexpected direction of some of the differences between male and female schizophrenia patients, we repeated the main analysis with the control participants focussing specifically on the effects of gender. We conducted 2 × 2 × 2 × 2 × 2 (see Footnote 3) mixed design ANOVA with time, valence and nature of the stimuli as within-participant factor and gender and sample as between-subject factors. Although overall female controls appeared to be more expressive than male controls, the main effect of gender was not significant. However, there was a significant interaction between the type of the stimulus, the valence and gender [F (1, 38) = 5.58, $P = 0.023$, $\eta_p^2 = 0.13$]. Female control participants were significantly less expressive ($M = 5.03$, SE = 1.67) than male participants ($M = 9.80$, SE = 1.26) when exposed to a video clip with a negative valence [F (1, 38) = 5.21, $P = 0.028$, $\eta_p^2 = 0.12$], whereas female controls were far more expressive ($M = 48.36$, SE = 8.24) than male controls ($M = 34.41$, SE = 6.23) when the video had a positive valence, although this difference was not significant due to the great variance in scores. During the emotion interviews, the mean scores of male and female control participants were very similar.

Differences between medicated and unmedicated schizophrenia inpatients

The samples were too small to statistically compare male and female T0-medicated inpatients and unmedicated inpatients [i.e. there were only seven T0-unmedicated patients (three males, four females) for whom facial activity data was also available]. An exploratory visual inspection of the data seems to suggest that in the unmedicated group, the male patients do indeed express more GFA, FAL and FAU than the female patients, whereas in the medicated group the mean and standard deviations for both genders are far more similar. This difference continued at T1 when all patients in this particular exploration had been receiving medication.

Discussion

Differences between male and female schizophrenia patients

In line with the findings of Brüne et al. [6], the female schizophrenia patients (both in and outpatients) in our study did not display more facial activity (GFA, FAU, and FAL) or a greater repertoire of AUs (REP) than male schizophrenia patients at any of the measurement points. On the contrary, female patients showed less facial activity than male patients on several of the parameters, significantly so for the repertoire of AUs. Therefore, the main hypothesis regarding gender differences was not supported.

Further, although in general, exposure to the positive stimuli did result in greater facial activity compared to the negative stimuli, we did not find a significant interaction between stimulus valence and gender. Thus, the hypothesis that female schizophrenia patients would specifically show more facial activity in case of positive stimuli was not supported also by the results.

It was expected that in non-psychotic patients (i.e. the outpatients) gender differences would be more clearly apparent and female schizophrenia patients would show more facial activity than male patients, more or less comparable to the gender differences found in healthy controls. However, no significant interaction was found between patient group and gender. Inspection of the data shows that male outpatients were equally expressive as female outpatients, if not more so.

There are several possible explanations for these unexpected results. First, the unexpected direction of the gender differences could have been caused by neuroleptic medication having a differential influence on men and women. A very tentative exploration seems to indicate that female patients who received medication when they were first admitted to hospital (T0) tended to show more facial activity (GFA) than female patients who did not receive medication at T0. Also, in the T0-medicated group, levels of GFA in the female patients were similar to those of the male patients. T0-unmedicated male patients also showed less GFA than medicated male patients, but yet the levels

were higher than those of the female unmedicated patients. This could be an indication that the medication especially influences the facial activity of female schizophrenia patients, which would be in line with previous research that indicates a better response to treatment with medication in female patients [e.g. 33]. However, the results of our unmedicated patients should be interpreted with extreme caution, as this subgroup only consisted of seven patients for whom facial activity data was available.

Overall, the effects of medication on facial activity in this study were not completely clear. One would expect, for instance, that in the inpatient sample at T1, when both subgroups were receiving medication, facial activity of both groups (T0 medicated and T0 unmedicated) would be more or less the same. This was not the case. Future studies should take into account the possible medication effects on facial activity and emotional reactions of schizophrenia patients and consider the possibility of gender-specific medication effects on affectivity in schizophrenia. Facial expression may form a sensitive indicator of the effectiveness of the medication.

A possible alternative explanation for the results related to gender is that schizophrenia patients do not follow the so-called display rules governing facial behaviour as much as healthy control participants do. Display rules are said to influence facial expressions [e.g. 9], by causing the facial expression of certain emotions to be reduced, neutralized, masked or exaggerated when expressed in particular social situations. Some of these rules are gender specific. Men, for instance, learn at a young age that they should not cry ("big boys don't cry!"). On the other hand, women learn, more than men, to smile in social situations (e.g. after receiving a gift [7, 27]). A display rule that men should not display facial expressions too openly could explain the reduced facial activity of healthy male participants in comparison to healthy female participants, as has been reported in the literature [20]. If the present results were due solely to the men with schizophrenia not adhering to this rule, however, it might be expected that levels of facial activity would be roughly the same for male and female patients. This was not always found in this study. Future research could determine the role of display rules during psychosis, for example, by varying the social situation to which the participants are exposed. It might be expected that schizophrenia patients would smile relatively less than healthy control participants when placed in a social situation compared with a neutral situation. Although the emotion interviews used in the current study were of a somewhat social nature, the fact that these took place via close-circuit television makes them very different from the more naturalistic social contexts used in other studies [e.g. 17] and do not provide the ideal circumstances to test that hypothesis.

There were also gender differences for the control group in an unexpected direction for the negative video clip condition. Men showed more facial activity in reaction to the negative clip than women. This might indicate that some of the gender-related findings for the schizophrenia patients were also due to the negative video clip being more effective for men than for women. It is unclear why this should be so. The negative video clips shown at each of the measurement points were considered to be gender neutral. General facial activity in reaction to the negative video clip was very low compared to the facial activity in the other conditions. Thus, the unexpected gender difference seems to be more general and not related to the characteristics of the schizophrenia group. The significant gender differences for the patients in the other conditions cannot, however, be explained in this way, as in most cases the female controls showed at least as much, if not more, facial activity as male controls. The fact that female controls did not consistently show significantly more facial expressivity than male controls is an interesting finding in itself. As indicated before, most research to date seems to suggest that women are more expressive than men [e.g. 5]. However, research by Frisch [17] has shown that one cannot assume a generalized greater facial expressivity in women. It appears that facial expressivity in men, especially, is very much dependent on the (social) situation.

Frisch [17] also describes how men and women differ in the variability in experienced emotionality across various situations, with women displaying greater variability in their emotional experience than men, possibly as a result of social rules and/or expectations. This study was not set up to deal with difference in emotional experience, but this should be explored in future research.

The current study was based on small and unequally distributed sample sizes. Larger sample sizes would, as in most clinical studies, be desirable and in case of a longitudinal design, as in the current study, enable repeated measure analyses to be carried out. Given the current results, further studies might also consider two-sided testing of the gender hypothesis.

Differences between control participants and schizophrenia patients

As expected, healthy control participants showed more facial activity than schizophrenia patients during the course of their illness, confirming previous findings [30]. Schizophrenia patients appeared to be socially inhibited, consistent with data from other studies [e.g. 14]. This social inhibition is apparent in the lack of upper face AUs (which mainly comprised AU 1 + 2). This movement (raising the eyebrows upwards) can be seen as an example of 'facial illustrators' that are used in social interaction [9]. The

social inhibition continued partly after the psychosis was over. Similar to findings of other researchers [e.g. 31], schizophrenia outpatients showed less facial activity in the upper face than healthy control participants, despite the fact that overall the levels of GFA, FAU and FAL for the controls in this sample (Düsseldorf) were lower than those in the Berlin sample.

Summary

Women with schizophrenia did not show more facial activity in reaction to emotional stimuli than men with schizophrenia. On the contrary, male patients repeatedly showed more activity than female patients. The reason for this unexpected finding is not yet clear, but it could very well be that women react differently to the medication they receive and are more sensitive to its affect-flattening effect.

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