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Computer-Based Analysis of Facial Action in Schizophrenic and Depressed Patients

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Summary. With a newly developed computer analysis the space coordinates of light-reflecting points, attached to a subjects' face, were recorded across time with high temporal and spatial resolution. Under different experimental conditions the facial actions of 20 schizophrenics, 20 depressives and 20 normal controls were analysed. Furthermore, raters watched the synchronously recorded video versions of the subject's face and rated them as to expressivity. The findings indicate that depressive and schizophrenic patients exhibited reduced facial activity in the upper part of their face in social interaction conditions. Schizophrenic patients showed reduced facial action responsivitiy across different conditions and emotions. All patients were judged to be less expressive than normal controls by raters, suggesting apparent disintegrated elements in facial activity, although when computer-analysed they exhibited the same amount of facial activity.

Key words: Facial action – Computer-based analysis – Facial expression – Schizophrenia – Depression

Introduction

Abnormal movements, especially facial expressions, are essential components of psychopathological disorders. Thus, the facial actions of schizophrenics seem to be either too fast or too slow, jolty, uncoordinated, expressionless, asymmetrical or bizarre, whereas depressives exhibit comparatively slower psychomotor behaviours and a lack of facial action responsivity in affective situations (Marsden et al. 1975).

Although in the past psychiatrists have repeatedly emphasized this unusual facial expressivity of schizophrenics and depressives (Kraepelin 1883; Bleuler 1911), there has been relative little research in this area until recently. This may be attributed to a shortage of available methodological facial action assessment procedures. To date several methods for the assessment of facial actions and expressions are available: the coding of facial actions by extensively trained scorers (Ekman 1982), rating of facial expressions by independent observers (Rosenthal 1982), assessment of facial electromyographic (EMG) activity (Fridlund 1983), as well as automatic analyses of facial action. So far the development of automatic facial action analyses has not been successful because of the insufficient spatial and temporal resolution and the "unreadability" of facial points by the computer.

In 1924 Landis presented the first procedure for assessing facial expressivity by photographing the subject's face. He marked the face with a burnt cork in such a manner as to set off functional muscle groups. A lattice screen was then held in front of the subject's face while photographs were taken. A specially constructed camera system allowed him to take rapidly one picture after another. With this procedure he was able to identify almost 20 previously defined patterns of facial action comprising principle groups of muscles which modify expression. In a study of healthy subjects Landis also classified the different emotional states of each individual facial-action pattern separately for each picture with a four-point intensity scale.

Lynn (1940) developed a so-called facial cinerecorder in order to measure the distances between specific facial points. Lynn and Lynn (1943) filmed subjects with this apparatus, recording the movements of the corners of the lips with a measuring instrument drawn on tracing paper.

A similar study was conducted by Wörner (1940), who filmed Rhesus monkeys in different settings, projected each frame onto a screen and copied the movements of individual facial points on tracing paper. Afterwards he placed the individual sheets of tracing paper on graph paper and determined how much these facial points had moved from their original positions.

Experimental subjects were also filmed by Heimann (1966) and Heimann and Lukàcs (1966). The individual frames of each filmed face were projected onto a glass plate. By using a set of coordinates placed over the pro-

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jected image of the face, the authors were able to determine the exact position of the facial points in each frame and were thus able to record the movements of both corners of the lips as well as the eyebrows.

Lasko (1979, unpublished) presented a formalized mathematical model capable of measuring the curvative changes of the lips, the cheeks, the eyebrows and the eyelids.

By analysing the video tapes of subjects and by measuring the individual lip movements frame by frame, Goodale and colleagues (Wolf and Goodale 1987; Wylie and Goodale 1988; Goodale 1988) and Graves and colleagues (Graves et al. 1982, 1985) applied a slightly different procedure.

Another computer-assisted technique for the mathematical description of facial expressions was developed by Thornton and Pilowsky (1982). In a further step these individual movements were assigned to specific emotions (Pilowsky et al. 1985, 1986).

All these techniques, however, have some disadvantages: they are extremely time consuming and unable to record facial action completely accurately, since the movements of the facial points, in these frame by frame procedures, were measured manually with a centimetre measuring tape or a digital pen.

Another point of interest was the assessment of specific facial features in patients with psychiatric disorders. Several methodological inventories have been utilized to determine the facial actions of schizophrenics and depressives. The facial characteristics displayed by unmedicated chronic schizophrenics were described by Heimann (1966) and Heimann and Spoerri (1957) as "disintegration of facial action". Against the background of holistic facial activity sudden quick movements appeared which contrasted the general pace of expression. Thus, for the observer these facial actions seemed out of place and bizarre. Furthermore, the facial expression became more or less asymmetrical. Focus and unity disappeared owing to the individual movements of the dissociated facial activity.

In a controlled study by Krause et al. (1989) ten medicated schizophrenic outpatients exhibited a reduction in the amount of facial action in the upper face and a reduced affective variability in their behaviour. The Facial Action Coding System (FACS) was used to measure facial "action units" based on the underlying muscle structures of the face (Ekman and Friesen 1978). Different results were obtained by Ekman and Fridlund (1987). In their study of a small sample, schizophrenics exhibited a reduced amount of facial action for the whole face.

To date the facial expressions of depressives have been studied more frequently than those of schizophrenics. These studies mostly used EMG measures. The purpose was to find specific EMG patterns for depressives and prognostic indices for therapeutic efficacy (Whatmore and Ellis 1959; Schwartz et al. 1976, 1978; Schwartz and Weinberger 1980; Teasdale and Bancroft 1977; Teasdale and Rezin 1978; Oliveau and Willmuth 1979; Brown 1982). However, the findings of these studies were not uniform.

Heimann (1973) investigated the facial action of several depressives, whereby the distances between facial points were measured with the method described above (1966). The findings showed a significant correlation between the total movement and the extent of anxiety and depression.

Ellgring (1989) did not find a reduction in the variety of facial patterns expressed by depressives with FACS. Only the smiling rate was reduced during the depressive phase and increased with improvement.

The present study, however, was designed to validate a newly developed computer-based technique for measuring facial action. Another aim was to replicate and specify characteristics in facial movements, such as the facial disintegration described in psychiatric patients.

Subjects and Methods

The study comprised 60 subjects: 20 medicated schizophrenic inpatients (DSM-III-R criteria), 20 medicated depressive inpatients (DSM-III-R criteria: Major Depression; American Psychiatric Association 1987), and 20 normal controls. Eight schizophrenics were subchronic, 3 subchronic with acute exacerbations, and 9 chronic with acute exacerbations. The characteristics of the depressed patient group were as follows. Six had only one single episode and 14 recurrent episodes; none of the depressives exhibited any psychotic symptoms. Normal controls had no history of psychiatric disorders nor were they on any psychotropic medication before or during the study.

Table 1. Demographical and clinical characteristics of the subjects (mean ± SD)

Variable	Schizophrenics	Depressives
BPRS (Overall and Gorham 1962)	58.05 ± 6.82	48.45 ± 7.29
Hamilton Depression Scale (1960)	17.70 ± 5.57	24.70 ± 7.48
SANS Summery Score (Andreasen 1981)	12.85 ± 3.27	9.00 ± 2.94
GAS (Endicott et al. 1976)	38.00 ± 8.93	41.80 ± 10.20
Length of current episode (weeks)	27.35 ± 35.42	22.50 ± 33.07
Total length of illness (years)	5.45 ± 5.54	5.50 ± 7.01
Number of previous hospitalizations	1.90 ± 2.43	1.00 ± 1.38

Table 2. Medication patients received and their side-effects

Variable/number of patients with	Schizophrenics	Depressives
Neuroleptics	20	4
Antidepressives	2	17
Benzodiazepine	1	3
Biperiden	4	0
Chlorpromazine units	966.00 ± 773.95	82.50 ± 197.53
Simpson and Angus Scale (1970)	3.25 ± 3.93	1.15 ± 2.93

Each of the three groups comprised 10 female and 10 male subjects. There was a significant age difference among the groups: the mean age (± SD) of schizophrenics was 31.5 ± 9.5 years, of depressives 40.5 ± 11.4 years, of controls 32.1 ± 12.9 years ($F = 3.96$; $df = 2{,}57$; $P = 0.025$). There were no significant differences as to educational level. Tables 1 and 2 show the sample characteristics.

None of the subjects had any previous facial injuries. All subjects were right-handed (Oldfield 1971). Moreover, all subjects were selected on the basis of being clean-shaven and not wearing glasses because of possible light reflections which might disturb the accurate recording of facial actions.

Experimental Conditions

The subjects watched two 7-min films on a monitor. One film was emotionally positive (funny sketch), the other one negative (horror film). Each film was immediately followed by a positive or negative 5-min interview. The positive or negative state was achieved by discussing either pleasant or unpleasant personal events experienced by the subject. The aim of the interview was to maintain the subject's mood he/she had experienced in the preceding film. The two affective blocks [(1) positive interview and positive film; (2) negative interview and negative film] were divided by a 10-min rest period, in order to reduce the emotions from each other. Furthermore, the sequences of these blocks were systematically varied within each group.

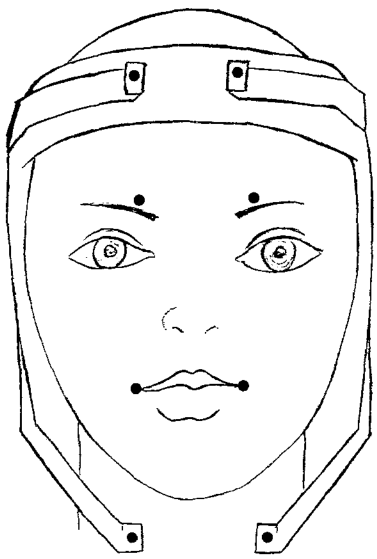

Fig. 1. Experimental subjects with four attached facial action foils and the positioned headgear with four reference points

Computer-Based Facial Action Analysis

The facial action was analysed with a specially constructed scanning unit consisting of a CCD-Chip Camera (uniserial pixel arrangement with 2048 elements) equipped with a high-powered lens. A rotating hexagonal prism was positioned between the lens and the CCD element. The camera took 10 pictures with a vertical and horizontal resolution of 2048 × 1024 pixels (for details, see Himer et al. 1991).

Small, strongly reflective points were attached to several facial points of the subject (Fig. 1). The scenario was illuminated with an intensive infra-red light. An infra-red filter covered the camera lens. With this arrangement the system provided "pictures" whereby the "facial action points" contrasted sharply from the pitch-black background. The exposures in effect contained only the information "light" (= "facial action point") or "dark" (= background).

The information collected by the CCD-Chip Camera was transferred to a controlling device, developed by our group, which prepared the information in such a manner that it could be transferred to the computer. Further data processing was done with a microcomputer system (68000-VME-Bus System). After the picture had been recorded, specialized programs transferred the collected information over X- and Y-coordinates into working memory. From the pixel clouds representing the individual "facial action points" the midpoint of the coordinates was determined. Moreover, the system corrected all head movements with the help of four reference points (see Fig. 1).

For optical control of the computer-analysed data the subjects' faces were recorded on video during the film-and-interview conditions. These videos were presented to the raters.

Quantizing Error

The facial action point analysis system produced a continuous white noise (quantizing error) caused by the system. With a motionless articifical head we measured a mean point movement (± SD) of 2.8 ± 0.12 mm/s. There were no significant differences among different points (for details, see Himer et al. 1991). In order to eliminate the system's white noise for the systematic calculations and the graphical presentations of facial actions the constant of 2.8 mm/s was subtracted from each individual score.

Actual Experimental Procedure

The subjects sat upright in a chair with their head placed comfortably against a head support. They faced the camera directly. The distance from the tip of the nose to the lense measured 280 ± 5 cm. A specially constructed headgear consisting of a headband and forehead-and-mouth frame was placed around the subject's head (see Fig. 1).

Two reflective points were attached to each side of the forehead-and-mouth frame comprising the referential coordinate system. With this arrangement the subjects' head movements could

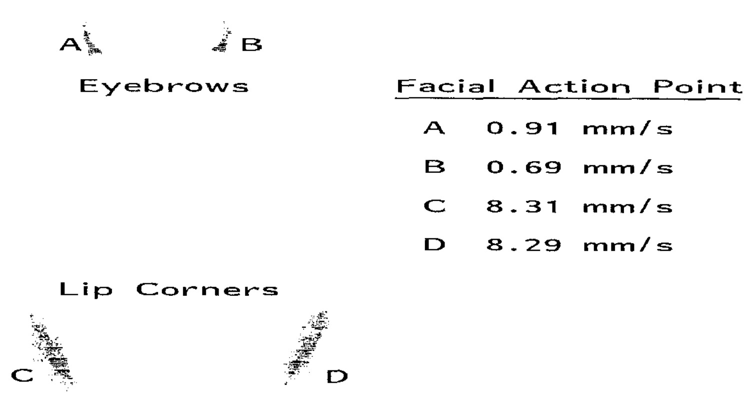

Fig. 2. Point clouds of facial action movements of a subject during an interview lasting about 2.5 min (example)

be processed and calculated by the computer program. The diameter of the points measured 2.5 mm and equalled 12.5 pixels. Two pieces of foil were attached next to each lip corner and the other two 1 cm laterally above the medial eyebrow (Fig. 1).

The facial action displayed in the last 2.5 min of each experimental condition was analysed with the facial action analysis.

Assessment Procedure

To date only simple analyses procedures are available: for example, Fig. 2 shows a point cloud and its corresponding mm/s values during an interview lasting about 2.5 min.

Rating Procedure

In two rating studies the soundless video versions of the 2.5 min computer-analysed facial action sequences, recorded under the four experimental conditions, were presented to novices (students without any medical experience) and experts (psychiatrists).

Group 1: Novice Raters. The participants were 16 male and 24 female students. Their mean age (± SD) was 25.25 ± 7.28 years. The observers were not informed about the purpose of the study, the contents of the films or the type of interview conducted, and they did not know the individuals to be assessed.

Group 2: Expert Raters. The participants were 8 male and 4 female psychiatrists. Their mean age was 36.45 years (SD = 9.27). Mean psychiatric professional experience was 6.3 years (SD = 6.65, MD = 4.0). The psychiatrists knew about the study's aim. Likewise some of them had previously treated several of the participating patients as inpatients or outpatients.

Each video sequence was rated by 5 (group 1) and 4 (group 2) raters, respectively. Each rater group rated all the video sequences of one individual subject. Assignment of subjects to rating groups was done randomly. The raters' task was to judge the extent of "expressivity" on a seven-point scale ranging from "0" (not at all) to "6" (very strong). Expressivity was defined to the raters as the intensity of expressed facial activity independent of the presented emotions. Before the actual rating took place the raters participated in a training session where six sequences representing the extremes on the rating scale were shown.

Results

Computer-Based Facial Action Analysis

There were no significant group differences when averaged across the two conditions (film and interview), comprising emotionally positive and negative contents. The mean facial action (± SD) averaged across the four facial-action points was 1.52 ± 0.57 mm/s. A one-way ANOVA revealed no significant group differences ($F = 0.24$, $df = 2{,}57$, $P > 0.05$).

Gender differences were not significant regarding the total facial action expressed (male subjects: mean = 1.49 mm/s, SD = 0.52; female subjects: mean = 1.94 mm/s, SD = 0.62; $t = 0.33$; $df = 58$; $P > 0.05$).

Various significant effects were obtained with a five-way ANOVA comprising the factor "group" (schizophrenics, depressives, controls) and the repeated measure factors "condition" (interviews, films), "position of facial action points" (corners of lips, eyebrows), "emotion" (positive, negative), and "hemiface" (left, right) (Table 3).

Table 3. Means and standard deviations in experimental conditions (mm/s)

		Schizophrenics	Depressives	Normal controls
Interview – lip corners	[a]	4.56 ± 2.73	4.93 ± 1.52	4.81 ± 1.61
	[b]	4.50 ± 2.65	4.15 ± 1.72	3.83 ± 1.91
Film – lip corners	[a]	1.00 ± 0.69	0.63 ± 0.43	0.86 ± 0.79
	[b]	0.56 ± 0.52	0.47 ± 0.40	0.51 ± 0.79
Interview – eyebrows	[a]	0.51 ± 0.33	0.59 ± 0.57	0.84 ± 0.35
	[b]	0.42 ± 0.48	0.36 ± 0.47	0.64 ± 0.43
Film – eyebrows	[a]	0.55 ± 0.47	0.33 ± 0.48	0.48 ± 0.39
	[b]	0.48 ± 0.28	0.12 ± 0.37	0.25 ± 0.42

[a] Positive; [b] negative

While the subjects were talking it became obvious that lip corner movements occurred more frequently in the interview than in the film conditions. The significant main effect "condition" ($F = 210.64$, $df = 1{,}57$, $P = 0.000$) emphasized this especially in addition to the significant interaction "condition × position" ($F = 201.57$, $df = 1{,}57$, $P = 0.000$).

Altogether the subjects expressed more facial action during the interviews than during the films, which, however, was due to the movements of the lip corners. Another significant main effect was "position" ($F = 237.69$, $df = 1{,}57$, $P = 0.000$). There were more significant facial actions of lip corners in comparison with eyebrow movements under all conditions. The findings indicate that the induced positive emotion condition elicited more facial activity for both eyebrows and lip corners than the negative condition [significant main effect "emotion" ($F = 31.17$, $df = 1{,}57$, $P = 0.000$), significant interaction "emotion × position" ($F = 10.89$, $df = 1{,}57$, $P = 0.002$)].

In the following, we present the results of four three-way ANOVAs (factor: "group"; repeated measure factors: "emotion", "hemiface"), separated according to interview-lip corners, film-lip corners, interview-eyebrows, film-eyebrows. Group effects were further evaluated with post hoc *t*-tests.

Interview – Lip Corners. In comparison with negative emotional conditions subjects reacted with an increase in facial activity to the positive emotional conditions. This highly significant main effect ($F = 17.94$, $df = 1{,}57$, $P < 0.000$) was obtained across all four conditions and facial point positions.

Although, the main effect "group" was not significant, the groups differed significantly as to emotional stimulus presented (Fig. 3; emotion × group: $F = 3.91$, $df = 2{,}57$, $P = 0.026$). Schizophrenic subjects in comparison with controls exhibited significantly different emotional behaviour ($F = 7.03$, $df = 1{,}57$, $P = 0.010$): the amount of facial activity was independent of emotional induction (schizophrenics: $t = 0.18$, $df = 19$, $P > 0.05$), while the facial activity of depressive subjects ($t = 4.23$, $df = 19$, $P < 0.000$) and controls ($t = 3.75$, $df = 19$, $P = 0.001$) differed significantly as to positive or negative content (Fig. 3).

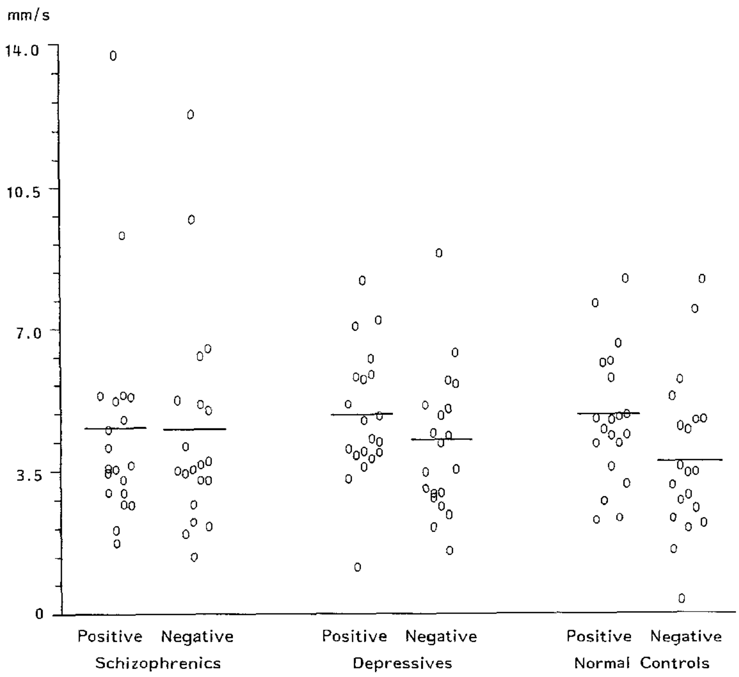

Fig. 3. Computer-analysed movements of each individual for positive and negative emotional induction: interview-lip corners. *Lines* indicate means

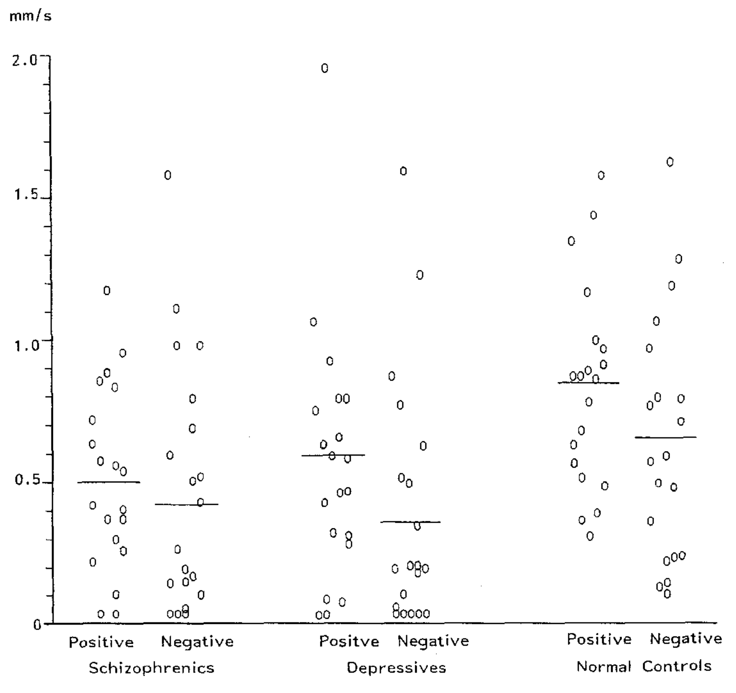

Fig. 4. Computer-analysed movements of each individual for positive and negative emotional induction: interview – eyebrows. *Lines* indicate means

Film – Lip Corners. The main effect "emotion" was significant: the positive stimuli elicited more facial activity in comparison with the negative ones ($F = 13.36$, $df = 1{,}57$, $P = 0.001$). There were no significant group effects while watching the films ($F = 0.98$, $df = 2{,}57$, $P > 0.05$).

Interview – Eyebrows. The three groups differed significantly as to eyebrow activity (Fig. 4; group: $F = 3.85$, $df = 2{,}57$, $P = 0.027$). Thus, schizophrenics exhibited significantly less facial action than normal controls ($F = 5.99$, $df = 1{,}57$, $P = 0.018$). The main effect "emotion" was significant for all subjects ($F = 5.66$, $df = 1{,}57$, $P = 0.021$). The following results showed that only controls exhibited more eyebrow activity with positive stimuli than with negative ones ($t = 2.09$, $df = 19$, $P = 0.025$; schizophrenics: $t = 0.70$, $df = 19$, $P > 0.05$; depressives: $t = 1.55$, $df = 19$, $P > 0.05$).

Film-Eyebrows. There was a significant group effect ($F = 3.91$, $df = 2{,}57$, $P = 0.026$; see Table 3). When all three groups were compared as to emotional effect, a significant effect could be observed in controls and depressives (paired t-test on the differences of positive and

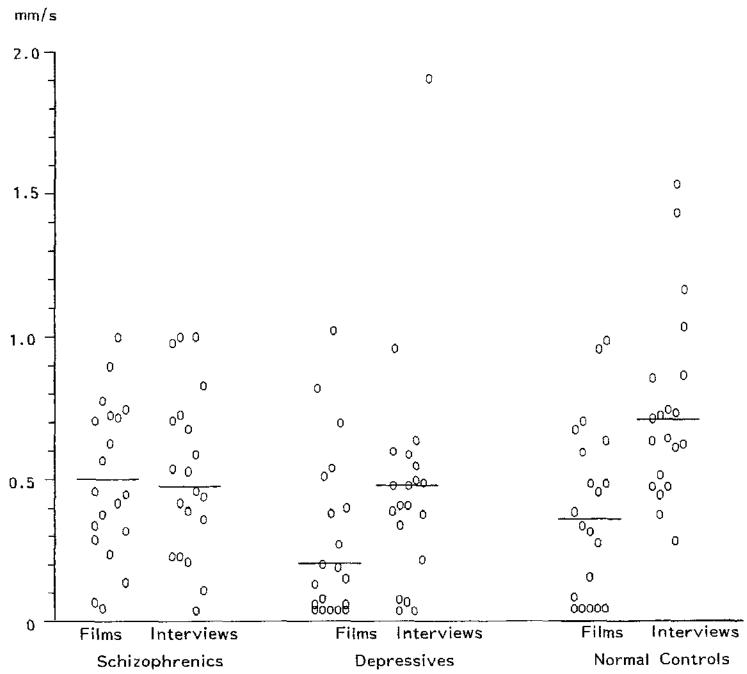

Fig. 5. Computer-analysed eyebrow movements of each individual based on conditions. *Lines* indicated means

Table 4. Intercorrelation of facial action variables (top: r; bottom: P)

Correlated variables	Schizo-phrenics	Depres-sives	Normal controls
Left – right	0.86	0.73	0.82
(Complete face)	(0.000)	(0.000)	(0.000)
Left – right	0.02	0.41	0.19
(Only eyebrows)	(>0.05)	(>0.05)	(>0.05)
Left – right	0.91	0.83	0.87
(Only lip corners)	(0.000)	(0.000)	(0.000)
Films – interviews	0.28	−0.01	0.02
	(>0.05)	(>0.05)	(>0.05)
Positive – negative	0.78	0.69	0.74
	(0.000)	(0.000)	(0.000)
Eyebrows – lip corners	0.33	0.00	0.24
	(>0.05)	(>0.05)	(>0.05)

negative films; controls: $t = 2.09$, $df = 19$, $P = 0.025$; depressives: $t = 1.98$, $df = 19$, $P = 0.031$), although the main effect "emotion" was significant across all 60 subjects ($F = 7.29$, $df = 1{,}57$, $P = 0.009$). Schizophrenic subjects showed no significant differences between negative and positive emotional inductions ($t = 0.64$, $df = 19$, $P > 0.05$).

Eyebrows. Schizophrenic subjects in comparison with depressive subjects and normal controls exhibited no differences in eyebrow activity in the film-and-interview conditions (paired t-tests for conditional effects: $t = 0.54$, $df = 19$, $P > 0.05$; depressives: $t = 3.55$, $df = 19$, $P = 0.001$; normal controls: $t = 3.49$, $df = 19$, $P = 0.001$; Fig. 5).

Laterality of Facial Action. There were no significant effects as to the laterality of facial action. For normal controls a trend in eyebrow movements was observed in the film condition. More eyebrow movements were recorded in the right hemiface. There were no significant main or interaction effects ("hemiface × group": $F = 2.74$, $df = 2{,}57$, $P > 0.05$).

Intercorrelation of Facial Action Variables. The within correlations of facial activity (expressed in mm/s) presented in Table 4 verified the findings obtained with the ANOVAs: high concordance for expressed facial activity in the two hemifaces. Since the subjects were talking during the interview, few covariations existed between the active and passive conditions (watching the film). Higher correlation coefficients for schizophrenic subjects were obtained, reflecting reduced variability to distinguish different emotional and situational conditions not only for facial action when watching films, but also for positive and negative emotional inductions.

Correlations Between Facial Activity and Symtomatology. The findings showed significant correlations for total facial activity expressed and the number of hospitalizations ($r_S = 0.53$, $P = 0.001$, $n = 40$) as well as complete length of illness ($r_S = 0.46$, $P = 0.003$), indicating that patients expressed more facial activity the longer they had been ill. This applied particularly to our schizophrenic subjects where the correlation r_S between facial activity and duration of illness was 0.63 ($P = 0.003$).

The absolute difference for facial action between the left and right hemiface was computed and then correlated with the duration of illness. In comparison with schizophrenics ($r_S = 0.73$, $P < 0.000$) the correlation for depressives was not significant ($r_S = -0.20$, $P > 0.05$).

Furthermore, the correlation between psychopathological measures and facial activity for schizophrenics in comparison with depressive subjects disclosed a different aspect. The correlation between total facial action and

Table 5. Means and standard deviations for rated scale

	Film		Interview	
	Positive	Negative	Positive	Negative
Novices				
Schizophrenics	2.74 ± 1.27	1.43 ± 0.94	3.64 ± 0.86	3.08 ± 0.78
Depressives	1.76 ± 1.27	0.99 ± 0.71	3.41 ± 1.04	2.92 ± 0.90
Controls	3.07 ± 1.43	1.73 ± 1.21	4.24 ± 0.74	3.64 ± 0.98
Experts				
Schizophrenics	2.80 ± 1.44	1.58 ± 0.72	3.66 ± 0.88	3.04 ± 0.61
Depressives	1.74 ± 1.22	1.25 ± 0.94	3.29 ± 0.83	3.15 ± 0.67
Controls	3.06 ± 1.50	1.91 ± 1.19	4.21 ± 0.69	3.55 ± 0.92

GAS scores ($r = -0.31$), BPRS ($r = 0.33$) and HAMD ($r = 0.29$) was not significant for schizophrenics, while the correlation coefficients for depressives all varied around 0.00.

The Influence of Medication. Out of 40 inpatients 24 received neuroleptics. The respective doses were converted into chlorpromazine units (CPZ; Davis 1974). The correlation "CPZ" and "total facial activity expressed" was not significant ($r = -0.33$). However, the relationship became more obvious when only the movements of the upper facial region during the interviews were analysed ($r = -0.42$, $P = 0.045$).

Rating Procedure. The video sequences were rated by 40 novices (students) and 12 experts (psychiatrists), respectively. Based on Winer (1971, p. 290) an adjusted reliability of mean rating was determined for each subject [Ra = 1 − (MS-error/MS-between)]. The interrater reliability was high (novices: Ra = 0.90; experts: Ra = 0.86).

There were no differences between experts and novices: neither the main effect "rater group" nor the interaction effect even approximated significance in a two-way ANOVA comprising the factors "experimental subject group" and "rater group". Across the 60 experimental subjects "expressivity" was rated "average" (mean ± SD: novices, 2.78 ± 0.82; experts, 2.77 ± 0.73; Table 5).

Depressives showed the fewest rated facial expressions (mean ± SD: novices, 2.29 ± 0.76; experts, 2.36 ± 0.72), normal controls the most (mean ± SD: novices, 3.17 ± 0.84; experts, 3.18 ± 0.76), and schizophrenics a moderate amount (mean ± SD: novices, 2.72 ± 0.63; experts, 2.77 ± 0.46). A three-way ANOVA yielded a highly significant main effect "group" (novices: $F = 6.90$, $df = 2{,}57$, $P = 0.002$; experts: $F = 7.89$, $df = 2{,}57$, $P = 0.001$) comprising the factors "condition" (novices: $F = 169.16$, $df = 1{,}57$, $P = 0.000$; experts: $F = 127.07$, $df = 1{,}57$ $P = 0.000$) and "emotion" (novices: $F = 64.49$, $df = 1{,}57$, $P = 0.000$; experts: $F = 39.39$, $df = 1{,}57$, $P = 0.000$) and the interaction "condition × emotion" (novices: $F = 9.46$, $df = 1{,}57$, $P = 0.003$; experts: $F = 5.61$, $df = 1{,}57$, $P = 0.021$). Facial actions in the interview conditions in comparison to the film conditions were rated more expressive. The ratings verified that positive emotional inductions in comparison to negative ones incur more expressed facial activity.

Nevertheless, rating studies failed to replicate the positive correlations ascertained in the computer-based analysis between facial action and duration of illness, the number of hospitalizations, psychopathological symptomatology, and doses of CPZ.

Comparison of the Results of the Computer Analysis and the Rating Studies

The correlation coefficients for rated expressivity and total computer analysed facial activity for healthy controls were highly significant (novices: $r = 0.80$, $P < 0.000$; experts: $r = 0.69$, $P < 0.000$). However, no significant correlations between the two procedures could be obtained for schizophrenics and depressives (schizophrenics: novices, $r = 0.24$; experts, $r = 0.10$; depressives: novices, $r = -0.09$; experts, $r = 0.03$).

For comparison the findings of the two methods were normalized by converting the ascertained values into z-scores. A two-way ANOVA was performed on each rating group (experimental groups: schizophrenics, depressives, controls; method: automatic analysis, rating). The main factor "experimental group" was significant for experts ($F = 3.52$, $df = 2{,}57$, $P = 0.036$), while novices only showed a trend in this direction ($F = 3.02$, $df = 2{,}57$, $P = 0.057$). The two analysing methods yielded significant group differences in the interacion "method × group" (novices: $F = 3.60$, $df = 2{,}57$, $P < 0.034$; experts: $F = 3.80$, $df = 2{,}57$, $P < 0.028$). We found that normal controls were rated more expressive by the raters (area under standardized normal curve: novices, 71%; experts, 72%) than by the objective computer analysis (51%; comparison with novices: $t = 3.74$, $df = 19$, $P = 0.001$; with experts: $t = 3.16$, $df = 19$, $P = 0.003$). This effect could not be found in schizophrenics (novices, 49%; experts, 50%; computer analysis: 42%) or in depressives (novices, 30%; experts, 28%; computer analysis: 42%).

Length of Verbal Activity

The presented group differences are not based on the length of verbal activity in the interviews (mean ± SD: 62.61 s ± 12.17; length of verbal activity based on the entire length of the interview). In a two-way ANOVA with the factors "emotion" and "experimental group" the three groups did not differ significantly as to mean length of verbal activity ($F = 0.07$, $df = 2{,}57$, $P > 0.05$), nor was the interaction "group × emotion" significant ($F = 0.30$, $df = 2{,}57$, $P > 0.05$).

Discussion

To date several authors have attempted to assess facial action automatically. So far, because of the technology, it has been impossible to study larger samples on facial action with the computer during longer periods of time that require an analysis of extreme spatial and temporal resolution. With a newly developed computer analysis, the space coordinates of light-reflecting points, attached to the faces of schizophrenics, depressives and healthy controls, were recorded across time.

The global comparison of total assessed facial activity independent of conditional and emotional stimuli or position of facial points yielded no significant differences across the three experimental groups. This effect corroborates the phenomenological descriptions of earlier facial expression researchers (Krukenberg 1913; Lersch 1932) and recent findings (Krause et al. 1989). Concordant findings of the computer analysis with an additionally conducted rating procedure showed more facial movements in the positive emotional inductions than in the negative ones (computer analysis: especially for lip corners: "smile effect").

It was shown that the facial actions of schizophrenics did not differ significantly between positive and negative stimuli in comparison with depressives and normal controls. This could be interpreted as a sign of reduced variability in emotional responses in schizophrenics. Using the FACS as a method with which to assess facial activity, Krause et al. (1989) also reported this effect in schizophrenics in a slightly different social interaction setting. Moreover, the researchers discovered that the facial expressivity of schizophrenics, interpreted unequivocally as affective, was reduced.

Findings with computer analysis indicate that schizophrenics also displayed a high invariance across different conditions. There were no differences in eyebrow movements in the film-and-interview conditions in schizophrenic patients. This effect did not occur in the rater studies, since the more distinct movements of the lower facial region probably masked the smaller effects of the brow movements.

The computer analysis did not yield any group differences for lip corner-and-eyebrow movements in the film conditions. Nevertheless, normal controls were rated more expressive than schizophrenics and depressives. This finding could be interpreted in terms of the raters' difficulty to judge the patients expression properly because of their apparent facial disintegration. Facial disintegration means the display of individual facial movements which do not agree with the rest of the expressed holistic facial activity. In the present study this facial disintegration possibly inclined raters to judge the patients as less expressive. The interaction partners of schizophrenics (Winkelmayer 1978) and depressives may perceive patients' facial expressions in a different manner. They probably do not, as they would with normals, attribute these characteristics to increased facial activity. Consequently this attribution might form the basis for the expressed facial symptomatology.

Positive correlations between the computer analysis of facial action and the ratings were only found for normal controls. For schizophrenics and depressives the findings did not yield any such correlations. According to observers' ratings these kinds of patients seemed to display less facial expressivity in comparison with normal controls, although their total facial activity possibly contained additional disintegrative facial elements. Consequently, the resulting facial actions of the three groups would not differ significantly when assessed by computer analysis. Therefore, the assumed disintegrated facial actions of schizophrenic and depressive patients were measured by computer analysis in addition to the other expressed facial actions.

Within the social interaction, designed to evoke active behaviour and not "one-way" communications as the film conditions, attributive and integrative rater factors encountered the phenomenon of facial disintegration. Our interpretation is that the faces of schizophrenics as well as depressives did not display an integrated, holistic facial expression; instead they expressed facial disintegrated actions. Consequently, normal controls who displayed integrated facial expression were judged to be more expressive than they really were. In addition, concordant findings of the two rater studies showed that the patients' observed "facial symptomatology" was ideopathic: psychiatrists were much better informed about the experimental conditions and objectives and they knew some of the patients.

As in previous studies on schizophrenics (Krause et al. 1989; Pitman et al. 1987), schizophrenic and depressive patients in our study also showed a reduction in facial actions in the upper facial region under the social interaction conditions. Ekman (1979) and Grammer et al. (1988) demonstrated the importance of eyebrow movements in social interaction settings. The findings seem to indicate that accompaning movements in addition to displayed facial expression during verbal activity function as signals and help regulate the alternations between listener and speaker.

Left-right differences in facial actions normally appear especially in short temporal movements. Thus, the right side of the mouth opens wider and faster than the left for both verbal and non-verbal movements (Wolf and Goodale 1987; Wylie and Goodale 1988; Goodale 1988; Graves et al 1982, 1985). Measuring and recording such micro-movements was not the objective of this computer-analysis study. Furthermore, the correlation between the difference of computer-analysed facial actions of the left and right hemiface and the duration of illness reflected the clinical symptomatology and the asymmetrical facial action within the context of the early facial action disintegration model as already described by Heimann and Spoerri (1957) for schizophrenics. The correlation for schizophrenics was 0.73 ($P < 0.000$) and for depressives -0.20 ($P > 0.05$).

The influence of psychotropic drugs on facial activity has not been completely determined. The most important argument against such an influence are the Heimann findings on unmedicated chronic schizophrenic patients who displayed the facial action disintegration phenomenon. However, Heimann did not report a reduction of facial action in the upper facial region (Heimann 1966, 1973; Heimann and Spoerri 1957; Heimann and Lukàcs 1966). The findings of Krause et al. (1989) agreed with our results, although they used a different methodology. They also reported a reduction of facial action in the upper region of the face in a social interaction setting in medicated schizophrenics.

One explanation for the reduced facial action in the upper region of the face is the fact that this region is innervated by nerval pathways connected to the reticular formation, the basal ganglia, and the affective centres of the brain, while the lower region of the face is innervated more by pathways originating in the speech centres of the brain and thus under greater volitional control of the subject (Rinn 1984). This might be one possible explanation of the reduced activity in the upper facial region exhibited by our patients during the interview if one considers the significant role facial actions play in interpersonal communications.

It is possible that the psychopharmacological medication – especially neuroleptics – were responsible for the reduction of facial activity in the upper face, but that they did not cause the other expressed facial disintegration effects described above, since neuroleptics have a special effect on the above-mentioned morphological structures, especially the basal ganglia (Rinn 1984). The assumption is reinforced by the significant negative correlation between the CPZ and the computer-analysed facial action in the upper region of the face of the 24 patients receiving neuroleptics during the interviews and by other recent findings with neuroleptically treated healthy subjects (Hartley et al. 1989).

This supposition is also not contradicted by the findings of Pitman et al. (1987), who showed that unmedicated schizophrenics displayed fewer eyebrow and lower facial movements during an interview. The facial activity was measured with a rating system that included different types of facial movements. Moreover, this effect could have been caused by the fact that these patients did not talk as much as controls. This study, nevertheless, seems to indicate that disintegrated facial movements, especially of the upper face, cannot be judged properly by raters.

The correlations between CPZ and computer-analysed facial actions ($r = -0.33$; $n = 24$ neuroleptically medicated patients), respectively and between CPZ and "expressivity" (novices: $r = -0.15$; experts: $r = -0.16$) were not significant, but could be interpreted clinically; it seemed that the facial expressivity was rated all the more reduced, the more neuroleptics a patient received.

Conclusion

Despite the fact that this newly developed computer-based procedure only analysed four facial action points in this pilot study, it proved to be efficient. The advantage of such a system compared with film-and-video recordings is its high pictorial resolution. Furthermore, this computer-based scanning unit has the ability to take 10 "pictures" per second. Moreover, with this technique rater bias can be completely eliminated. To date the major limitation of this method is the fact that at the present time facial activity cannot be paired with different emotions. Thus, no statements can be made as to the emotional content expressed by facial action.

Elements of disintegration may offer a possible explanation for facial actions in schizophrenic and depressive patients; normal controls were rated more expressive when they exhibited more facial actions. Patients were rated as less expressive, although they had the same amount of facial activity with the computer analysis as normal controls. This could probably have been caused by apparent disintegrated facial expressions exhibited by the patients, i.e. individual facial movements differing from the general expressed facial mobility. These disintegrative and non-holistic appearing facial movements possibly gave the raters the impression that the facial activity of these patients was less expressive. However, the number of disintegrated movements probably increased the longer a patient had been ill and the more severe his/her illness became.

Schizophrenic and depressive patients expressed reduced facial activity in the upper facial region in the social interaction conditions, but not in the passive conditions comprising film watching. This may be due to the nerve pathways which are innervated by the basal ganglia, the reticular formation and the affective centres of the brain.

The emotional responsivity of schizophrenic patients under social interaction conditions in comparison with the passive film conditions was not only impaired in the upper facial region, but also in the lower region. A communication behavioural disorder of schizophrenic patients could possibly explain this impairment.

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