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ORIGINAL PAPER

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# Instability in functional motor laterality of children and adolescents with endogenous psychosis and predominantly motor disturbances

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**Abstract** A group of eight unmedicated right-handed children and adolescents with endogenous psychosis and predominantly motor disturbances and two right-handed control groups (6 healthy subjects and 10 patients with different psychiatric diseases) were investigated with the help of a tapping-test series. The most important finding was related to differences in the stability of functional motor laterality between controls and psychotics. Stability or instability in functional motor laterality was identified by referring to the standard deviation (SD) of percentile right-left tapping differences calculated for each subject for the various parts of the tapping-test series. The high SDs in psychotics, in contrast to the low SDs in both control groups, point to increased variations or instabilities in the functional superiority of the preferred hand. Instability in functional motor laterality in this test is considered characteristic of this subgroup of patients, and may be due to a partial relapse to a lower hierarchical stage of handedness.

**Key words** Children · Endogenous psychosis · Predominant motor disturbances · Instabilities in functional motor laterality

## Introduction

Due to the fact that in the central nervous system higher cognitive functions are closely integrated with motor and emotional processes, in schizophrenic disorders there is a coincidence of cognitive impairment, psychotic features and motor abnormalities. Motor disturbances in schizophrenic patients comprise diverse voluntary and involuntary movements and may be related to severity of illness [7, 21, 20, 30]. Günther [12] describes motor disturbances in schizophrenics and depressed patients which involve changes in the fine and gross movements of the dominant right-hand and the complex motor coordination of their extremities. Bracha [3] found that in contrast to the controls with equal right- and left-turning movements, schizophrenic patients showed a left-prone circling behaviour. In addition, Lyon et al. [19] detected a greater left-turning response in right-handed manic patients than in right-handed controls when engaged in a two-button task with reinforcements.

These abnormalities occurring during psychosis may be due to changes in hemispheric asymmetries involving cortical and subcortical structures [4, 10, 19]. They depend on various individual and clinical factors, such as differences in clinical subgroups, in the manifestation of symptoms and in the course of illness. Previous findings have shown that according to asymmetries in a tapping-test series, schizophrenic patients can be divided into different subgroups [11]. In one subgroup of definite right-handers according to the questionnaire, the faster tapping frequency shifted from right to left hand in at least one part of the tapping test. These patients were marked by more pronounced psychotic symptoms than those who did not change motor laterality. We felt that this abnormality should be investigated more thoroughly in psychotic children and adolescents with predominantly motor disturbances: in catatonic schizophrenics and in patients who, according to Leonhard [16], were diagnosed as suffering from motility psychosis. Because drugs shift motor laterality [1, 5, 27], our study was performed only in unmedicated patients. The goal was to find those changes in motor laterality which are capable of characterising our particular subgroup of patients.

## Subjects and methods

A group of eight unmedicated children and adolescents (inpatients; four females and four males) with endogenous psychosis and predominantly motor disturbances were investigated and compared

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with two control groups. The healthy control group was made up of six subjects (one female and five males). The psychiatric controls consisted of ten unmedicated nonschizophrenic children and adolescents (inpatients; two females and eight males). Diagnosis of all psychiatric patients was based on ICD-10 criteria. Psychotic patients were additionally diagnosed according to Leonhard [16]. Furthermore, for comparing controls and psychotic patients individual and clinical features were selected from the case histories (intelligence quotient, perinatal complications, development during infancy, onset of disease and manifestation of predominant symptoms). Intelligence quotients (IQs) were assessed by the HAWIK-R test. Perinatal complications comprise abnormalities during pregnancy, birth and postnatal period, such as prematurity and/or blue or apnoeic-state at birth. Retarded development during infancy may manifest by a delayed development of speech or other motor or cognitive functions. The age of all subjects varied between 10 and 18 years. The mean age (± SD) or all psychotic patients and controls was 14.4 (± 3.0) and 14.2 (± 2.3) years, respectively. All subjects were right-handers. First, the handedness was assessed by means of the Edinburgh Handedness Questionnaire [26] and then checked with the help of a simple tapping-test series.

### Procedure

The test was performed from 9.00–10.00 a.m. and consisted of four successive parts. In all sessions subjects had to press a button as fast as possible for a period of 15 s, first with their right index fingers and then with their left. In contrast to parts a and c, in parts b and d finger-tapping was carried out with concurrent tasks. In part b the patients were asked to tap while reading aloud a passage from a text, and in part d while simultaneously humming a tune. The number of taps was recorded and right–left differences were established in percentages with respect to the faster hand. For all subjects mean and SD of percentile right–left tapping differences were calculated.

The following two examples (subject 1 = case number 5 of the healthy controls and subject 2 = case number 5 of the psychotic patients) explain the tapping procedure and the data that were recorded or calculated from each subject.

The SDs of the percentile right–left tapping differences were used a indicators for stability or instability in the functional laterality of the finger-tapping task. In the motor laterality test a low SD represents stability, whereas a high SD is characteristic of instability.

Statistical calculations were based on nonparametric tests. Either the Mann-Whitney U-test or the $\chi^2$ analysis (contingence table) with the help of the SPSS/PC + 4.0 system were used.

Tapping-test series

| Tapping data | Parts of the tapping-test | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (a) Rest right/left | | (b) Reading right/left | | (c) Rest right/left | | (d) Humming right/left | |
| *Tapping frequency* | | | | | | | | |
| Subject 1 | 96 | 70 | 87 | 70 | 97 | 74 | 93 | 74 |
| Subject 2 | 46 | 47 | 34 | 28 | 55 | 43 | 50 | 44 |
| *Percentile right–left tapping differences* | | | | | | | | |
| Subject 1 | 27.1 | | 19.5 | | 23.7 | | 20.4 | |
| Subject 2 | −2.1 | | 17.6 | | 21.8 | | 12.0 | |
| *Mean ($\bar{X}$) ± SD of the 4% right–left tapping differences* | | | | | $\bar{X}$ | | SD | |
| Subject 1 | | | | | 22.7 | | 3.5 | |
| Subject 2 | | | | | 12.3 | | 10.4 | |

## Results

### Selected individual and clinical features in healthy controls, psychiatric controls and psychotic patients

As shown in Tables 1 and 2, the age of the subjects in all three groups is almost identical. The same is true of the IQ in psychiatric controls and psychotic patients. In healthy subjects no IQ was determined. Furthermore, Table 2 illustrates that psychiatric controls do not differ markedly from psychotic patients in the following features: (1) perinatal complications, (2) development during infancy, (3) premorbid personality, (4) onset of disease and (5) manifestation of symptoms. This was proved by the SPSS/PC + 4.0 system using the $\chi^2$ test (contingence table).

Thus, it may be concluded that both groups are compatible in this respect. Even the healthy control group shows the same behaviour as the psychotic patients in terms of their individual features, perinatal complications and development during infancy. Only in their personality structures do the psychotic patients show significantly more deviations than the healthy controls [SPSS/PC + 4.0 system, $\chi^2$ test (contingence table) and Pearson $P = 0.0375$]. Regarding gender there are certain insignificant differences between controls and psychiatric patients. Both control groups consisted of more males than the psychotic group.

Table 3 demonstrates that all patients were diagnosed according to ICD-10 criteria, and the psychotic patients were additionally diagnosed according to Leonhard [16]. Psychotic patients are characterised by pronounced motor disturbances. This becomes much more evident in the diagnostic classification according to Leonhard [16], cases 2 and 6 of the psychotics were suspected of suffering from

**Table 1** Selected individual features in healthy controls

| Case no. female/male (f) (m) | Age (years) | Perinatal complications | | Development during infancy | | Personality | |
|---|---|---|---|---|---|---|---|
| | | Present | Not present | Retarded | Normal | With deviations | Without deviations |
| 1 (m) | 18 | × | | | × | | × |
| 2 (f) | 17 | × | | | × | × | |
| 3 (m) | 15 | | × | | × | | × |
| 4 (m) | 16 | | × | | × | | × |
| 5 (m) | 12 | × | | × | | | × |
| 6 (m) | 12 | | × | × | | | × |

**Table 2** Selected individual and clinical features in psychiatric controls (II) and psychotic patients (III)

| | Case no. female/male | Age (years) | IQ | Perinatal complications | | Development during infancy | | Premorbid personality | | Onset of disease | | Manifestation of symptoms | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (f) (m) | | | Present | Not present | Retarded | Normal | Changed | Unchanged | Gradual | Acute | Slight | Less-pronounced | Pronounced |
| II | 1 (m) | 10 | 104 | | × | | × | × | | × | | | × | |
| | 2 (m) | 11 | 86 | × | | × | | × | | × | | | | × |
| | 3 (m) | 13 | 77 | × | | × | | × | | × | | | | × |
| | 4 (m) | 13 | 98 | × | | × | | × | | × | | | | × |
| | 5 (m) | 17 | 120 | | × | | × | × | | × | | | | × |
| | 6 (m) | 14 | 113 | × | | | × | × | | | × | | | × |
| | 7 (f) | 13 | 73 | | × | × | | × | | × | | | × | |
| | 8 (f) | 16 | 128 | | × | | × | | × | × | | | × | |
| | 9 (m) | 15 | 93 | | × | | × | × | | × | | | | × |
| | 10 (m) | 15 | 106 | × | | | × | × | | | × | | | × |
| III | 1 (m) | 10 | 91 | | × | × | | × | | × | | | | × |
| | 2 (f) | 17 | 100 | | × | | × | × | | × | | | | × |
| | 3 (m) | 13 | 112 | × | | | × | | × | × | | | | × |
| | 4 (f) | 18 | 88 | | × | × | | × | | × | | × | | |
| | 5 (m) | 12 | 94 | | × | × | | × | | × | | | | × |
| | 6 (f) | 13 | 96 | × | | × | | × | | × | | | | × |
| | 7 (f) | 18 | 115 | | × | | × | × | | × | | | × | |
| | 8 (m) | 14 | 93 | | × | × | | | × | | × | | | × |

**Table 3** Diagnoses in psychiatric controls (II) and psychotic patients (III)

| Controls II | | Patients III | | |
|---|---|---|---|---|
| Case no. | Diagnosis according to ICD-10 | Case no. | Diagnosis according to ICD-10 | Diagnosis according to Leonhard [16] |
| 1 | F90.1 Hyperkinetic conduct disorder | 1 | F20.1 Catatonic schizophrenia | Mannered catatonia |
| 2 | F42.1 Predominantly compulsive acts (obsessional rituals) | 2 | F21 Schizotypal disorder | Cataphasia |
| 3 | F60.4 Histrionic personality disorder | 3 | F25.2 Schizoaffective disorder, mixed type | Akinetic–hyperkinetic motility psychosis |
| 4 | F98.1 Nonorganic encopresis | 4 | F25.2 Schizoaffective disorder, mixed type | Akinetic–hyperkinetic motility psychosis |
| 5 | F40.1 Social phobias | 5 | F20.2 Catatonic schizophrenia | Periodic catatonia |
| 6 | F42.1 Predominantly compulsive acts (obsessional rituals) | 6 | F21 Schizotypal disorder | Periodic catatonia |
| 7 | F43.23 Adjustment disorders with predominant disturbance of other emotions | 7 | F20.2 Catatonic schizophrenia | Mannered catatonia |
| 8 | F34.0 Cyclothymia | 8 | F20.2 Catatonic schizophrenia | Periodic catatonia |
| 9 | F07.8 Other organic personality and behavioural disorders due to brain disease, (brain damage and dysfunction) | | | |
| 10 | F45.1 Undifferentiated somatoform disorder | | | |

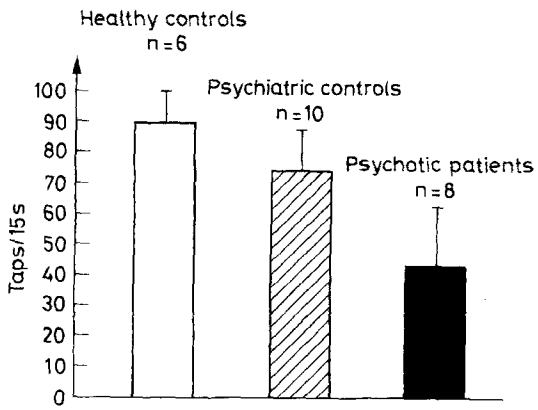


**Fig. 1** Mean right-hand taps and their standard deviations (SDs) in three groups of subjects under the condition: tapping while simultaneously reading

**Table 4** Standard deviations (SDs) of all percentile right–left tapping differences in each subject of three groups

| Healthy controls | | Psychiatric controls | | Psychotic patients | |
|---|---|---|---|---|---|
| Case no. female/male (f) (m) | SD | Case no. female/male (f) (m) | SD | Case no. female/male (f) (m) | SD |
| 1 (m) | 7.4 | 1 (m) | 8.3 | 1 (m) | 16.6 |
| 2 (f) | 6.3 | 2 (m) | 7.8 | 2 (f) | 13.2 |
| 3 (m) | 5.1 | 3 (m) | 6.1 | 3 (m) | 11.5 |
| 4 (m) | 4.2 | 4 (m) | 5.9 | 4 (f) | 10.6 |
| 5 (m) | 3.4 | 5 (m) | 5.9 | 5 (m) | 10.4 |
| 6 (m) | 3.3 | 6 (m) | 3.5 | 6 (f) | 9.2 |
| $\bar{X}$ | **4.95** | 7 (f) | 3.1 | 7 (f) | 9.1 |
| | | 8 (f) | 3.1 | 8 (m) | 7.7 |
| | | 9 (m) | 1.4 | $\bar{X}$ | **11.04** |
| | | 10 (m) | 1.3 | | |
| | | $\bar{X}$ | **4.64** | | |

cataphasia (2) and periodic catatonia (6). All patients are marked by chronic courses with different outcomes. If a further subdivision of patients were made into the two categories of those with predominantly negative or positive symptoms, a general trend towards one subtype could be detected. Whereas in most cases classic positive symptoms such as delusions and hallucinations were absent, almost all psychotics in the course of illness show more negative symptoms, which mainly involve psychomotor poverty, lack of drive, emotional withdrawal and attentional impairment. In the present study these symptoms were found to be pronounced in most psychotics.

Tapping results in healthy controls, psychiatric controls and psychotic patients

Figure 1 shows that the mean right-hand taps under the concurrent task of tapping while simultaneously reading in the three groups of subjects are different. There is a significant reduction in right-hand taps in descending order from healthy controls to psychiatric controls and to psychotic patients (SPSS/PC + 4.0 system, Mann-Whitney U-test, two-tailed test and $P = 0.0343$ between the controls; $P = 0.0039$ between psychiatric controls and psychotic patients).

The most important results of this study are related to SDs of the percentile right–left tapping differences between psychotic patients and both control groups. As indicated in Table 4, whereas healthy controls and psychiatric controls do not differ in SDs, and as a rule show low values, psychotic patients are characterised by high SDs, differing significantly from both control groups ($P = 0.0001$ for all controls compared to the psychotic patients, SPSS/PC + 4.0 system, Mann-Whitney U-test and two-tailed test). The high SDs of the percentile right–left tapping differences in psychotic patients point to instabilities in their functional superiority of the preferred hand.

The latter phenomenon is supported by the additional facts that four psychotic patients (cases 1, 5–7), although pronounced right-handers according to the handedness questionnaire, showed faster left- than right-hand tapping frequencies in at least one part of the tapping test, and two psychotics (cases 3 and 8) scored the same number of taps in both hands in one session of the test. In healthy controls no subject demonstrated such behaviour and in psychiatric controls only one patient (case 8) was faster with the left hand than with the right in one part of the tapping-test.

## Discussion

Because the present study was intended to establish abnormalities in motor asymmetries that are relevant for psychotic patients only, two control groups were formed: one consisting of healthy controls and the other of patients with different psychiatric diseases.

Although in almost all individual and clinical traits psychiatric and healthy controls show similar results as the psychotic patients, in the tapping findings marked differences between controls and psychotics were noted. In the tapping frequency of the right-hand taps with the concurrent task of tapping while simultaneously reading, a general trend towards a continuous reduction in speed was seen in descending order from healthy controls to psychiatric controls and psychotic patients. In these findings gender should be taken into consideration, because it has been noted that males generally tap faster than females. Consequently, a reduced percentage of males in the psychotic group (compared to the controls) may result in lower tapping frequencies. However, because (in contrast to what should have been expected) in our psychotic group the females tapped faster than the males, the reduction in tapping frequency in the psychotics could not be due to differences in gender. The reduced tapping frequency, particularly in psychotic patients, may be related to disturbances in frontal regions [15, 17]. These findings are in accordance with previous investigations in unmed-

icated psychotics marked by predominantly negative symptoms [11], and with those of Schwartz et al. [28], who found a lower tapping speed in long-term psychotic inpatients than in psychiatric controls.

In contrast to the tapping frequency in the most important tapping finding, the SDs of percentile right–left tapping differences, both control groups showed similar values. Within one tapping-test series the SDs, calculated for each subject, constitute variations of the percentile superiority in the faster hand. The high SDs in psychotics, as opposed to the low SDs in controls, point to greater variations or instabilities in the lateralisation of this task. Instability in functional motor laterality is also supported by the fact that in many psychotics the faster tapping frequency shifted from the right hand to the left.

In this connection the special subgroup of patients is worth mentioning. Almost all patients were characterised generally by predominantly negative symptoms particularly involving psychomotor poverty, which became especially evident in the diagnostic classification according to Leonhard [16]. In addition, most of them show a retarded development during infancy, changes in premorbid personality, gradual onset of disease and a pronounced manifestation of clinical symptoms.

In preliminary investigations in different groups of psychotics, e.g. those who are mainly marked by positive symptoms, an unchanged premorbid personality, an acute onset of disease and without prevalent motor disturbances, such pronounced variations in the stability of functional motor laterality could not be found. In contrast to this, in most of the individual psychotics of the present study the SDs were strikingly higher than those of the controls that included different psychiatric patients. Thus, instability in this motor laterality test may be considered characteristic of this particular subgroup only.

The question that now arises is: Which abnormalities of this subgroup may lead to such changes in laterality? There are some anatomical findings that reveal a greater thickness of the corpus callosum in early onset chronic schizophrenics with predominantly negative symptoms compared to late onset schizophrenics [2, 6]. Further investigations established that disturbances in normal development resulting in reduced asymmetric regions are associated with a greater percentage of callosal terminals [9, 33]. Developmental processes are assumed to be dependent on genetic as well as prenatal and early-postnatal influences [33]. Moreover, psychotic episodes in turn lead to decreased or reversed functional hemispheric asymmetries [25, 31, 32]. Consequently, there may be an interaction of developmental and psychotic-related deviations in interhemispheric asymmetries [8]. Reduced hemispheric asymmetries may be a common precondition for instabilities in motor laterality. Further insights into the disturbed mechanism of this special function, however, may be related to specific developmental changes. Normal development of handedness is a complex phenomenon that displays interesting trends and transition periods [22, 24].

The direction of hand preference in normal children becomes consistent beyond the age of about 18 months after passing through a phase with an unstable or fluctuating hand preference [13, 18, 24]. The degree of handedness increases at least until the age of 3–7 years, then perhaps more slowly from the age of 7–9 years [22]. For this reason our subjects were not younger than 10 years. Within the tapping-test stability in the preferred hand was present in the controls, but not in the psychotics. Our results are compatible with some findings in autistic children [23]. In autistic children compared to normal and mentally retarded controls, the consistency of hand usage within particular tasks was found to be reduced [23]. This was explained by an incomplete passage through the stage of preference formation, leaving some residual parts of the unstable (chaotic) phase of development. In addition, Tsai [29] revealed that 5-year-old autistic children with established hand lateralisation, in contrast to those without this feature, tended to perform better in terms of intelligence, language and visuospatial abilities assessed by the Developmental Profile. In this connection it is interesting to note that in normal children also consistency of hand preference is believed to be advantageous for specific kinds of cognitive processing. Early consistency of hand preference in females is thought to predict school-age intellectual precocity and should be connected with verbal superiority persisting during childhood [14].

Based on the literature mentioned it is suggested that handedness in psychotic patients with predominantly motor disturbances may be established on a partially lower hierarchical stage involving instabilities in motor laterality. This relapse is possibly favoured by prenatal and early-postnatal changes, and may be elicited by psychotic episodes.

A few studies that were performed in the course of psychosis in these patients indicate that neuroleptic drugs reduce variations or instabilities in the functional motor laterality of this tapping-test. This points to the fact that these changes may be "state markers". The latter assumption should be proved in further experiments.

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