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Gesture impairments in schizophrenia are linked to increased movement and prolonged motor planning and execution

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ABSTRACT

Schizophrenia patients present with a variety of impaired nonverbal communication skills. Performance of hand gestures is frequently impaired and associated with ratings of motor abnormalities. However, the impact of motor abnormalities to gesture performance remains unclear. To test the association between quantitative measures of motor behavior and qualitative ratings of gesture performance, we quantified movement parameters semi-automatically in videotaped recordings of gesture assessment. Thirty-one patients with schizophrenia (77.4%), schizophreniform (19.4%) or schizoaffective disorder (3.2%) and 32 healthy controls matched for age, gender and education underwent clinical assessment. Performance of the test of upper limb apraxia (TULIA) was video-taped in all subjects. The videos were analyzed with motion energy analysis software (MEA) to determine motion and time parameters.

Patients and controls differed significantly in quantitative gesture performance: patients required more movement and more time to complete the tasks. Differences increased in patients with qualitatively impaired gesture production ratings ($p < 0.01$). Group differences were most pronounced in the pantomime domain, when gestures are performed following verbal instruction. In patients, ratings of motor abnormalities correlated with duration of movement, while behavioral disorganization correlated with the amount of movements during gesture performance.

Disorder related motor symptoms, aberrant action observation, planning and monitoring as well as internal clock abnormalities may explain the poor performance of hand gestures in schizophrenia. Quantitative video analysis offers a unique possibility to analyze movement patterns as a direct functional output of the motor system. In the future, it may assist monitoring, staging and prognosis in schizophrenia.

1. Introduction

Patients with schizophrenia frequently present impaired non-verbal communication skills (Kohler et al., 2010; Kupper et al., 2015; Lavelle et al. 2013; Toomey et al. 2002; Troisi et al. 1998). Gesture is an important component of non-verbal communication (Cartmill et al. 2012). Hand gestures usually may substitute or support speech, aiding both the speaker and the listener (Kelly et al. 2010; Obermeier et al. 2012).

Schizophrenia patients use gestures less frequently than controls during conversation and they are critically impaired in gesture interpretation (Bucci et al. 2008; Lavelle et al. 2013; White et al. 2016). Up to 50% of schizophrenia patients present with hand gesture deficits, including errors of timing, movement sequencing, spatial hand configuration, and content (Walther et al. 2015; Walther et al. 2013a). Likewise, studies in subjects at risk for psychosis demonstrate less gesture use, errors of timing and incorrect content (Millman et al. 2014; Mittal et al. 2006; Osborne et al. 2016). Gesture deficits in schizophrenia are associated with negative symptoms and illness chronicity (Stegmayer et al. 2016; Walther et al. 2015; Walther et al. 2013b). Impaired gesture performance may also predict poor functional outcome (Walther et al. 2016b). Finally, poor gesture performance in schizophrenia correlated with frontal lobe dysfunction and motor abnormalities (Walther et al. 2015; Walther et al. 2013b).

Schizophrenia patients frequently present with motor abnormalities such as Parkinsonism, catatonia, neurological soft signs or abnormal involuntary movements, which may impair correct motor execution (Walther and Strik 2012). Furthermore, cognitive slowing may hamper motor planning (Morrens et al. 2014; Morrens et al. 2007). Both, impaired motor planning and execution probably impact the performance of hand gestures. In our previous reports, motor abnormalities were

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quantified with clinical rating scales. However, observer based ratings of motor abnormalities have been challenged by objective, quantitative assessments with instruments such as actigraphy or video motion analysis (Kupper et al. 2010; Walther et al. 2009). Thus, the association of motor abnormalities with impaired gesture accuracy in schizophrenia requires further exploration, i.e. direct quantitative motor assessment during hand gesture performance. The aim of the current study was to supplement the qualitative ratings of gesture performance with a tool for quantitative assessment of the motor behavior during gesture performance. Video-based motion energy analysis (MEA) (Ramseyer and Tschacher 2011) may objectively inform on the amount and duration of movement. The Test of Upper Limb Apraxia (TULIA) allows testing hand gesture accuracy and evaluates content errors as well as spatial-temporal errors (Vanbellingen et al. 2010). We assumed inferior gesture performance in schizophrenia patients compared to controls. Furthermore, we expected that qualitative impairments (i.e. spatial or content errors) in patients would be associated with aberrant motor behavior, such as increased duration of movements during the gesture task, particularly in meaningless gestures (Walther et al. 2013a). We hypothesized that aberrant quantitative motor behavior would be most frequently found in patients with clear-cut gesture performance deficits. Finally, we suspect correlations between the quantitative movement parameters during gesture performance and current ratings of the DSM-5 schizophrenia dimensions.

2. Methods and materials

2.1. Participants

In total, 31 patients and 32 healthy control subjects matched for age, gender and education were included in this study. Patients were recruited from the inpatient and outpatient departments of the University Hospital of Psychiatry Bern, Switzerland. Healthy controls were recruited from the community via advertisement. All subjects were right-handed as determined by the Edinburgh handedness inventory (Oldfield 1971). Exclusion criteria included substance abuse or dependence other than nicotine, past or current medical or neurological condition impairing movements, such as dystonia, idiopathic Parkinsonism or stroke, history of head trauma with concurrent loss of consciousness, or history of electroconvulsive treatment. Please note that patients with motor abnormalities in the context of psychosis were not excluded. Exclusion criteria for controls were a history of any psychiatric disorder, as well as any first-degree relatives with schizophrenia or schizoaffective disorder.

All subjects were interviewed with the Mini International Neuropsychiatric Interview (MINI) (Sheehan et al. 1998). Diagnoses were given according to DSM-5 criteria ($n = 24$ schizophrenia, $n = 1$ schizoaffective disorder, $n = 6$ schizophreniform disorder). All patients received antipsychotic pharmacotherapy. Clinical and demographic data are given in Table 1. All participants provided written informed consent. The protocol was approved by the local ethics committee.

Table 1
Clinical and demographic characteristics.

	Patients	Controls	Patients vs. Controls	
	($n = 31$)	($n = 32$)	***U***	P
% male	67.7	62.5	470.0	0.665
Age (y)	37.0 (11)	37.5 (13)	485.5	0.885
Education (y)	13.6 (2.8)	14.4 (2.8)	428.0	0.346
TULIA	208.3 (25.5)	225.3 (8.2)	257.5	0.001
TULIA deficit (n)	11	1		
PANSS total	72.2 (16.5)			
PANSS positive	18.7 (6.4)			
PANSS negative	18.2 (4.8)			
Episodes (n)	7.5 (7)			
Duration of illness (mo)	153 (127)			
CPZ, mg (5y mean/d)	252.9 (291.2)			

Note: numbers refer to means (sd), group differences were tested with Mann-Whitney-*U* Test.
TULIA – Test of Upper Limb Apraxia, PANSS – positive and negative syndrome scale, CPZ – chlorpromazine equivalent dosage.

2.2. Procedures

2.2.1. TULIA gesture assessment

Gesture performance and gesture perception were assessed with the Test of Upper Limb Apraxia (TULIA)(Vanbellingen et al. 2010), which proved sensitive to detect hand gesture impairments in schizophrenia (Walther et al. 2016a; Walther et al. 2015; Walther et al. 2013a,b). TULIA allows comprehensive assessment of hand gesture performance in two domains: imitation (following demonstration of the examiner) and pantomime (after verbal command). Each domain includes three semantic categories with items representing intransitive (symbolic, communicative meaning), transitive (tool or object related) and meaningless gestures. In this study, performances of the 48 TULIA items with the right arm were videotaped. A single rater blinded to diagnoses and clinical presentation evaluated gesture performance accuracy according to the TULIA manual (Walther et al. 2015). Performance ratings ranging from 0 to 5 focus on content and temporo-spatial errors. Higher scores indicate superior performance. Scores ≥3 indicate correct content but inadequate timing or sequencing. Scores <3 indicate major content errors which may be associated with temporo-spatial errors (Vanbellingen et al. 2010). Total TULIA gesture scores range 0–240. The cut-off for apraxia-like errors is 210 in studies with middle aged subjects, i.e. average of 42 years (Walther et al. 2013b).

2.2.2. Video motion analysis

Videos of TULIA gesture performances were converted into MPEG-4 files downsized to 340 × 240 pixels with a frame rate of 12 per second. Films were manually cut so that each domain and category was presented by a clip starting with the examiner's first demonstration (imitation) or command (pantomime) and ending with the last movement. From these processed clips we quantified movement with the program Motion Energy Analysis (MEA) (Ramseyer and Tschacher 2011), which uses a frame-differencing algorithm that analyzes the pixel-value changes between video frames resulting from movement. Given a static camera and no movement in the background, MEA calculates a motion equivalent for subsequent frame pairs. Specific regions of interest may be defined, and MEA generates numeric time-series of motion for each region of the video being processed.

The following video parameters were computed from the extracted MEA data: The duration of the item (TI) corresponds to the mean duration of planning and performing the gesture. It was computed for each category by dividing the number of frames by the number of items performed (12 frames = 1 s). The time with movement per item (TMI) refers to the duration of actual gesture performance. It was calculated as the number of seconds per category, in which the frame value for movement was >0 and divided by the number of items analyzed. The amount of movement per item (MI) corresponds with the total of motion values per category divided by the number of items.

Even though recording procedures were standardized, some subjects were filmed from slightly different angles and varying distances. This resulted in different body size representations on the screen and size-dependent amounts of activated pixels respectively. To account for this variability a screen size ratio was applied on MI before entering statistical analyses. The screen size ratio was computed by dividing the head size by the width of the video. Only items with complete recordings of gesture performance were entered into MEA. All video processing and analyses was done blind to diagnosis and clinical presentation.

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