Head movements during conversational speech in patients with schizophrenia

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Abstract:

Background: Motor abnormalities are frequently described in schizophrenia, and work by Altorfer and colleagues suggests that measuring head movements during conversational speech shows differences at the level of the individual. We wished to see whether their findings, conducted using computer analysis of video obtained in motion capture suites, could be replicated using compact, portable movement sensors, in a case–control study comparing the mean amplitude of head movements during general conversation.

Methods: A referred sample of inpatients and outpatients with a diagnosis of paranoid schizophrenia was identified from case note information. Movement sensors, mounted in a baseball cap worn by subjects, transmitted data via Bluetooth to a laptop, which simultaneously captured audio to identify who was speaking. Subjects also completed a series of rating scales.

Results: Data from the final 11 cases and 11 controls demonstrated a substantial group difference in mean amplitude of head movement velocity during speech ($p < 0.0001$), although this was not significant at the level of the individual.

Conclusions: Movement sensors proved well suited to capturing head movements, demonstrating a large effect size in subjects with schizophrenia.

Keywords: Accelerometer, conversation, movement, psychosis, schizophrenia, speech

Introduction

Motor abnormalities are frequently described in patients receiving antipsychotic treatment. However, patients with schizophrenia also display neurological motor abnormalities prior to the initiation of any psychotropic medication [McCreadie *et al.* 2005; Honer *et al.* 2005; Koning *et al.* 2010]. Honer and colleagues reported that 44.9% of antipsychotic-naïve patients with schizophrenia (and related disorders) had signs and symptoms consistent with basal ganglia dysfunction and 28.1% had at least mild signs of an extrapyramidal disorder, most commonly hypokinesia. Thus, it has been proposed that the abnormal movements occurring with schizophrenia are markers of the neurodysfunction implicated in the pathogenesis of schizophrenia [Pappa and Dazzan, 2009]. The link between abnormal movements and psychosis may well be disruption to neuronal circuits of the basal ganglia, cerebral cortex and cerebellum [Whitty *et al.* 2009] and it has been

further proposed that, given the likelihood of this shared neural circuitry, there is potential value in the assessment of motor signs when screening for psychosis risk [Mittal *et al.* 2008].

The investigation of motor abnormalities in patients with mental illness has historically relied on rating scales. A more complex objective measure has been employed by neurologists investigating nonverbal communication [Altorfer *et al.* 2008]. They employed a motion-capture technique using video of a subject in general conversation with an interviewer. Subsequent analysis demonstrated a reduction in the frequency and amplitude of a subject's head movements during speech in patients *versus* controls, significant at the level of the individual regardless of whether subjects were taking antipsychotics or drug-naïve. Their technique required specialized equipment in a specialized environment in order to make these assessments.

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Schizophrenia has been implicated in many aspects of communication and the neuronal circuitry involved. Abnormalities in head movements, including those during speech, may shed light upon abnormalities at both behavioral and neuronal levels, including the abnormalities in the basal ganglia that lead to conditions such as tardive dyskinesia. Objective measurement of these movements could be more sensitive than existing scales used to rate abnormal movements. We sought to capture and compare head movements during conversation, in patients with schizophrenia and controls, using a commercially available movement sensor in a variety of clinical settings.

Methods and materials

Ethical approval was obtained from the local research ethics committee, Nottingham Research Ethics Committee 1 (NHS National Research Ethics Service). Informed consent was obtained from a referred sample of patients with capacity, assessed by an experienced senior clinician (BDM). Clinical case note ICD-10 diagnoses were made by a consensus of three senior clinicians. Data was initially analyzed from the first 6 cases and controls; a power calculation at this stage suggested that 11 cases and 11 controls would be sufficient to demonstrate an effect at the level of the individual with $p < 0.05$. A total of 11 patients with an ICD-10 diagnosis of paranoid schizophrenia and 11 healthy controls were recruited to the study.

Equipment

A commercially available movement sensor the size of a matchbox was obtained (Insight SENS Advanced IMU 110: Insight Sports, <http://www.insight-sports.com>). This is a self-powered unit measuring rotation and linear displacement in three axes using accelerometers and magnetometers. It was mounted on the peak of a baseball cap, such that the sensor was not in the wearer's visual field, and was linked via Bluetooth to a laptop computer that recorded the data in real time. Simultaneous audio recording was employed to allow identification of who was speaking.

Measurements

Interviews took place in a variety of settings, chosen as most convenient to the subject.

All interviews were conducted by the same investigator (BDM). The subject matter of the conversation was kept to general topics including the weather and recent activity, rather than following a fixed script or questionnaire. Clinical rating scales capturing psychopathology and abnormal movements were also completed (Signs and Symptoms of Psychotic Illness (SSPI), Abnormal Involuntary Movements Scale (AIMS), Simpson–Angus Scale for Extrapyrarnidal Side-Effects, Barnes Akathisia Rating Scale, Beck Depression Inventory (BDI) and the Scale for the Assessment of Negative Symptoms (SANS)), and examined for any broad trends.

Analysis

Data was initially captured to a Microsoft Excel spreadsheet, before import into the R statistics package [R Development Core Team, 2011] for further analysis. A variable, indicating when the subject was speaking, was added using the audio recording. Initial analysis was restricted to rotational displacement measured by the magnetometers, preferred because the readings were not subject to drift. Rotational displacement was converted into rotational velocity, so as to remove individual differences in initial orientation with respect to magnetic field lines (both local and global).

Results

The magnetometer data, measuring the local magnetic field strength in three axes, was divided by time then combined in a Pythagorean manner, to create a single magnitude vector, a rate of change of magnetic field by time, to remove the effects of differing seating positions and magnetic field orientation between subjects. An average value for cases and controls was calculated (rate of change of magnetic field strength, in units of milli-Teslas per second [mT/s]).

The mean, while speaking, for cases was 72.1 mT/s (standard deviation [SD] 58.5), and for controls 99.1 mT/s (SD 70.6), a highly significant difference ($t = 171.3252$, $df = 673$, 380.6 , p -value $< 2.2 \times 10^{-16}$).

Discussion

This study demonstrated that this type of movement sensor can be used to capture head

movements in a variety of settings in a clinical population. We also demonstrated that simple 'amplitude of head movement velocity while speaking' shows a large effect size for patients on treatment for schizophrenia, although not at the level of the individual. This supports the previous work undertaken by Altorfer and colleagues. The technology employed in this study was less intrusive and more convenient for the participants in comparison with the motion-capture techniques employed by Altorfer and colleagues. Therefore, the use of solid-state sensors, as opposed to video capture techniques, may have a number of significant advantages. The technology is less likely to interfere with nonverbal communication and allows for data capture to occur in clinical and nonclinical settings. In addition, data capture with movement sensors requires limited training or expertise and the units are relatively inexpensive.

All patients recruited to the study were receiving treatment with antipsychotic treatment, thus it is not possible to distinguish between effects due to primary neurodysfunction associated with schizophrenia and effects of antipsychotic treatments.

This technique shows potential for quick and easy objective investigation of neurodysfunction in a variety of clinical conditions, potentially including screening for psychosis risk and monitoring for medication side-effects.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

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