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Deeper into schizotypy and motor performance: Investigating the nature of motor control in a non-psychiatric sample

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ABSTRACT

Numerous studies have demonstrated that motor control deficits are characteristic of patients diagnosed with schizophrenia and those at-risk for the development of the disorder. Recent advances in the quantification of motor dysfunction have confirmed this, but these methods fail to consider an important aspect of subject performance: the *qualitative* nature of their psychomotor dyscontrol. We report on a novel technique used to quantify the qualitative nature of psychomotor performance and its relation to schizotypy. Control ($n=35$) and schizotypic subjects ($n=47$) completed a line-drawing task that yields metrics for psychomotor control and predominant frequency. Schizotypes evidenced greater psychomotor dyscontrol and lower predominant frequencies than controls. These results are interpreted as evidence of reduced visual-motor integration, self-monitoring capacity, or adherence to basic motor principles in schizotypes. The potential use of these metrics as putative endophenotypes for the liability for schizophrenia and the implications of these findings for the relationship between schizophrenia and schizotypy are discussed.

1. Introduction

Motor abnormalities have long been recognized as a feature of schizophrenia (Bleuler, 1950; Kraepelin, 1971). Despite this, the laboratory study of motor control in patients diagnosed with schizophrenia did not begin in earnest until the early 1980s (Manschreck, 1986). Since then, numerous studies have demonstrated that both fine and gross motor abnormalities are present in patients with schizophrenia (Manschreck, 1986; Blyler et al., 1997), their first-degree biological relatives (Ballard, 2000; Erlenmeyer-Kimling et al., 2000), and people with schizophrenia-spectrum pathology (Cassady et al., 1998; Neumann and Walker, 1999; Neumann and Walker, 2003; Kaczorowski et al., 2009). Further, these abnormalities have been shown to antedate the onset of a first-episode of psychosis (Fish, 1977, 1987; Walker and Lewine, 1990) and the initiation of treatment with antipsychotic medication (Manschreck, 1986; Wolff and O'Driscoll, 1999), and to predict earlier diagnosis of schizophrenia in affected individuals (Manschreck et al., 2004). Importantly, such abnormalities also correlate with schizotypic features in non-clinical populations uncontaminated by medication, deterioration, and other variables associated with treated psychiatric illness (Lenzenweger and Maher, 2002; Kaczorowski et al., 2009). Given the nature, abundance, and strength of this evidence, motor control issues have been identified as a potentially important endophenotypic marker for the liability for schizophrenia (Gottesman and Gould, 2003; Chan and Gottesman, 2008; c.f., Lenzenweger, 2013).

One factor that limits the potential value of motor control data is the use of observer-rating methods. Generally, observer-rating methods require advanced training for valid and reliable assessment. However, even when well-trained, but non-expert raters are used in lieu of experts, research has demonstrated that these raters do not necessarily produce valid assessments of observationally-defined constructs (Hooley and Richters, 1991). Further, observational ratings are known to be subject to experimenter bias (see Rosenthal and Rosnow, 2008 for discussion). Finally, observer-rating methods produce ordinal-level data that are limited in their precision and therefore, may fail to identify subtle deficits and serve to limit the application of the statistical methods that can meaningfully be applied to them (Nunnally, 1978). Simple, objective, and truly quantitative measures of psychomotor control circumvent these issues and as such, are highly desirable (Lenzenweger, 2010).

One such measure is the Maher Line Drawing Task (Blyler et al., 1997). This fine motor control task requires participants draw four diagonal lines and then uses a regression procedure to objectively and precisely quantify the degree of motor deviance in those lines (Maher, 1993). The MLDT has been found to be related increased Parkinsonian

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symptoms and decreased integrative functions, but unrelated to dyskinetic movements in patients with schizophrenia (Blyler et al., 1997). Empirically, the MLDT has been used to distinguish patients diagnosed with schizophrenia (Blyler et al., 1997; Manschreck et al., 2004) and their first-degree biological relatives (Ballard, 2000) from control subjects, and the MLDT's motor control output variable has been found to correlate with multiple measures of positive schizotypy and schizophrenia proneness (Lenzenweger and Maher, 2002). Importantly, MLDT performance has been demonstrated to be independent of a variety of potentially confounding variables (e.g. attentional deficits, age, symptom intensity, medication dosage) in non-clinical (Lenzenweger and Maher, 2002) and psychiatric samples (Manschreck et al., 2004).

While the MLDT confers many advantages over observer ratings, it is limited in that a potentially valuable aspect of motor performance goes unanalyzed: the qualitative nature of the motor performance. That is, different line patterns (e.g. arc, sine wave) can give rise to the same deviance value and the MLDT's output variables do not capture these differences. Evaluating this qualitative aspect of participants' lines quantitatively may thus provide important information about the nature (i.e. degree of tremulousness) and cause of their motor deviance and thereby increase the usefulness (e.g. predictive or discriminating power) of MLDT data.

In light of the above data, our purpose in conducting this study was twofold. First, we sought to extend the study of motor control in schizotypy by demonstrating that schizotypes (psychometrically-defined) have increased levels of psychomotor dyscontrol as compared to non-schizotypic control subjects. Lenzenweger and Maher's (2002) results suggest, but do not confirm this conjecture, thus inviting empirical study. We anticipated, building upon Lenzenweger and Maher (2002), that schizotypes would display increased motor deviance as compared to controls.

Second, extending beyond Lenzenweger and Maher (2002), we sought to apply a novel quantitative method that defines the qualitative nature of the psychomotor dyscontrol captured by the MLDT to determine if the nature of the lines schizotypic subjects draw distinguishes them from controls. The method of analysis we employed (described in detail below) involves identifying the predominant sinusoidal frequency present in participants' lines and was developed in our laboratory (Roche et al., 2009). The results of a pilot study (Roche et al., 2009), which employed a completely independent sample from the one described herein, demonstrated that measures of positive schizotypy correlated with lower predominant frequency scores (i.e. less tremulous lines). As such, we also hypothesized here that schizotypes would draw lines that were characterized by lower predominant frequencies than non-schizotypic control subjects.

2. Method

2.1. Subjects

In this study, 1000 SUNY- Binghamton undergraduate students completed the Perceptual Aberration (PAS; Chapman et al., 1978) and Magical Ideation scales (MIS; Eckblad and Chapman, 1983), as well as the Jackson Infrequency Inventory (INF; Jackson, 1984). From this sample, participant selection followed the standard psychometric high-risk method (Lenzenweger, 1994). First, respondents with scores 3 or greater on the INF were removed from the dataset, as scores in this range suggest a random or reckless response style. Second, participants who scored in excess of two standard deviations from the sample mean on either the PAS or MIS were recruited for our schizotypy group ($n=45$); and, participants who scored from the bottom of the distribution to within a half of a standard deviation above the sample mean on both measures ($n=37$) were recruited for our control group. In exchange for their participation, participants received experimental credit in an undergraduate psychology course. All experimental procedures were reviewed and approved by SUNY-Binghamton's Institutional Review board and informed consent was obtained prior to subject participation.

2.2. Measures

2.2.1. Schizotypy scales

Each subject completed the PAS and MIS. The PAS is a 35-item true-false measure of body image and perceptual aberrations (Chapman et al., 1978). The MIS is a 30-item true-false measure of belief in forms of causation that by conventional standards are invalid (Eckblad and Chapman, 1983). A vast corpus of empirical studies support the reliability and validity of these scales as measures of schizotypy (Chapman et al., 1994, 1995; Lenzenweger, 2010). We are mindful that there are many measures of schizotypy available, however the PAS and MIS enjoy a level of construct validation that is remarkable.

2.2.2. Infrequency scale

Participants completed the Jackson Infrequency Inventory (Jackson, 1984) to assess for random, invalid, or reckless response styles.

2.2.3. Psychotropic medication

Information about psychotropic medication usage was collected using an author-generated form. Participants were asked to circle "Yes" if they were taking any psychiatric medication or "No" if they were not. Information about the types of medications participants were taking was not recorded.

2.2.4. Axis I pathology

The Computerized Diagnostic Interview Schedule IV (CDIS; Blouin et al., 1988) was used to assess for lifetime history of psychosis. The CDIS is a computer-based, structured, self-report measure designed to assess for current or past DSM-IV-TR Axis I psychopathology (Robins et al., 1981; Blouin et al., 1988) and previous research (Blouin et al., 1988) has demonstrated the reliability of the computer-based procedure and its equivalence to the interview-based Diagnostic Interview Schedule.

2.2.5. Intellectual functioning

We used the Digit Symbol Coding (DSC) task from the Wechsler Adult Intelligence Scale-III (Wechsler, 1997) to estimate general intellectual functioning. The DSC has excellent test-retest reliability and correlates highly with full scale IQ (Wechsler, 1997).

2.2.6. Maher Line Drawing Task (MLDT)

The MLDT is a measure of fine motor performance that requires participants to draw four diagonal lines. Participants were instructed to draw diagonal lines in 2×2 in. boxes using both their right and left hands. Lines were always drawn from the bottom corners to the top corner diagonally opposite. Ultimately, lines are drawn in two directions (left-to-right and right-to-left) with each hand. Participants were asked to draw lines that were as straight as possible and to use their wrist, as opposed to their arms, to create the lines. These lines are then digitized using a flatbed scanner, *X–Y* coordinates are extracted using the UN-SCAN-IT software package (Un-Scan-It Version 5.0, 1998), and the primary outcome variables, psychomotor dyscontrol (*logRMS*) and absolute laterality (*logAL*), are calculated. In keeping with previous research, participants only completed this task once and no time demands were imposed on their performance (e.g., participants were not asked to draw as quickly as possible). Previous research has demonstrated the validity of this task as a measure of psychomotor control (Blyler et al., 1997) and its reliability (Candela, unpublished results). Furthermore, previous research (Blyler et al., 1997) has demonstrated the scanning process to be highly reliable with correlations between the output of repeated scans ranging from 0.94 to 1.0. The resolution of the scanning procedure is quite high with a typical scanned line consisting of 300 data points. Finally, in addition to collecting objective motor performance data, as a measure of handedness, participants were also asked which hand they normally write with.

To derive *logRMS* scores, a first-order regression line is passed through each line a participant draws and the standard deviation of the residuals (RMS) from each regression is computed. The RMS scores for each individual line are then summed and logarithmically transformed to produce *logRMS*. Lower *logRMS* scores indicate less psychomotor dyscontrol, while higher scores indicate greater psychomotor dyscontrol.

In addition to *logRMS*, a quantitative measure of the shape of participant's lines, predominant frequency (*PF*), was derived. *PF* represents the normalized spatial frequency that best characterizes the line a subject has drawn. Calculating *PF* is a three-step process. First, the Fourier transform is applied to the residuals created in the RMS calculations. The Fourier transform is a mathematical technique that allows one to determine the degree to which a range of frequencies are present in time series data. More specifically, for each possible frequency the Fourier transform outputs a number (i.e. magnitude) that indicates the degree to which that frequency is present in the time series. Second, the frequencies with the 30 highest magnitude scores are selected and entered into a statistical stepwise regression. Finally, *PF* is calculated by entering the frequencies retained in the regression into a weighted average. The numerator of the weighted average is the sum of the retained frequencies multiplied by their associated magnitude and the denominator of the