Fluctuating asymmetry in patients with schizophrenia

is related to hallucinations and thought disorganisation

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Running title: Fluctuating asymmetry and schizophrenia

Abstract

Fluctuating asymmetry represents the degree to which the right and left side of the body are asymmetrical, and is a sign of developmental instability. Higher levels of fluctuating asymmetry have been observed in individuals within the schizophrenia spectrum. We aimed to explore the associations of fluctuating asymmetry with psychotic and affective symptoms in schizophrenia patients, as well as with propensity to these symptoms in non-clinical individuals. A measure of morphological fluctuating asymmetry was calculated for 39 patients with schizophrenia and 60 healthy individuals, and a range of clinical and subclinical psychiatric symptoms was assessed. Regression analyses of the fluctuating asymmetry measure were conducted within each group. In the patient cohort, fluctuating asymmetry was significantly associated with the hallucination and thought disorganisation scores. T-test comparisons revealed that the patients presenting either hallucinations or thought disorganisation were significantly more asymmetrical than were the healthy individuals, while the patients without these key symptoms were equivalent to the healthy individuals. A positive association with the anxiety score emerged in a subsample of 36 healthy participants who were rated on affective symptoms. These findings suggest that fluctuating asymmetry may be an indicator of clinical hallucinations and thought disorganisation rather than an indicator of schizophrenia disease.

Keywords: developmental instability, fluctuating asymmetry, schizophrenia, positive symptoms, anxiety

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1. Introduction

1.1. Schizophrenia and morphological anomalies

Schizophrenia is a disease of unknown cause, but genetic and neurodevelopmental factors play a crucial role. In a seminal finding, it was Crow who first suggested that a single gene that affects cerebral lateralization was a primary factor in increased risk for developing schizophrenia (Crow, 1989). Building on this earlier work, the study of modern evolutionary genetics provides an alternative model firmly based on the concept of developmental instability (Yeo et al., 1999). Developmental instability refers to an organism's inability to carry out the genetic blueprint due to genetic factors —such as mutations— or environmental perturbations —such as stress or infection. Associated with poorer health and less successful social functioning (Prokosch et al., 2005), developmental instability is often reflected by very slight morphological or even cerebral abnormalities (Clarke, 1998). In patients with schizophrenia, it is reflected by a wide range of alterations of certain biological markers that do suggest an epigenetic foundation. In particular, increased rates of minor physical anomalies (MPAs) of the head, face, hands, and feet (e.g., high steepled palate, epicanthal folds, gaps between toes) have been observed in schizophrenia patients (Compton and Walker, 2009; Euler et al., 2009; Gourion et al., 2004; Weinberg et al., 2007; Xu et al., 2011) as well as in relatives of schizophrenia patients (Gassab et al., 2013; Gourion et al., 2004; Hajnal et al., 2016) and adolescents with schizotypal personality disorders (Weinstein et al., 1999).

Dermatoglyphic anomalies, such as differences in the formation of naturally occurring ridges in the morphological landscape of the palmar and plantar surfaces, are another

biological marker of developmental instability also found to be more prevalent in schizophrenia patients (Avila et al., 2003; Divakaran et al., 2013; Golembo-Smith et al., 2012; Zvi Shamir et al., 2015) and relatives of schizophrenia patients (Avila et al., 2003; Fatjó-Vilas et al., 2008).

The measurement of fluctuating asymmetry (FA), which may be described as the subtle deviation from an expected symmetrical morphological development (Ludwig, 1932), might provide an alternative to the measurement of MPAs to estimate the degree to which a genotype is accurately reflected in the phenotype. Indeed, one would assume that the right and left side of an individual's body develop symmetrically. However, developmental insults or 'noise' enter into the naturally occurring developmental plan and this is often reflected by an asymmetrical morphology (Graham and Özener, 2016). In the study of psychosis, fluctuating asymmetry has mostly been examined through asymmetry of dermatoglyphic features. Greater dermatoglyphic fluctuating asymmetry has been observed in youth at ultra-high risk for psychotic disorders (Russak et al., 2016). Patients with schizophrenia, when compared to healthy individuals, have also demonstrated greater dermatoglyphic fluctuating asymmetry in some studies (Karmakar and Sengupta, 2012; Markow and Wandler, 1986; Mellor, 1992; Reilly et al., 2001) but not others (Avila et al., 2003; Divakaran et al., 2013; Golembo-Smith et al., 2012). Wang et al. (2008) observed greater fluctuating asymmetry in schizophrenia patients on novel, but not conventional, dermatoglyphic asymmetry measures. Using a measure that reflected asymmetry in various body parts rather than dermatoglyphic asymetry, Euler et al. (2009) observed greater fluctuating asymmetry in schizophrenia patients than in healthy individuals, while Edgar et al. (2006) did not.

1.2. Associations of morphological anomalies with clinical and subclinical psychiatric symptoms

Studies of the potential associations of such morphological anomalies with clinical symptoms in patients within the schizophrenia spectrum, and with subclinical psychiatric symptoms in otherwise healthy individuals, have yielded inconclusive results. In the general population, MPAs have been associated with social anhedonia (Blanchard et al., 2010). They have also been associated with negative, but not positive, schizotypy in adolescents at risk for schizophrenia (Hans et al., 2009). In schizophrenia patients, MPAs were found to be associated with positive, but not negative, symptoms by Franco et al. (2012) and John et al. (2008), while Gassab et al. (2013) reported, in contrast, a correlation between MPAs and negative, but not positive, symptoms. Other studies have failed to reveal any association between MPAs and positive, negative, or disorganized symptoms (Aksoy-Poyraz et al., 2011; Lohr and Flynn, 1993; McGrath et al., 1995).

Dermatoglyphic abnormalities have been associated with social anhedonia in a non-clinical sample (Daly et al., 2008), and with positive (Chok et al., 2005) and disorganized (Gabalda and Compton, 2010) schizotypy. In schizophrenia patients, an association between dermatoglyphic abnormalities and predominant negative symptoms was reported by Páez et al. (2001), whereas Gabalda and Compton (2010) did not observe any association with either positive or negative symptoms.

Fluctuating asymmetry assessed by dermatoglyphic asymmetry was not associated with positive or negative symptoms in a sample of youth at ultra-high risk for psychotic disorders (Russak et al., 2016). However, it was associated with thought disorders in children with a psychiatric disorder (de Bruin et al., 2012), with distressing attenuated positive symptoms in non-clinical young adults (Mittal et al., 2012), and with negative schizotypy in an adolescent sample (Rosa et al., 2000). Páez et al. (2001) reported higher

dermatoglyphic fluctuating asymmetry in schizophrenia patients with predominant negative symptoms than in those with predominant positive symptoms. Using a different asymmetry measure that included several body parts, Thoma et al. (2008) revealed an association between fluctuating asymmetry and magical ideation, but not social anhedonia, in a sample of university students.

Thus, the way developmental instability might contribute to various symptoms within the schizophrenia spectrum remains very unclear. The range of approaches that have been used to investigate developmental instability may be one reason for the observed discrepancies. Further, most studies have used correlational or group-comparison analyses which did not control for the potentially confounding effects of other clinical or subclinical psychiatric symptoms. Lastly, potential associations with individual positive symptoms might be masked when a global positive symptom score is used.

1.3. Aims of the study

The objective of the present study was to examine the predictive nature of fluctuating asymmetry in the formation of different clinical manifestations of schizophrenia. We used a measure of anatomical fluctuating asymmetry —which has been less studied than dermatoglyphic asymmetry— and sought to determine which specific clinical symptoms this morphological asymmetry was related to in a sample of schizophrenia patients. We also investigated whether subclinical psychiatric symptoms in healthy individuals demonstrated associations with morphological asymmetry, and whether the pattern of associations was similar to that observed in patients. Psychotic symptoms —positive, negative, and disorganised— were examined. Further, we explored, in both the patient and healthy cohorts,

the associations of morphological asymmetry with affective symptoms, which are frequently observed in schizophrenia patients but seldom taken into account in this population.

2. Method

2.1. Participants

Thirty-nine in- and outpatients with schizophrenia (DSM-IV criteria) recruited from our network of mental health services in Barcelona were included in this study (see Table 1 for socio-demographic information). The inclusion criteria were age between 18 and 60 years, fluency in Spanish, and the ability to provide informed consent. Exclusion criteria were organic mental disorder, dementia, intellectual disability, head injury, alcohol or drug abuse in the prior 6 months, and current severe physical disease. Sixty healthy participants recruited from the general population by means of announcements were also included (see Table 1). They were screened to rule out any neurological or mental disease, alcohol or drug abuse, and current severe physical disease. The two groups were equivalent in age, sex distribution, and handedness. However, the patients had significantly lower education level ($p < .001$) and verbal IQ ($p < .025$) than the healthy participants. Ethical approval was obtained from the Parc Sanitari Sant Joan de Déu research and ethics committee. All participants provided written informed consent.

2.2. Symptom assessment

Clinical assessment was conducted in patients by means of the *Scale for the Assessment of Positive Symptoms* and the *Scale for the Assessment of Negative Symptoms* (Peralta and Cuesta, 1999). Hallucination, delusion, and thought disorganisation scores were computed by adding up the scores for all the subscale items except the 'global rating' item. A negative symptom score was computed by adding up the scores for affective flattening,

alogia, avoliton, and anhedonia. Affective symptoms were assessed by means of the *Calgary Depression Scale* and the *Hamilton Anxiety Rating Scale*. In the healthy sample, self-questionnaires assessing proneness to hallucinations (*Launay-Slade Hallucination Scale – LSHS;* Launay and Slade, 1981) and proneness to delusions (*Peters Delusion Inventory – PDI;* Peters et al., 2004) were administered. The last 36 healthy participants recruited were also administered self-questionnaires assessing social anhedonia (*Revised Social Anhedonia Scale*; Fonseca-Pedrero et al., 2009) and affective symptoms (*Beck Depression Inventory*; Beck et al., 1988, and *Beck Anxiety Inventory*; Creamer et al., 1995). In all cases, the Spanish adaptation of the various clinical and subclinical rating scales was used. The clinical and subclinical symptom scores are presented in Table 1.

2.3. Measure of fluctuating asymmetry (FA)

A standard approach to measuring the degree of FA was used. Here, a digital calliper was used to measure the right and left side of seven body features to the nearest 0.05 mm: length of each finger (from tip to knuckle), wrist width, and ear pinna length, taken from the uppermost aspect of the helix to the bottom of the lower lobule (see Table 2). FA values for each body feature were derived from these measurements, using the formula: $FA(trait) = 2\times|R-L|/(R+L)$ (Prokosch et al., 2005), which is equivalent to the FA2 index described by Palmer for a single trait (Palmer, 1994). A composite FA score (Clarke, 1998) was obtained by adding up the seven individual FA(trait) scores. The collection of measures from several body features from both sides ensured that the potential confound of directional asymmetry was controlled (Graham et al., 2010).

2.4. Statistical analyses

The variables that did not follow normal distribution were normalized by square-root transformation. We first compared the patients and the whole sample of healthy participants on FA by means of a Student's t-test to test the hypothesis that greater asymmetry was observed in the patient group. Then, regression analyses of FA were conducted in patients and in healthy participants to explore potential associations with symptom ratings. In the patient group, the independent variables were the scores for the clinical symptoms of interest: hallucinations, delusions, thought disorganisation, negative symptoms, depression, and anxiety. The symptoms that were found to be significantly associated with FA were further investigated by comparing the patients presenting these symptoms to the healthy control group. In the 60 healthy participants, the independent variables were the scores for hallucination proneness and delusion proneness. A second regression analysis was conducted in the subsample of 36 healthy participants who were rated on affective symptoms and social anhedonia. This included hallucination proneness, delusion proneness, social anhedonia, depression, and anxiety scores. Age and sex were not included because preliminary analyses demonstrated that they were unrelated to fluctuating asymmetry.

3. Results

3.1. Group comparison

The t-test indicated that FA tended to be more elevated in the patient than in the healthy sample (m = .146, sd = .044 vs. m = .130, sd = .045; $t(97) = 1.70$, $p < .10$), reflecting only a trend toward greater morphological asymmetry in patients.

3.2. Associations between fluctuating asymmetry and clinical symptoms in patients

In the patient sample, the regression analysis revealed significant positive associations between FA and the hallucination scores (β = .59, p <.002) as well as the thought disorganisation scores (β = .65, p <.0001), indicating that higher ratings on hallucinations and thought disorganisation were associated with greater morphological asymmetry. On the other hand, the association of FA with the delusion score was non-significant, and, if anything, negative (β = -.32). No association with negative symptoms (β = -.17), depression (β = .19), or anxiety (β = .04) was observed[1].

To further investigate the finding of an association between FA and hallucinations, we divided the patient group into two subgroups: 18 patients with significant hallucinations (score ≥ 2 on at least one of the hallucination items) and 21 patients without them (score < 2 on all hallucination items). Each subgroup of patients was compared to the healthy participant group to determine whether hallucinations were associated with abnormal asymmetry (see Figure 1a). T-tests indicated that the 21 patients without hallucinations were not significantly different from the healthy participants (m = .137, sd = .047 vs. m = .130, sd = .045; $t(79) < 1$, $p > .55$). In contrast, the 18 hallucinating patients were indeed significantly more asymmetrical than were the healthy participants (m = .156, sd =.041 vs. m = .130, sd = .045; $t(76) = 2.20$, p <.05, partial η^2 = .06).

Similar complementary analyses were conducted to determine whether thought disorganisation too was associated with abnormal asymmetry (see Figure 1b). The patient group was divided into 15 patients with thought disorganisation (score ≥ 2) and 24 patients without (score < 2). T-tests indicated that the non-disordered patients were equivalent to the healthy participants (m = .128, sd = .041 vs. m = .130, sd = .045). In contrast, the thought-

[1] In order to control for the potential confound of directional asymmetry due to increased dexterity in the dominant hand, we recomputed the regression analysis after excluding the thumb and index finger measures from the fluctuating asymmetry formula. The alternative FA score was, like the original score, significantly associated with hallucination (β = .45, p <.02) and thought disorganisation (β = .68, p <.0001) scores.

disordered patients were significantly more asymmetrical than were the healthy participants (m = .173, sd = .037 vs. m = .130, sd = .045, $t(73) = 3.44$, p <.001, partial η^2 = .14).

3.3. Associations between fluctuating asymmetry and subclinical symptoms in healthy participants

In the healthy participants, the regression analysis conducted in the whole sample indicated that the association with hallucination proneness was negative and not significant (β = -.18), and that the association with delusion proneness was near zero. The regression analysis conducted in the subsample of 36 participants who were rated on affective symptoms and social anhedonia revealed that the anxiety score was associated with FA (β = .78, p <.001), in the sense that greater asymmetry was related to more anxiety[2]. In contrast, depression (β = -.65, p <.002) and social anhedonia (β = -.35, p <.05) were inversely associated with FA. No association with hallucination proneness emerged (β = -.09). It should be noted that, when the anxiety score was removed from the model, no significant association with either depression (β = -.32, p > .12) or social anhedonia (β = -.13, p > .44) was observed.

4. Discussion

Developmental instability studied through the examination of minor physical and dermatoglyphic anomalies has been consistently reported in schizophrenia patients and individuals within the schizophrenia spectrum (Golembo-Smith et al., 2012; Weinberg et al., 2007). However, greater fluctuating asymmetry, another sign of developmental instability, has not been clearly established in these populations. The studies that have attempted to determine the clinical correlates of developmental instability —assessed by minor physical or

[2] The association between anxiety score and the alternative FA score excluding the thumb and index finger measures was β = .73, p <.002.

dermatoglyphic anomalies or by fluctuating asymmetry— have yielded inconsistent results. It is therefore unclear whether the signs of developmental instability in schizophrenia are a characteristic of the disease, or rather exist only in patients presenting certain clinical symptoms.

We assessed fluctuating asymmetry by means of a measure that included asymmetry between the right and left sides of several body parts. This measure was found to be related to hallucinations in our schizophrenia sample. As far as we know, this is the first time that an association between developmental instability—assessed by whatever means—and this specific clinical symptom has been reported. Previous studies have indeed used global positive symptom scores rather than focusing on individual positive symptoms. This association has to be interpreted with caution though, considering the small size of the patient sample and the lack of any a priori hypothesis relative to potential associations with the various clinical symptoms investigated in our study. It is a preliminary finding that clearly warrants replication in larger samples. If this association with hallucinations were to be consolidated by further studies of schizophrenia patients, it would be of interest in future research to investigate whether patients who suffer hallucinations in the context of another clinical diagnosis —e.g. major depression— similarly demonstrate greater morphological asymmetry than do their non-hallucinating counterparts.

Our measure of fluctuating asymmetry was also found to be associated with thought disorganisation. Although this result is reported here for the first time in a schizophrenia sample, as far as we know, it is in agreement with a study which demonstrated an association between dermatoglyphic asymmetry and thought disorders in children with a psychiatric disorder (de Bruin et al., 2012). More generally, our finding of a significant association with both hallucinations and thought disorganisation is compatible with studies which indicated that neurodevelopmental abnormalities assessed on the basis of minor physical anomalies

were associated with a global positive symptom score in schizophrenia patients (Franco et al., 2012; John et al., 2008).

In our data, fluctuating asymmetry was not significantly increased in the whole patient group relative to the healthy participants. Abnormal asymmetry, rather, appears to involve specifically the patients presenting with hallucinations or thought disorganisation. The subgroups of patients who did not present hallucinations or thought disorganisation were equivalent to the healthy participants with respect to fluctuating asymmetry. In contrast, the patients suffering either of these symptoms were significantly more asymmetrical than were the healthy participants, with small and medium effect sizes, respectively. Thus, morphological asymmetry may be an indicator of hallucinations and thought disorganisation rather than one of the disease itself. Previous reports of potentially abnormal fluctuating asymmetry in schizophrenia have been conflicting, and our data suggest that low prevalence of these symptoms might contribute to the failure to observe greater fluctuating asymmetry in some patient samples. While a certain degree of right-left asymmetry is to be expected even though the body is assumed to develop in a symmetrical way (Corballis, 2009), our findings indicate that patients presenting hallucinations and/or thought disorganisation deviate more from symmetry than what might be considered a healthy developmental trajectory.

A different pattern of associations was observed in the healthy sample, with more fluctuating asymmetry being related to greater anxiety rather than to greater hallucination proneness. Hallucination proneness might not have been prevalent enough in this sample to allow a potential association with fluctuating asymmetry to emerge. Anxiety is nonetheless relevant to the study of schizophrenia symptoms insofar as it might be a crucial triggering factor in the formation of hallucinations (Allen et al., 2005; Ratcliffe and Wilkinson, 2016). Our observation is compatible with that of Sabanciogullari et al. (2010) who reported

increased rates of dermatoglyphic abnormalities in a sample of patients with panic disorder compared to healthy individuals.

Fluctuating asymmetry was further inversely related to social anhedonia and depression in the healthy participants. The inverse association with social anhedonia is in conflict with several studies which have reported that negative schizotypy was, on the contrary, associated with increased rates of minor physical (Blanchard et al., 2010; Hans et al., 2009) and dermatoglyphic (Daly et al., 2008) anomalies and with greater dermatoglyphic fluctuating asymmetry (Rosa et al., 2000). Thoma et al. (2008) nonetheless reported no association between social anhedonia and either MPAs or anatomical fluctuating asymmetry in their student sample. The different measures used to assess developmental instability, allegedly reflecting alteration in different phases of the neurodevelopmental process, may partly account for the inconsistency of the obtained patterns of associations. The statistical approach too is likely to contribute to the discrepancies. In our study, the symptoms of interest were examined simultaneously in regression analyses, thereby allowing us to identify the specific effect of each while controlling for the others. The inclusion of an anxiety score appears to have substantially altered the pattern of associations with fluctuating asymmetry in the healthy sample. Indeed, no significant association with depression or social anhedonia emerged when anxiety was removed from the model. The inverse association with depression observed in the model that includes anxiety is certainly puzzling, but it is nonetheless compatible with our previous finding that depression and anxiety scores, when entered together in a regression analysis, demonstrated opposite associations with brain activity in a schizophrenia sample (Stephan-Otto et al., 2016). Potential associations with anxiety have never been explored in similar studies of developmental instability, as far as we know, and further investigation is warranted to determine whether this symptom is authentically related to fluctuating asymmetry in the general population.

Our conclusions are limited by the small size of the participant samples and the exploratory nature of the study. Although significant associations were observed in both the patient sample and the subsample of healthy participants who were assessed on affective symptoms, we cannot rule out the possibility that these associations emerged merely by chance, or that the samples from which they were derived were in some way atypical. Another important caveat is that fluctuating asymmetry only provides an approximate measure of developmental instability. Further, each body feature was measured only once, thereby precluding the assessment of measurement error.

Caveats must also be added with respect to the comparisons between patients and healthy participants. Indeed, the two groups differed in their education level and verbal IQ, and possibly in other characteristics that might be relevant to fluctuating asymmetry and its associations with symptomatology. Further, different scales were used in patients and healthy participants for the assessment of psychotic and affective symptoms, which limits the validity of pattern comparisons between groups. Lastly, proneness to thought disorganisation was not assessed in the healthy sample while it might have been a strong correlate of fluctuating asymmetry, as it was in patients.

In summary, these preliminary findings, which call for replication, suggest that fluctuating asymmetry may be related to specific symptoms of schizophrenia, namely hallucinations and thought disorganisation, rather than to the disease itself. Associations with anxiety in various populations might also be a worthwhile area of investigation.

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Table 1. Socio-demographic information on all participants, clinical information on patients, and subclinical symptom scores for the whole sample and a subsample of healthy participants

	Schizophrenia patients (n = 39)	**Healthy participants (whole sample, n = 60)**	**Healthy participants (subsample, n = 36)**
Sex	15 F, 24 M	27 F, 33 M	17 F, 19 M
Age	40.8 (10.2)	37.9 (10.3)	38.2 (11.0)
Left-handedness	4	4	3
Verbal IQ[3]	98.7 (10.3)	103.3 (8.6)	103.0 (8.0)
Education level[4]	4.7	5.7	5.4
Illness duration	14.4 (9.7)	/	/
Hallucinations	4.2 (6.6)	/	/
Delusions	7.4 (7.5)	/	/
Thought disorganisation	2.4 (3.9)	/	/
Negative symptoms	7.8 (8.3)	/	/
Calgary Depression Scale	3.9 (5.2)	/	/
Hamilton Anxiety Rating Scale	9.8 (7.3)	/	/
LSHS: hallucination proneness	/	5.6 (4.4)	6.5 (5.0)
PDI: delusion proneness	/	6.3 (6.7)	7.5 (7.6)
Social anhedonia	/	/	11.1 (5.6)
Beck Depression Inventory	/	/	4.9 (4.3)
Beck Anxiety Inventory	/	/	5.3 (6.2)

[3] *Test de Acentuación de Palabras* (Gomar et al., 2011)

[4] The scale used was: 1 = no studies; 2 = uncompleted primary studies; 3 = completed primary studies; 4 = uncompleted high school; 5 = completed high school; 6 = uncompleted undergraduate studies; 7 = bachelor's or master's degree; 8 = doctorate

Table 2. Morphological information for the sample of patients and for the whole sample and a subsample of healthy participants (mean, standard deviation, and range). All measures are expressed in millimetres except for height.

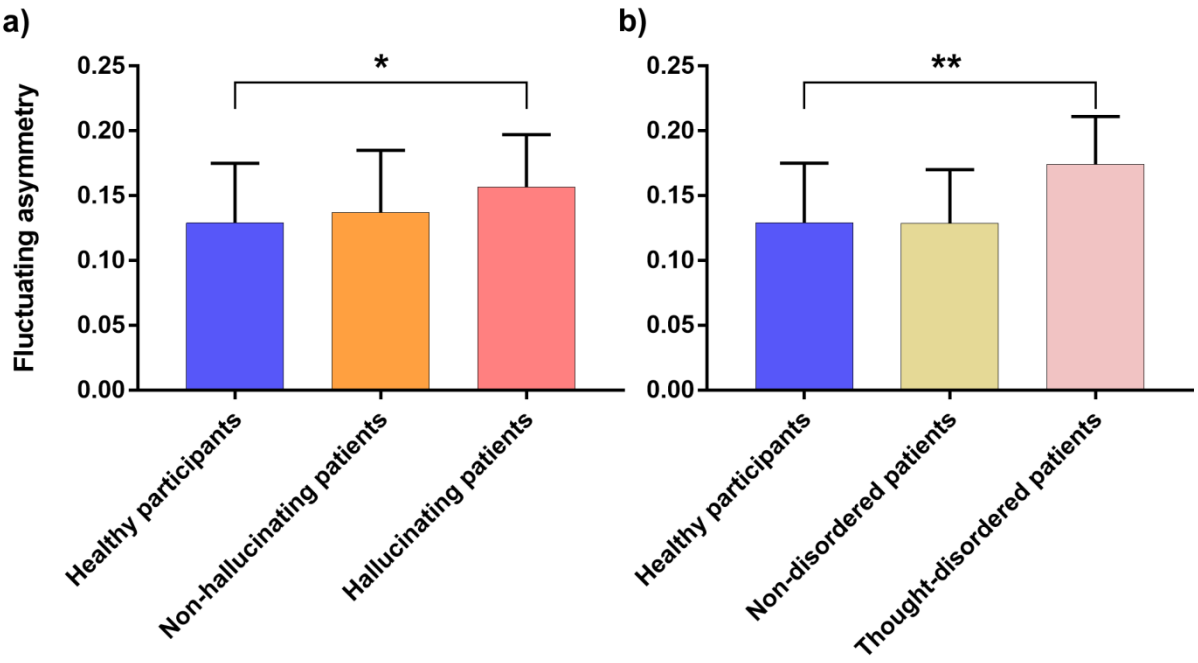
	Schizophrenia patients (n = 39)	Healthy participants (whole sample, n = 60)	Healthy participants (subsample, n = 36)
Height (metres)	1.72 (.10) [1.52-1.96]	1.69 (.09) [1.51-1.87]	1.69 (.09) [1.51-1.84]
Left thumb	73.43 (6.40) [60.70-87.30]	73.36 (4.93) [64.50-84.60]	73.37 (5.04) [64.50-84.60]
Right thumb	73.44 (6.37) [61.60-88.70]	72.89 (4.94) [63.20-84.10]	73.01 (4.94) [63.20-84.10]
Left index finger	101.56 (8.79) [83.60-120.20]	101.63 (6.59) [90.60-116.00]	101.55 (6.75) [90.60-113.80]
Right index finger	101.37 (8.12) [85.80-121.60]	101.32 (6.66) [90.10-114.20]	101.45 (6.90) [91.20-114.20]
Left middle finger	112.11 (9.27) [95.10-134.20]	112.00 (7.25) [99.70-125.50]	111.89 (7.39) [99.70-124.10]
Right middle finger	112.31 (9.17) [95.30-134.20]	112.04 (7.12) [99.50-125.10]	111.67 (7.11) [99.50-123.50]
Left ring finger	105.97 (9.06) [87.70-124.20]	106.40 (7.09) [94.10-122.40]	105.94 (7.01) [94.10-117.90]
Right ring finger	107.22 (8.85) [88.40-125.90]	106.73 (6.82) [93.10-119.70]	106.17 (6.88) [93.10-117.60]
Left little finger	85.48 (8.87) [64.90-102.80]	85.58 (5.44) [76.20-96.50]	85.18 (5.46) [76.20-96.40]
Right little finger	86.81 (8.50) [68.30-104.60]	87.21 (5.67) [77.00-100.00]	86.68 (5.69) [77.70-98.50]
Left wrist	59.11 (4.85) [50.60-69.70]	57.69 (4.29) [49.90-68.30]	58.72 (4.53) [51.30-68.30]
Right wrist	59.56 (4.51) [51.50-70.10]	58.15 (4.14) [50.10-66.10]	59.06 (4.33) [50.10-66.10]
Left ear	66.97 (5.71) [58.50-79.90]	64.90 (4.76) [50.50-78.70]	64.80 (5.15) [50.50-78.70]
Right ear	66.54 (5.37) [56.40-77.50]	64.20 (4.82) [54.00-77.60]	64.03 (4.78) [54.00-77.60]

Legends for Figure 1

Figure 1a: Fluctuating asymmetry in 60 healthy participants, 18 patients with hallucinations, and 21 patients without hallucinations.

Figure 1b: Fluctuating asymmetry in 60 healthy participants, 15 patients with thought disorganisation, and 24 patients without thought disorganisation,

Figure 1



* p < .05 ** p < .001