Original Investigation

Title:

Development of a sensory and perceptual assessment test for psychosis and schizophrenia

Running title:

Development of sensory test for psychotic symptoms

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Abstract

Results from the development of a novel sensory and perceptual test to assess the level of altered visual size perception in people with schizophrenia are presented. Here we compare the performances in a visual sensory and perceptual test between a control group and an experimental group of people diagnosed with schizophrenia. We have been using paintings by Salvador Dalí and Rorschach plates to assess images size perception. In this transversal, ex-post-fact and quasi-experimental study we show differences between EG (Experimental Group) and CG (Control Group). Schizophrenics in-patients as compared to controls perceived sizes about 1.3 fold greater than healthy volunteers ($p=0.006$), thus showing that size perception is altered in schizophrenia. Together with previous results, this particular sensory test for size perception seems to be a useful assessment tool to evaluate the degree and severity of psychotic symptoms in prodromal schizophrenic states, and neuropsychiatric patients in general. It may help prevent acute crisis with proper, and most likely, lower dosages of medication.

Key Words: Schizophrenia; Psychosis; Visual perception; Spatial perception; Size perception; Pareidolia.

INTRODUCTION

Although the evidence that sensory processes are altered in schizophrenic patients is widely accepted, the exact nature and impact of these alterations are not fully understood. Studies on size perception (Davis, et al., 1967), perceptual organization (Silverstein, et al., 2011), illusions (King, et al., 2017), contrast sensitivity and spatial frequency (Flevaris, et al., 2014; Graham and Meng, 2011; Green, et al., 2008; Shoshina, et al., 2015; Silverstein, et al., 2017), face perception and recognition (Kim, et al., 2015; McBrain, et al., 2010; Silverstein, et al., 2014; Vakhrusheva, et al., 2014), visual integration (Postmes, et al., 2014; Silverstein, et al., 2009; Silverstein, et al., 2012; Silverstein, et al., 2015), visual search (Chen, 2011; Dias, et al., 2013), mismatch negativity or odd ball paradigm (Avissar, et al., 2018; Hamilton, et al., 2019) among others, have all addressed issues related to sensory processes in schizophrenia.

Most relevant to our study are those on size perception of the Muller-Lyer and Ponzo illusions (King, et al., 2017; Pessoa, et al., 2008; Shoshina, et al., 2011; Weckowics and Witney, 1960) and those about pareidolia in Lewis-body dementia and Parkinson disease (Uchiyama, et al., 2012; Uchiyama, et al., 2015; Yoko, et al., 2014; Mamiya, et al., 2016) whose observed effects seem to be related to psychotic symptoms.

Weckowics and Witney (1960) found that schizophrenics presented larger illusion effects than controls, but their group of non-schizophrenic psychiatric patients also showed larger magnitude effects than controls but, in turn, lower than schizophrenics. They could not explain those latter results. In 2008, Pessoa et al. suggested the use of the Muller Lyer illusion for screening schizophrenic patients based on an animal model.

Shoshina et al. (2011) conducted studies on the Ponzo and the Muller Lyer illusions with schizophrenic patients and non-psychiatric ‘healthy’ patients. On one hand, they found opposite results for schizophrenics either with less or more than 10 years of illness. The former group showed lower sensitivity to Ponzo illusion than healthy patients, whereas the opposite was true for those patients with more than 10 years from the diagnosis of schizophrenia. On the other hand, they found that schizophrenic patients with more than 10 years of illness were more susceptible to the Muller Lyer illusion than those with less than 10 years of illness, who in turn were more susceptible than healthy patients. However, they found gender differences. Apparently, male schizophrenic patients are less susceptible to the Ponzo illusion than schizophrenic females.

In this study, we argue that schizophrenic patients present a disrupted size perception with a tendency towards perceiving large magnitudes compatible with very high sensitivity to low fundamental spatial frequencies when dealing with form and object perception.

Our hypothesis arises from the observation that, in acute crisis, some schizophrenics report perceiving pareidolia e/or pareidolic like images, PPLI, in natural scenes that are of very large magnitudes, or at least, perceived as larger than the actual size of the referred object. This observation together with the above findings, appear to be consistent with such a hypothesis.

Here we consider pareidolia those images spontaneously perceived in natural everyday scenes deriving from the assembly of bits and pieces of the natural observed scene into large magnitude meaningful or meaningless objects. An example of pareidolic image (PI) is shown in Figure 1 (left) where a highway landslide appears to be a huge “beggar or homeless”. When we use the term pareidolia e/or pareidolic-like

image (PPLI) it includes meaningless assembled images having no clear identifiable characteristic, or preexisting form, like the encircled image shown in Figure 1 (right).

INSERT FIGURE 1 ABOUT HERE

Our approach have been using images for the observation of PPLI. We assume a view quite distinct from that of Uchiyama et al. (2012; 2015; Mamiya, et al., 2016; Suzuki et al., 2017; Yoko, et al., 2014) for dementia with Lewy bodies (DLB), as well as for Parkinson Disease. In their view, pareidolia is taken literally, and the perception of the pareidolia itself is the key point of the investigation since patients suffering from DLB tend to have visual hallucinations. Also, most of the images used in these studies to induce the perception of pareidolia in DLB adopted as stimulus low-pass-filtered images of visual scenes. In our case, we used some paintings by Salvador Dalí and the *magnitude* of the perceived PPLI are the major issue under investigation. The choice of paintings by Salvador Dali as a tool to assess image size perception is related to the great variety of sizes, and to a possibility of seeing PPLI within a single picture that are present in many of his works. For comparison purposes, we also used Rorschach Test plates with part of the volunteers, exclusively measuring diameter size perception of the first perceived image, with the aim of illustrating the occurrence of the effect regardless of the configuration of the images.

In our initial studies (Simas, et al., 2011), we used a selection of 24 paintings by Dalí and asked people with schizophrenia and healthy volunteers to point out the first image they perceived in each of those paintings. We were able to reproduce the same results repeatedly from 2002 to 2012 with a total of over 100 experimental and 100 healthy volunteers (Modesto, 2012; Simas, et al., 2011). Those studies have shown that schizophrenics perceive larger images than controls, and that different populations of schizophrenics perceive progressively larger images that seem to be related to the

severity of the prodromal or acute/chronic states. In this early work we used the concept of “concatenation of forms” in a way that was analogous to the concepts of PPLI that we now adopt.

This study reports experiments run in a clinic and a hospital comparing in-patients to healthy volunteers. Our hypothesis was that we would reproduce previous results (Modesto, 2012; Simas, et al., 2011) even though using a selection of only 10 Dalí paintings (and 10 Rorschach plates with a partial sample) in an iPad2 display where the volunteers encircled, by themselves, the first perceived image in each of the paintings (and plates).

In this way, we aim to develop an instrument for assessing the progressive worsening of sensory and perceptual phenomena with the objective of preventing full blown psychotic episodes in schizophrenic patients and, perhaps, avoiding the first acute event of those patients seeking help in psychological clinics or day-in hospitals.. This idea stands from the empirical observation that under treatment and remission, this effect of “seeing” large images changes into the perception of progressively smaller PPLI up to a point where they disappear and are no longer spontaneously seen.

METHOD

Study Setting

Experiments were conducted at the “Hospital Ulysses Pernambucano”, the “Clínica Santo Antônio de Pádua”, the public school “Escola Maria da Conceição do Rêgo Barros Lacerda” at Recife, Pernambuco, Brazil, and at the “Serviço de Atenção Psicológica da UFSC (SAPSI)”. Volunteers of the former two were in the Experimental Group, EG, and those of the latter two, in the Control Group, CG. The trial was approved by the Institutional Review Board (Comitê de Ética em Pesquisa, CEP) at the

Federal University of Pernambuco (Trial Registration Number: CAAE n°15479213.5.0000.5208) and volunteer patients (or legal guardians) as well as controls read and signed Consent Forms agreeing to freely participate in the experiment, and were free to leave the study at any time.

Experimental Group (EG)

Fifty-nine patients diagnosed with schizophrenia (34 men, 25 women) participated in the study (mean = 34.7 ± 12.9 yrs old). The inclusion criteria were: (i) age 18-60 yrs old, (ii) minimum four years of formal education and compatible Mini-Mental State Examination, MMSE, scores (≥ 10), (iii) F20 CID-10 diagnostic, and (iv) at least a week long continuous medication, whereas the exclusion criteria were: (i) patients with ocular diseases, (ii) with organic cerebral diseases, (iii) excessive agitation or aggressivity. Formal education of experimental volunteers was characterized by 66.67% high school level; 30.55% incomplete fundamental and 2.78 % omitted this information.

Regarding medications, 43.13% of the volunteers used typical antipsychotics, 11.37% risperidone, 2.37% other atypical antipsychotics, 18.48% used mood stabilizers, 12.3% antihistamines, 3.79% anxiolytics and 8.53% used other medications including antidepressants. Most of the patients are regular smokers.

Control Group (CG)

Fifty-nine healthy volunteers (mean = 26.44 ± 9.18 yrs old), students, servants and professionals from fundamental, or high public schools, or university were selected for the CG (24 men, 35 women). The inclusion criteria were: (i) 18-60 years old, (ii) low, medium and high levels of formal education, while the exclusion criteria were: (i)

ocular diseases, (ii) familial history of neuropsychiatric disorders, (iii) drug or alcohol abuse, (iv) last eventual use of alcohol for a period longer than 24hs. Formal education of control volunteers was characterized by 85.42% high school level and 14.58% incomplete fundamental. Table 1 shows the characteristics of each sample.

INSERT TABLE 1 ABOUT HERE

Instruments and Equipment

Instruments for the EG consisted of medical records, consent forms, sociodemographic and familial history interview, as well as the Brazilian validated versions of Mini-Mental State Examination, MMSE, and the Scale of Positive and Negative Symptoms, PANNS, as well as the Rasquim E Acuity Chart. These same instruments were used for the CG, except for medical records and PANNS.

The Sensory and Perceptual Assessment Test Prototype for Psychosis and Schizophrenia, (Dali-Simas Test)

The Dalí-Simas test was adapted to a digital version from the studies previously reported (Modesto, 2012; Simas, et al., 2011) and originally carried out with printed photographs of 24 Dali paintings (10x15 cm).

Thus, ten 10x15 cm photos of paintings by Salvador Dali, were used together with the ten 10x15 cm photos of Rorschach plates for evaluation and comparison of sizes of the first perceived and reported images, regardless of any attribution of meaning.

Paintings and plates were presented in an iPad2 (or paper for 26 controls) at 30 cm distance from the eye. (We completed the CG sample after running a test between

the volunteers that used paper photographs or iPad2 methods and having found no statistical difference between both control groups).

The images measured 30 degrees of visual angle in its larger dimension. We also used iPad pens, iPad stands, pens and printed photos, as well as forehead and chin rests (refer to Figure 2).

INSERT FIGURE 2 ABOUT HERE

Either the app “PDF Notes”, or the PowerPoint for the iPad, were used to display the stimuli. So were the programs “Klonk Image Measurement” by Christian Andersen, and “ImageMeterPro” by Dirk Farin, for measuring diameter, perimeter and area, though only diameter in degrees of visual angle are the focus here.

Procedure

Volunteer patients were informed about the general aspects of the experiment followed by reading and signing the consent form after the full understanding of the research explanation and the task to be performed was assured. A socio-demographic and familial history interview was followed by the acuity test at both 30 cm and 300 cm distances. Patients with normal (or corrected to normal) visual acuity were then assessed with both, MMSE and PANNS. Following the same initial procedure, healthy volunteers were told about the experiment, read and signed the consent form, answered the same interview, run the acuity tests and were also assessed by the MMSE, but not the PANNS.

As shown in Figure 2, the volunteer sat with his head at 30 cm from the iPad2 display while resting his forehead and chin on a suitable support. The instruction given was: “You will see some paintings, please encircle with the iPad pen the first image you see”, followed by a single training trial (see Figure 2). The experiment would start with

a block of 10 Dali paintings (succeeded by the block of 10 Rorschach plates for 66 of the volunteers – 33 EG and 33 CG) always in the same order. Although there were no time restrictions, the experiment was short and lasted about 10 minutes on the average. For some in-patients, short intervals were made whenever requested. When the experiment was run over a period of two or three days for the in-patients, a short version of the MMSE was run each day previously to the experimental session.

RESULTS

The diameters of the encircled images were measured in centimeters and converted to degrees of visual angle, then tabled by participant, configuration, picture and group. An ANOVA with one factor between (group: GC vs EG) and one factor within (picture: 10 paintings) showed significant difference between groups, $F(1, 64)=9.2441$, $p=0.00342$ when only Dalí paintings were considered. The EG perceived images 1.2 folds greater than CG, showing that in-patients with schizophrenia, even medicated, have a tendency to perceive larger images than people without known history of neuropsychiatric disease. There was no interaction between groups and pictures. (refer to Figure 3, top).

INSERT FIGURE 3 ABOUT HERE

The tendency to perceive larger magnitudes can be seen in Figure 3, bottom, where the frequency of perceived sizes is distributed by degrees of visual angle. The EG picked images mostly between 10° and 20° of visual angle, while the CG pointed mostly to images between 5° and 15° of visual angle. Only EG picked images greater than 15° of visual angle, and only CG pointed to images smaller than 10° of visual angle.

Another ANOVA with one factor between group (GC vs EG) and two factors within group (configuration: Dalí vs Rorschach, and pictures: 10 paintings vs 10 plates)

also showed significant differences between groups $F(1, 64)=6.1027$, $p=0.01617$ when only Rorschach plates were analyzed. In this case, EG saw images 1.2 folds greater than CG. When we consider both Dali paintings and Rorschach plates, we also observed a difference between groups, $F(1, 64)=8.1236$, $p=0.00587$, where the EG saw images 1.3 greater than the CG. But we found a significant difference between configurations. A difference that disappears when we subtract from the stimulus set, Rorschach's plate number 5 (a bat like image seen by both groups as the same size, refer to Figure 4, top). For comparison purposes, we arbitrarily subtracted Dalí's painting number 7 and re-did the analysis.

This new ANOVA (with nine pictures and nine plates only) yielded again significant difference between groups [$F(1, 64)=8.9722$, $p=0.0039$], but this time, there was no difference between configurations, $F(1, 64)=3.0489$, $p=0.08559$. The interaction between groups and configurations was not significant, showing a similar trend for Dalí's paintings and Rorschach's plates in both groups (Figure 4, bottom).

INSERT FIGURES 4 AND 5 ABOUT HERE

When we extract the fundamental spatial frequency (FSF) from the size given in degrees of visual angle (SIZE) by considering that $FSF=1/SIZE$, we observe quasi parallel interpolated lines for both, Dalí's paintings (Figure 5, top) and Rorschach's plates (Figure 5, center). In doing so, we verify that EG picks fundamental spatial frequencies mostly below 0.07 cpd (cycles per degree), while CG seems to select FSF predominantly above such a value, either for paintings or plates.

In Figure 5 (bottom), we observe this tendency most clearly. The EG (red and orange bars) are mostly observed below the axis value of 0.07 FSF, while the CG (light and dark blue bars) are mostly distributed- above FSF of 0.09 cpd. This is true even for the complete stimulus set.

DISCUSSION

As shown in Figure 3 and 4, EG perceive sizes that are significantly larger than the CG, Results are consistent with previous studies (Modesto, 2012; Simas, et al., 2011) reported in terms of spatial frequencies that have shown a progressive increase in perceived size of PPLI by schizophrenic patients, as compared to healthy volunteers, that seems to correspond to the degree and severity of the psychotic and/or prodromal states.

INSERT FIGURE 6 ABOUT HERE

Figure 6 is an adapted summary of sizes for the first observed image from three previous studies (Modesto, 2012; Simas, et al., 2011) that have used the Dali-Simas Test with printed photographs. It illustrates the fact that controls perceive smaller images than patients with depression who, in turn, perceive smaller images than schizophrenic out-patients who, in turn, perceive smaller images than schizophrenic day-in-patients who, in turn, perceive images smaller than schizophrenic in-patients. Thus, revealing the sensitivity of the Dali-Simas Test to the severity of symptoms in prodromal or more critical states. Figures 3 (bottom) shows results from the present experiment in terms of percentage of observed frequency of sizes per degrees of visual angle for each population, for comparison with Figure 6. Figure 5 also shows data in terms of FSF suggesting that patients perceive spatial frequencies below 0.07 cpd (compare to Figure 6, right).

This preference for large magnitudes in the Dali-Simas Test is consistent with the reported alterations in processing fundamental low spatial frequencies (LSP) (Dias, et al., 2011; Graham and Meng, 2011; Kantrowitz, et al., 2009; Laprevote, et al., 2013). Our studies, however, seem to show increased sensitivity to FSF that would be in the

range of 0.075-0.050 cycles per degree (cpd) and out of the commonly investigated range (generally 0.2 cpd, rarely down to 0.1 cpd). In addition, if we hypothesize that sensitivity to brightness in schizophrenic acute or chronic states is abnormally increased, one would expect higher contrast sensitivity at fundamental LSF, as is indeed generally observed. This could be because the visual system is saturating even at low contrast levels (seen as a consequence of higher perceived brightness) across the spectrum. This also could explain the finding by Kantrowitz et al. (2009) of poor performance in the illusion of the Herman grid at high contrasts.

In addition, a study investigating paintings by schizophrenic artists (Graham and Meng, 2011) showed that the images had a high content of LSF, coherent with our findings. Further, consonant with that, the perception of hybrid stimuli with high and LSF content, by schizophrenics, rely heavily on the coarse visual information content of LSF. That is, when observing a picture, schizophrenics prefer fundamental LSF contents that would be equivalent to perceiving large/huge PPLI. In this sense, it is also relevant the fact that Uchiyama et al. (2012) did not find correlation between perceiving hallucinations and perceiving pareidolias, though they suggested that those people with DLB that see pareidolia, but do not hallucinate, may be susceptible to hallucinations. In agreement with that observation, our studies did not show correlation between the frequency of positive symptoms (in PANNS), including hallucination, and the perception of larger PPLI. Thus, we conceive our results as measuring a new and distinct kind of phenomenon in schizophrenia that resides heavily on LSF and disrupted preferred size perception.

Results from studies with the illusions of Ponzo and Muller Lyer, like those of Weckowicz et al. (1960), Pessoa et al. (2008), as well as Shoshina et al. (2011) are in

complete agreement with our current and previous results, all suggesting hypersensitivity to the very low spatial frequency spectrum of forms and objects.

Considering these results altogether, and the progressive changes we have observed, we can infer that the Dali-Simas Test might be useful as an assessment tool to be employed in the screening of neuropsychiatric patients by testing the frequency and severity of schizophrenic or psychotic symptoms in early prodromal states. Presumably by indicating a risk factor, eventually preventing a full blown psychotic episode and avoiding excessive dosages of medication. Perhaps, even avoiding the first psychotic or schizophrenic acute episode altogether.

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Author Contributions: Dr. Simas had full access to the data in the study and takes responsibility for the integrity of the data and the accuracy of data analysis.

Study concept and Design: Simas, Lacerda, Maranhão.

Acquisition of data: Maranhão, Lacerda, Menezes, Teixeira, Raposo, Modesto, Freire.

Analysis and Interpretation of data: Simas, Maranhão, Lacerda.

Drafting of the Manuscript: Simas, Lacerda, Maranhão.

Critical revision of the manuscript for important intellectual content: Simas, Lacerda, Maranhão.

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Study supervision: Simas, Maranhão.

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TABLE TITLE

Table 1. Characterization of the EG and CG in terms of age, gender and formal education.

FIGURE CAPTIONS

Figure 1. On the left, the pareidolia of a “beggar or homeless” is perceived in large size in a highway landslide; on the right, an assembled pareidolic-like image.

Figure 2. Experimental apparatus and instructions. The actual setting depended on the site where data was being collected

Figure 3. Diameter size of 1st encircled image for Dalí’s paintings by group (top graph) The differences between group was significant. Frequency of mean sizes, in degrees of visual angle, of the first images seen by volunteers in the 10 paintings of Dalí (bottom). Differences between groups are consistent across stimuli.

Figure 4. Diameter size of 1st encircled image for Dalí and Rorschach stimuli by group (top). Diameter size of 1st encircled image for Dalí without number 7 and Rorschach

without number 5 (bottom) for EG and CG. Differences between groups were significant in both cases.

Figure 5. Fundamental Spatial Frequencies for both Dalí (top) and Rorschach (centre) pictures. Notice the parallelism of the linear tendency lines. Observe that most of the FSF for EG are in the range of 0.06- 0.07cpd, and below. Spatial frequency contrast sensitivity values yet to be measured and reported in the literature (bottom).

Figure 6. Sizes of the first perceived images from previous studies (Modesto, 2012; Simas et al., 2011) both in degrees of visual angle (left) and in spatial frequency of the respective fundamentals (right). The control groups of three experiments were treated as a single group (N=66).

Table 1.

	Healthy Control Participants	Patients with Schizophrenia
Age (mean, SD)	26.44 ±9.18	34.7 ±12.9
Gender	24 male, 35 female	34 male, 25 female
Education level	85.42% High school; 14.58% incomplete fundamental	66.67% High school; 30.55% incomplete fundamental, 2.78 % no response

Figure 1

Figure 2

Figure 3

Figure 4

Figure 5

Figure 6