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Original article

Latent structure of the symptomatology of hospitalized patients with bipolar mania

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ABSTRACT

Several studies have attempted to understand the dimensions of psychiatric symptoms in manic episodes, but only a few have been able to model the latent structure of mania in bipolar disorder patients using confirmatory factor analysis. The objective of the present study was to search for the best model of the symptomatology of hospitalized manic patients. To achieve this goal, 117 manic inpatients during a manic crisis participated in this research. Exploratory factor analysis was conducted followed by confirmatory factor analysis using an exploratory factor analysis solution and three other theory-based models. The exploratory factor analysis results revealed a six-factor structure: depression, suicide, insomnia, mania, psychosis, and anxiety. This solution also presented the best fit to the data when tested with confirmatory factor analysis. A five-factor solution, without suicide as a separate dimension, appeared to be more theoretically suitable. Another important finding was that anxiety was an independent dimension in mania. Some hypotheses are discussed in light of contemporary theories, and future studies should investigate this aspect further.

1. Introduction

Until 2013, bipolar disorder was classified as a mood disorder characterized by manic and depressive episodes. This means that modern diagnostic criteria according to the International Statistical Classification of Diseases and Related Health Problems, 10th revision (ICD-10) [60], and Diagnostic and Statistical Manual of Mental Disorders, 4th edition (DSM-IV) [3], strongly relied on the definition of manic symptoms as increase on mood states other than excessive activation, such as: elation, inflated self-esteem, and excessive involvement in pleasurable activities that have a high potential for painful consequences. Regardless, the hallmark indicated by those two criteria for bipolar disorder are manic episodes as they are enough to ascertain a valid diagnosis. In 2013, the 5th edition of the DSM (DSM-V) abolished the mood disorder classification, differentiating bipolar disorder from depressive disorders [4]. Several studies have discussed the symptomatology of bipolar patients, questioning whether this classic classification relies on empirical evidence [53,54,57,55,46,35]. Based on this and other evidence, the DSM-V includes an increase in energy/activity to the same degree as mood changes when considering manic or depressive episodes in bipolar disorder [4].

Although bipolar disorder is known to present two distinct mood poles, depression and mania, evidence suggests that it is possible to find depressive symptoms in patients during manic episodes and vice versa. The DSM-IV suggested a mixed state in bipolar disorder patients [3,56,14], but to have this diagnosis, the patient needed to fulfill the diagnostic criteria of both episodes at the same time. One hypothesis in the psychiatric literature is that bipolar disorder is not a mood disorder but rather an energy/activation disorder [17,38,32,2,7], which justifies the changes in the DSM-V, which considers an increase in activity as a symptom that is as important as elation and grandiosity [4].

To show the latent structure of bipolar disorder symptomatology, several authors have used factor analysis to organize symptoms into dimensions [15,50,12,28]. One of the most used measures in clinical psychiatry to understand these symptoms is the Schedule for Affective Disorders and Schizophrenia (SADS)

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[22]. The SADS was initially proposed as a structured interview for psychiatric diagnosis based on the Research Diagnostic Criteria (RDC), measuring four dimensions of psychiatric symptoms: depression, anxiety, mania, and psychosis. A different version – called the changed version (SADS-C) – with 36 items and the same factorial structure, was suggested to help screen the severity of mental disorders in the clinical context because it presents an ordinal scale for assessing each symptom [52].

The SADS-C is an interesting measure to assess the latent structure of symptoms. Understanding the dimensions of symptoms in a disease can help focus future treatment efforts in the symptomatology found in the factor analysis. For example, Johnson et al. [35] theoretically suggested that the SADS-C shows only three dimensions: depression, mania, and schizophrenia. In manic episode patients, Swann et al. [53] used cluster analysis and found six factors: impulsivity, anxious pessimism, hyperactivity, distress appearance, anger/hostility, and psychosis. These dimensions of manic episodes are relatively well known, with the exception of anxiety. Regardless, much evidence supports the presence of anxious symptoms in manic patients [14,24,51,13].

Clusters analyses are a wide variety of techniques for deriving natural groups (or clusters) in data sets. This means that variable cluster analysis, in addition to having a more clear organization of items into groups, tends to present more clusters than exploratory factor analysis (EFA), thus decreased parsimony [23,10]. Confirmatory factor analysis (CFA) has the advantage over variable cluster analysis of allowing the testing of several theoretical hypotheses with the empirical data. Confirmatory factor analysis also permits researchers to find the most precise and parsimonious theoretical model, which is usually difficult to accomplish with variable cluster analysis [6]. Finally, CFA does not rely on distance metrics used by cluster analyses, which can be misleading on ordinal data sets [44].

Rogers et al. [46] analyzed empirical SADS-C data from two clinical samples of prison inmates using CFA. The SADS-C showed a four-factor solution in both samples: dysphoria, psychosis, mania, and insomnia. Despite the results of Rogers et al. [46], no studies of CFA have used the SADS-C to understand the underlying structure of psychiatric symptoms in bipolar disorder during a manic episode. This was the objective of the present study. We assessed different models of symptomatology based on the SADS-C using CFA in a sample of hospitalized manic patients.

2. Methods

2.1. Participants

A total of 117 manic inpatients during a manic crisis participated in this study. The study was conducted in the infirmary of the Psychiatry Institute of the Federal University of Rio de Janeiro, Brazil. Sample's characteristics are depicted on Table 1 and are similar to other studies in Brazil using hospitalized manic patients [42,11,19]. The local ethical committee approved the study, and all of the patients gave verbal consent (Table 1).

2.2. Procedures

Patients who were hospitalized from June 2010 to August 2011 were evaluated using the Mini International Neuropsychiatric Interview (MINI) [59], a structured interview that allows the formulation of psychiatric diagnoses according to the criteria of the DSM-IV [3] and ICD-10 [60], which was validated and translated to Brazilian Portuguese [5]. In cases in which the same patient was hospitalized more than once during the study period, only the first hospitalization was considered. The patients who met the criteria for an actual manic episode were administered the Brazilian version of the SADS-C [26]. Both the MINI and SADS-C were applied in the first 7 days of psychiatric hospitalization for each patient. All of the evaluators were psychiatrists who received training on the use of these tools by one of the authors (EC). The evaluators were unaware of the goals of the study. The team of evaluators was divided into two groups: some applied the MINI, and others applied the SADS-C. The evaluators did not individually administer both measures for the same patient.

Table 1
Sample's demographic data – sex, age, education, age and polarity of the first crisis, and number of hospitalizations.

Variable	Descriptive statistics *N*(%)
Sex	
Male	49 (42%)
Female	68 (58%)
Age	
$\leq$25 years old	10 (9%)
$>$25 years old	107 (91%)
Education	
Primary education	90 (77%)
Secondary or tertiary education	27 (23%)
Age of the first crisis	
$\leq$25 years old	77 (66%)
$>$25 years old	40 (34%)
Polarity of the first crisis	
Manic	67 (57%)
Depression	34 (29%)
Euthymic	1 (1%)
No information	15 (13%)
Number of hospitalizations	
$\leq$5 hospitalizations	52 (44%)
$>$5 hospitalizations	65 (56%)

2.3. Statistical analysis

Exploratory factor analysis was initially conducted to understand the factorial organization of the empirical data. The EFA extraction method, due to the ordinal nature of the SADS-C data, was based on the recommendations of Jöreskog and Moustaki [36]. The polychoric correlation matrix was used with the full-information maximum likelihood (ML) as the extraction method with oblique rotation (Promax) because the factors tended to correlate with each other. The results of the EFA were then tested using CFA alongside three other models to evaluate which is the best model to explain the empirical data: the model of Johnson et al. [35], the model of Swann et al. [53], and the model of Rogers et al. [46]. All of the analyses were conducted using LISREL 9.10 software [37]. Three fit indices and one error measurement index were considered to evaluate the models [29]: χ^2 and significance levels, goodness-of-fit index (GFI), and parsimony goodness-of-fit index (PGFI). Root mean square error of approximation (RMSEA) was used as the error index. To be acceptable, the χ^2 test should present no significant difference between the proposed model and empirical data. Values for the other two fit indices (GFI and PGFI) should be $>$ 0.95 to be considered ideal, between 0.90 and 0.95 to be considered good, and $<$ 0.90 to be considered poor. Finally, the RMSEA must be $<$ 0.05 to show that the model presents a tolerable level of errors when approximated from the empirical data [29,40].

3. Results

The initial results of the EFA was adequate based on Kaiser-Meyer-Olkin (KMO) measure of sample adequacy (0.773) – it

should be above 0.50 to be considered ideal. Data appeared to confirm the hypothesis of Swann et al. [53] of a six-factor solution. However, the structure was very different, suggesting the need for deeper analysis (i.e., CFA). The factors extracted from the EFA, despite being six and the same as the model of Swann et al. [53], were organized differently and were more similar to the structure proposed by Rogers et al. [46]. The dimensions were the following: depression (factor 1), suicide (factor 2), insomnia (factor 3), mania (factor 4), psychosis (factor 5), and anxiety (factor 6). Those factors also proved to be adequate for oblique rotations because only one pair of factors presented weak correlation—$r < 0.30$: factor 1 and factor 3 ($r = 0.28$). Table 2 depicts the six-factor solution for the SADS-C in the manic inpatient sample. The adopted criteria for excluding an item from a dimension was factor loading < 0.40 [29].

The CFA revealed that no model was capable of explaining the entire variance of the obtained data. The χ^2 test showed significant differences between all of the models and the empirical results. Identifying which model was the best among those modeled was still possible based on other fit indices. Only the EFA-extracted solution presented GFI > 0.95, and no model was ideally parsimonious (i.e., PGFI > 0.95). The same phenomenon occurred with the RMSEA, but not even the six-factor EFA solution showed RMSEA < 0.05. To judge the best model among the proposed models, the model that presented the closest results to those that were established as preferable was the six-factor EFA solution, consistent with Rogers et al. [46] and confirming the EFA results. Table 3 presents the CFA results.

Table 3
Results for the SADS-C models, including χ^2, degrees of freedom, χ^2 *P* value, goodness-of-fit index (GFI), parsimonious goodness-of-fit index (PGFI), and root mean square error of approximation (RMSEA).

Model	Confirmatory factor analysis indices					
	χ^2	*df*	*P* value	GFI	PGFI	RMSEA
Johnson et al. [9]	1289.75	659	<0.05	0.58	0.88	0.11
Rogers et al. [8]	375.98	284	<0.05	0.92	0.90	0.08
Swann et al. [4]	451.72	386	<0.05	0.83	0.81	0.09
Six-factor EFA solution	287.13	154	<0.05	0.96	0.91	0.06

4. Discussion

The objective of the present study was to understand the latent structure of the SADS-C in the evaluation of psychiatric symptoms in bipolar patients who presented a manic episode. The dimensions of bipolar disorder can be better understood, leading to a better comprehension of how psychiatric symptoms appear together or separately in manic inpatients. For this purpose, CFA was conducted after EFA to determine the best fit of the collected data. The EFA revealed a six-factor structure, likely confirming the model of Swann et al. [53]. These authors' model presented the following dimensions: impulsivity, anxious pessimism, hyperactivity, distressed appearance, anger, and psychosis. However, only two overlaps with the six-factor EFA solution were extracted in this study's sample: anxiety/anxious pessimism, and psychosis. These

Table 2
SADS-C items with factor loadings for the six-factor solution found in the present study.

SADS-C item		Factor					
		1	2	3	4	5	6
216	Negative evaluation	0.83					
217	Discouragement	0.77					
213	Depressed mood	0.68					
214	Worrying	0.66					
229	Worry: physical health	0.57					
227	Fatigue	0.54					
219	Somatic anxiety	0.52					
228	Poor appetite	0.52					
246	Depersonalization	0.48					
230	Loss of interest/anhedonia	0.44					
218	Suicidal tendencies	0.40	0.92				
248	Diurnal mood (PM)		0.48				
243	Impaired functioning		0.42				
247	Diurnal mood (AM)		0.40				
224	Initial insomnia			0.96			
226	Terminal insomnia			0.91			
223	General insomnia			0.69			
237	Increased Energy				0.82		
238	Increased activity				0.74		
235	Elated mood				0.73		
236	Less need for sleep				0.71		
239	Increased self-esteem				0.67		
231	Anger				0.55		
253	Bizarre behavior					0.91	
242	Hallucinations					0.78	
241	Delusions					0.75	
240	Distrustfulness					0.69	
221	Phobias					0.41	
220	Psychic anxiety	0.43					0.77
233	Agitation						0.68
222	Obsessions/compulsions						0.48
215	Self-reproach	0.42					0.45
225	Middle insomnia						
232	Overt irritability						
234	Psychomotor retardation						
249	Weight loss						
% of common variance explained		17.01	12.38	10.35	7.67	6.34	5.55
Eigen value		5.13	3.46	2.73	1.76	1.28	1.01

Note: factor loadings < 0.40 were not included in the table.

findings suggest that manic patients indeed show a dimension of anxiety. Some evidence supports the idea that those kind of patients present anxiety symptoms [56,32,15,24,51,13,26,36]. Not every manic patient experiences these symptoms—on the contrary this seems not a common condition; however the organization of these symptoms into one isolated factor is reasonable. Two hypotheses can be extracted from these findings with regard to anxiety:

- manic patients experience implicit anxiety caused by the manic episode itself (for more information about implicit anxiety see Egloff and Schmukle [20,49] and Filgueiras et al. [25]);
- only some manic inpatients feel anxiety caused by a confinement state during a manic crisis. Both explanations are plausible, and future studies are required to understand anxiety in mania.

The experience of some psychotic symptoms, such as delusions and hallucinations, have been reported in several studies with regard to mania in bipolar disorder [53,54,46,2,15,28,43,48]. These symptoms are presented as typical during manic crises. Nonetheless, it is not a common symptom in patients during hypomanic or depressive states [60,3,4,53,17]. Thus, psychotic symptoms are more likely to be associated with a manic state and less with other levels of energy in bipolar disorder, such as hypomania, euthymia, and depression.

4.1. The search for more parsimonious models in manic episodes

The other factors that the EFA presented were not similar to the results reported by Swann et al. [53]. Another thing that probably contributed to the presently found dissimilarity is that these authors used variable cluster analysis to extract the SADS-C dimensions, which tends to present a higher number of groups because of a clearer separation of the items into clusters, making the model less parsimonious [23,10]. Other issue in cluster analysis is that it uses distance metrics that can be misleading when grouping ordinal items or variables, whereas factor analytical techniques does not rely on those assumptions [44].

The search for a parsimonious model and use of CFA are justified for different reasons. First, the fewer parameters that a model has to explain the variance of a sample is statistically closer to reality [9]. Second, from the perspective of psychopathology, if a model has fewer symptoms, then the disease would likely be easier to identify and consequently treat [16,39]. Finally, CFA is better for searching for simpler models than other statistical techniques because it has the appropriate indices in this regard – GFI, RMSEA, PGFI, among others [29,16]. However, there still is the hypothesis of more parsimonious models do not explain the whole set of symptoms in bipolar disorder, thus its symptomatology cannot be reduced to less factor, in contrast, more factors should be considered.

Comparisons between the EFA model and more parsimonious models (i.e., Johnson's et al. [35] and Rogers et al. [46]) were attempted in the present study. Both authors suggested a depression factor and a manic factor, which were also found in the present study. Several studies suggested that manic patients do not necessarily need to show only euphoria and grandiosity symptoms. The mood change either can or cannot be toward the increase in affective expression (i.e., elation or irritability); it could alternatively be sadness or anxiety [56,17,7,1,8]. This evidence perhaps explain why the results showed correlation above 0.30 in those two dimensions, this means that some patients indeed show depressive and manic symptoms at the same time.

Regarding the six-factor EFA solution, it was consistent with the model of Rogers et al. [46] that hold an insomnia factor as well. This means that the SADS-C appears to be a good measure for detecting insomnia symptoms. Finding a manic patient with insomnia problems caused by excessive energy and agitation is not unusual, and several studies show evidence supporting it [46,30,34,48,31]. However, why did insomnia not load in the manic factor? One possible hypothesis is that manic patients do not experience insomnia the same way: some of the patients feel that they are not sleeping adequately, however, it does not matter to them; differentially, other patients are not aware of their own insomnia leading to other phenomenology as shown by Harvey et al. [30]. The present study holds a cross-sectional design, then it does not allow to be sure about the temporal evolution of insomnia symptoms. Nonetheless, it seems that the symptomatology of insomnia needs to be followed objectively for several days to be accurately measured, in contrast to other manic symptoms, such as elation, grandiosity or activity, which can be observed at the first contact with the patient. Another hypothesis about insomnia is that it could be associated with the level of severity of bipolar disorder [30]. Manic patients with lower levels of symptoms feel more insomnia than manic patients in more acute states, or vice versa. However, this statement can only be made when considering other analyses and experimental designs, such as the information curve in Item Response Theory that allows the researcher to see different levels of symptoms throughout the entire spectrum of the disease [17,47,18].

Finally, the EFA solution of the present study extracted a specific dimension to explain the variance of suicidal symptoms. This was an unexpected result because suicidal symptoms tend to appear among depressive symptoms [46,34,18,33]. To understand these results, two hypotheses could be raised:

- suicidal tendencies are an isolated dimension in psychiatric diseases and need to be separated from other symptomatology because they could appear because of several factors (e.g., aggressive behavior [39], impulsivity [55], rejection [1], pain [8], and depression [48]);
- suicide indeed loads in depression and the present study's results are misleading due to the adopted methods. Table 1 shows that one symptom—suicidal tendencies; cross-loaded with the depression factor. However, the variance of this symptom correlated better with three other symptoms – diurnal mood (AM and PM) and impaired function – which created a new dimension.

There are reports in the literature showing that suicidal ideation is indeed a symptom to be closely watched by psychiatrists in bipolar patients. Despite of seeming an expression of depressive symptoms, manic patients might show suicidal tendencies for different reasons, which explains partially this study's results [42,27]. Altogether, this is evidence of the first raised hypothesis.

An alternative explanation is that suicidal tendencies are indeed part of depression, but as factor analytical techniques for ordinal responses use polychoric correlations [36,41], those symptoms seemed empirically closer to other symptoms rather than depression that led to the appearance of a new dimension. However, all those hypotheses are not possible to be tested in a cross-sectional study such as the present research, thus further studies seem needed to investigate deeper this issue.

4.2. Testing and searching for the best model

When attempting to explain manic symptomatology, the CFA clearly presented the best results for the six-factor EFA solution found earlier. The first explanation arises from the fact that CFA was used to retest the same results extracted from the EFA; therefore, it was analyzed in the same dataset to ensure previous

statistical findings. Hair et al. [29] suggest to use bootstrapping techniques on those cases to replicate the CFA in diverse segments of the sample to test stability of the model. The present study tried to find a parsimonious model to explain variance in manic patients. This attempt perhaps is just not possible. As it was said above in this discussion, there is still the hypothesis of symptoms in bipolar disorder being too diverse to be explained in four or five factors. Despite of simpler thus more parsimonious findings from Rogers et al. [46] and Johnson et al. [35] using SADS-C to assess psychiatric symptoms, there are evidence of more complex and precise models using different measures in samples of bipolar patients reaching 10-factor solutions [45]. The model of Swann et al. [4] for manic episodes with regard to psychiatric symptoms showed the same number of dimensions as the EFA in the present study. This probably means that mania is more complex and presents more groups of symptoms than schizophrenia – which normally shows three dimensions [58]. However, the real number of dimensions in mania remains unclear.

4.3. Limitations of the study

Gathering manic inpatients for a study is difficult for any researcher. Several authors have argued that the ideal sample for CFA studies is approximately 400 subjects [5,47,18,33]. Therefore, the present study may have been limited by its sample size ($n = 117$). The present results suggest that the variance of the sample was not sufficient to adequately model manic symptomatology. Another limitation of the present study was that we did not study the different levels of mania severity. Other techniques, such as Item Response Theory [21], allow researchers to better understand the functioning of one symptom or an entire group of symptoms, depending on the theta level of the patient (i.e., the severity of the entire disease). This statistical method would be useful in future studies. Factor analysis is a set of techniques that were used in a set of cross-sectional collected data in this study, then any cause-effect conclusion, such as the relation between depression and suicidal ideation, is merely speculative.

4.4. Future directions

The present study raises three important questions about psychiatric symptoms in manic inpatients:

- which is the real latent structure of bipolar disorder? Does it change throughout samples and/or assessment measures?
- how does anxiety play a role in mania?
- does suicide depend on depression, or can it appear separately from depressive symptoms in mania (e.g., with psychosis)?

These questions remain unanswered.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

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