Published in final edited form as:

Psychiatry Res. 2016 November 30; 245: 83–90. doi:10.1016/j.psychres.2016.08.029.

The latent structure of psychiatric symptoms across mental disorders as measured with the PANSS and BPRS-18

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Abstract

Raw data were used from five studies of adults with mental illnesses ($N=4,480$) in an attempt to identify a psychiatric symptoms factor structure, as measured by the Positive and Negative Syndrome Scale or the Brief Psychiatric Rating Scale, that was generalizable across participant characteristics. First, the fit of four extant models was tested via confirmatory factor analysis (CFA), then exploratory factor analyses (EFA) were conducted with a 50% random sample, followed by a CFA with the remaining 50% to confirm the EFA factor structure. Measurement invariance of the factor structure was also examined across diagnosis, sex, race, age, and hospitalization status. The extant models were not generalizable to these data. However, a 4-factor (*Affective, Positive, Negative, Disorganized Cognitive Processing*) model was identified that retained all items and showed invariance across participant characteristics. It is possible to obtain a psychiatric symptoms factor structure that is generalizable across patient characteristics, which has clinical and research implications. Specifically, future research examining the impact of various interventions on psychiatric symptoms among adults with mental illnesses should confirm, and assuming good model-data fit, use the 4-factor model identified in this study.

Keywords

Factor structure; Between-diagnoses; Mental illness; Invariance

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Conflicts of interest and source of funding

Drs. Van Dorn, Desmarais, Grimm, Tueller, Johnson, Sellers, and Swartz all report no competing interests. The authors declare no conflicts of interest. Funding for this study was provided by the National Institute of Mental Health (NIMH), Award Number R01MH093426 (PI: Dr. Van Dorn). The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIMH or the NIH.

1. Introduction

Efforts are underway to move from categorical classifications of mental disorders to a focus on dimensions of functioning (Barch et al., 2013) that cross-cut disorders (Insel et al., 2010), such as the National Institute of Mental Health's Research Domain Criteria (RDoC). Though progress has been made in understanding biological pathways underlying dimensions of functioning (Brandon et al., 2009; Huang et al., 2010; Purcell et al., 2009), similar advances have been slower to develop for self-reported and behavioral measures. The use of psychiatric symptom assessments in both clinical practice and research studies illustrate this slower than desired progress in identifying generalizable dimensions of functioning. Specifically, psychiatric symptoms among adults with serious mental illnesses, including schizophrenia, bipolar, and major depressive disorders, are a primary target of clinically- and research-based psychopharmacological and psychosocial interventions (Mueser et al., 2002a). However, in order to evaluate the effectiveness, and generalizability, of these interventions across studies and patients, symptoms need to mean the same thing and be measured on a common metric; that is, there must be measurement invariance. Yet, an invariant model of psychiatric symptom severity, as measured via standardized research and clinical assessments, including, for example the Brief Psychiatric Rating Scale (BPRS, Overall, 1974) and the Positive and Negative Syndrome Scale (PANSS, Kay et al., 1987), which includes the 18 items from the BPRS-18, has rarely been identified for adults with mental illness (Wallwork et al., 2012). Within mixed-diagnosis samples, invariance assessments are rarely employed to test the factor structure against relevant variables, such as diagnosis and treatment setting (cf., Guy, 1976). Because of this, some studies have relied on psychiatric symptom total scores (Kane et al., 1988; McEvoy et al., 2006; Miller et al., 2005). However, latent symptom factors, not total scores, are better indicators of patient functioning and provide a more nuanced understanding of treatment effectiveness across domains of functioning (Thomas et al., 2004). Consequently, researchers also have sought to identify latent symptom factors that describe psychiatric symptoms, but this evidence is largely disorder-specific (Biancosino et al., 2010; Pacchiarotti et al., 2013; Park et al., 2015; Wallwork et al., 2012) or based on single-study designs that are often underpowered (Grimm et al., 2015).

Even within disorder-specific evaluations of symptom severity, there is only modest consensus regarding the factor structure and composition of symptoms. For example, unitary (Reininghaus et al., 2013) and multi-dimensional models with 2–11 factors (Peralta and Cuesta, 1999) have been identified when using the BPRS-18, PANSS, or other assessment instruments. There is general agreement, however, that positive and negative factors are not adequate representations of core illness states (van Os et al., 1999); most attempts to identify the factor structure of these assessment instruments result in 4- or 5-factor solutions, commonly including psychotic/positive, negative, mood, cognitive/disorganized, and activation symptoms (Wallwork et al., 2012).

Establishing an invariant psychiatric symptoms factor structure for adults with mental illness has important clinical and research implications. For example, an invariant factor structure could be used to evaluate patients' symptom change over time, regardless of any one individual's diagnosis (Sanislow et al., 2010) or course of treatment. Additionally,

psychiatric symptom factor structures may document specific areas of change or stability over time despite consistency in total scores (Thomas et al., 2004). Finally, as noted above, invariant latent factors are necessary for results to be comparable across patients and studies (Lyne et al., 2012).

2. Methods

2.1. Pooled sample

We used raw data from five studies ($N=4,480$) that had broad inclusion and minimal exclusion criteria and enrolled a range of participants, from exacerbated inpatients to partially remitted outpatients. Due to differing sampling locations and timeframes, it is unlikely that any participants were ever enrolled in more than one study.

The Facilitated Psychiatric Advance Directive Study (F-PAD; Swanson et al., 2006) investigated the implementation of a facilitated psychiatric advance directive intervention ($n=469$). Inclusion criteria were: (a) 18–65 years of age; (b) schizophrenia-spectrum or major mood disorder; and (c) currently in treatment. Data were collected between 2003 and 2007.

The MacArthur Mental Disorder and Violence Risk Study (MacRisk; Steadman et al., 1998) examined violence risk among civil psychiatric patients ($n=1,136$). Inclusion criteria were: (a) English-speaking Caucasian, African American, or Hispanic patients; (b) 18–40 years of age; and (c) schizophrenia-spectrum, depression, mania, brief reactive psychosis, delusional disorder, ‘other’ psychotic disorder, substance abuse/dependence, or personality disorder. Data were collected between 1992 and 1995.

The Schizophrenia Care and Assessment Program (SCAP; Swanson et al., 2004) examined clinical, functional, and service utilization outcomes for adults with schizophrenia ($n=404$). Inclusion criteria were: (a) 18–65 years of age; (b) schizophrenia; and (c) current service use. Data were collected between 1997 and 2002.

The MacArthur Mandated Community Treatment Study (Mac-Mandate; Monahan et al., 2005) collected data regarding experience of leverage to improve treatment adherence ($n=1,011$). Inclusion criteria were: (a) 18–65 years of age; (b) English- or Spanish-speaking; (c) current outpatient treatment; and (d) first service occurred at least 6 months prior. Data were collected between 2002 and 2003.

The Clinical Antipsychotic Trials of Intervention Effectiveness Study (CATIE; Lieberman et al., 2005) examined the effectiveness of second compared to first generation antipsychotic medication among adults with schizophrenia ($n=1,460$). Inclusion criteria were: (a) 18–65 years of age; (b) schizophrenia; and (c) ability to take oral antipsychotics. Data were collected between 2001 and 2004.

2.2. Measures

The BPRS-18 (Overall, 1974) and the PANSS (Kay et al., 1987) were used to assess psychiatric symptoms in the prior week via an anchored 7-point scale (1=*Not reported/Not*

observed or Absent to 7= Very severe or Extreme) indicating the presence and severity of symptoms observed during the interview or reported by the patient. The 18-item BPRS was used in the F-PAD, MacMandate, and MacRisk and the 30-item PANSS was used in the CATIE and SCAP; data were provided by study PIs.

The PANSS (Kay et al., 1987) is based on the 18-item BPRS and 12 additional items from the Psychopathology Rating Schedule (Singh and Kay, 1975). The 18 items shared between the PANSS and BPRS-18 are: *somatic concerns, anxiety, emotional withdrawal, conceptual disorganization, guilt feelings, tension, mannerisms and posturing, grandiosity, depressive mood, hostility, suspiciousness, hallucinatory behavior, motor retardation, uncooperativeness, unusual thought content, blunted affect, excitement, and disorientation*. The 12 additional PANSS items are: *delusions, poor rapport, passive social withdrawal, difficulty in abstract thinking, lack of spontaneity, stereotyped thinking, poor attention, lack of judgment and insight, disturbance of volition, poor impulse control, preoccupation, and active social avoidance*. All 30 items were included in our analyses.

2.3. Procedures

2.3.1. Ethics—Assessments were completed by trained research staff following a clinical interview. Study protocols were approved by relevant institutional review boards (IRBs). All participants gave written informed consent for the original studies and the Research Triangle Institute International IRB approved the current analyses.

2.3.2. Combining and imputing data—Item responses on the PANSS and the BPRS-18 were initially examined and certain response categories were combined due to low response frequency. For certain items, the high response categories were not well populated (<1% of responses for the pooled sample) and the higher response categories were combined such that at least 1% of the pooled sample responded in the highest observed category. For example, if less than 1% of the sample responded in category 7, then category 6 and 7 were combined. If this combination did not yield more than 1% of the sample, then response categories 5, 6, and 7 were combined. Approximately three-fourths (76%) of data were complete for the 30 items. Items had responses from approximately 41% or 100% of the total sample due to study; thus, data were essentially incomplete by design (McArdle, 1994). Twenty imputed datasets were generated and the imputation model contained all BPRS-18 and PANSS items and no auxiliary variables. Multiple imputation was carried out using Bayesian analysis (Rubin, 2004; Schafer, 1997) with an unrestricted model. In this approach, a Markov chain is constructed that is long enough for the distribution to stabilize to a common distribution. Once the distribution is stabilized, a draw is taken, which yields a dataset with complete values. Imputations were carried out using *Mplus*, and the ordinal nature of the BPRS-18 and PANSS items was accounted for using an ordered logistic model, in which an underlying normal continuous latent variable is assumed (see Sections 2.1 and 3.1 of Asparouhov and Muthén (2010)). Factor models were fit separately to each dataset. The reported estimates are the mean over the 20 imputed datasets and the reported standard errors account for both within-imputation (i.e., mean standard error across imputations) and between-imputation variability (i.e., variability in point estimates across imputations).

2.4. Analysis

We used CFA, with a probit link and the WLSMV estimator in *Mplus*, to evaluate the fits of the extant factor analytic models to the integrated data. Next, we conducted EFAs with a 50% random sample of the data. This step was important because the extant models only demonstrated poor to adequate fit and some of the proposed models removed several items from their published solutions. EFAs with one to eight factors were fit. Rotation criteria were examined and Geomin (Oblique) rotation was utilized. A CFA model with the remaining 50% of our data was used to confirm the EFA structure. Finally, we examined the measurement invariance of our final factor structure across psychiatric disorder, sex, race/ethnicity, age, and hospitalization status within three months of the baseline assessment. A *configural* invariance model was fit by the same factor structure across groups (i.e., same location of estimated and fixed factor loadings). This model was evaluated with absolute and incremental fit indices. If the *configural* model represents the data well, then the groups have the same number of factors and the factors are similarly defined. A *metric* invariance model was then fit by constraining estimated factor loadings to be equivalent across groups. The fit of this model was evaluated based on absolute and incremental fit indices and in comparison to the *configural* model. If the *metric* invariance model represents the data well, then the factors have the same meaning across groups and the differences in the factors account for all of the differences in the covariance structure across groups. A *scalar* invariance model was then fit by constraining the threshold parameters to be equivalent across groups (Widaman and Reise, 1997). As with the metric invariance model, the fit of this model was evaluated based on incremental and absolute fit indices and in comparison to the metric and configural invariance models. If the *scalar* invariance model represents the data, then the factors have the same meaning and scale across groups and the factors account for all of the differences in both the mean and covariance structure across groups.

3. Results

3.1. Demographics

Almost two-thirds of participants were male (59.8%). About half (51.4%) were white, one-third (37.7%) black, 7.1% Hispanic, and 3.9% other race/ethnicity. Age ranged between 18 and 71 years ($M=38.97$; $SD=11.30$). Schizophrenia was the most prevalent diagnosis (63.5%), followed by depression (18.4%), bipolar (9.6%), substance use (6.1%), and other disorders (2.5%; e.g., anxiety). Over one-third of participants (39.6%) had been hospitalized within three months of the baseline assessment.

3.2. Comparison of model fit

White and colleagues' (1997) model showed adequate fit (see Table 1), but had six item loadings less than 0.200. van der Gaag et al.'s (2006) model also showed adequate fit, but had nine item loadings less than 0.200. Overall et al.'s (1967) model showed poor fit, but the majority of factor loadings were strong (>0.470). However, the *Extropunitiveness/Intropunitiveness* and *Thought Disturbance* factors were correlated 0.985, indicating overextraction of factors. Shafer's (2005) model showed marginal to poor fit with two weak factor loadings. Additionally, the *Positive* and *Resistance* factors correlated 0.989, again indicating overextraction of factors.

3.3. Factor structure

Given the poor to adequate fit of extant models to our data, we proceeded to examine the factor structure of our integrated data, as described above. The eigenvalues and associated scree plot, as well as a parallel analysis (Horn, 1965), suggested four factors should be retained. Absolute and global fit indices also suggested that four factors were sufficient (CFI=0.949, RMSEA=0.067, TLI=0.931).

The factor loading pattern from the 4-factor model is presented in the upper portion of Table 2. The four factors were not highly correlated, as seen in the lower portion of Table 2. The strongest correlation was between the *Positive* and *Disorganized Cognitive Processing* factors (.342).

A CFA model constructed from this four-factor EFA model was then fit to the remaining 50% random sample. Bolded (i.e., >0.300) factor loadings in Table 2 were estimated and the remaining factor loadings were set to 0, with the exception of disorientation and difficulty in abstract thinking on the *Negative* factor, which were included because their respective cross-loadings onto the *Disorganized Cognitive Processing* factor were only slightly higher. The resultant model fit (CFI=0.911, RMSEA=0.081, TLI=0.900) was degraded slightly from the EFA due to these constraints, but the factor loadings (upper part of Table 3) held with three exceptions: hostility, lack of spontaneity and flow of conversation, and poor rapport failed to load on the *Disorganized Cognitive Processing* factor. Factor intercorrelations (lower part of Table 3) were stronger than their estimated values from the EFA, which was expected because many small, but significant factor loadings, were set to 0. Notably, the correlation between the *Positive* and *Negative* factors was 0.515, the correlation between the *Positive* and *Disorganized Cognitive Processing* was 0.710, and the correlation between the *Negative* and *Disorganized Cognitive Processing* was 0.690. A final CFA was fit to the entire dataset with the factor loadings from the *Disorganized Cognitive Processing* factor to hostility, lack of spontaneity and flow of conversation, and poor rapport fixed at 0. The fit of this model was good (CFI=0.915, RMSEA=0.078, TLI=0.906) and was utilized in subsequent analyses to assess measurement invariance.

3.4. Measurement invariance

Measurement invariance was tested by fitting the configural, metric, and scalar measurement invariance models in the multiple group structural equation modeling framework with psychiatric disorder, sex, race/ethnicity, age, or hospitalization status within three months as grouping variables. The fit of these three models were compared to determine what level of invariance was achieved. Typical approaches to model comparisons (e.g., chi-square difference tests) are not available because we used the WLSMV estimator. With WLSMV, *Mplus* recommends the use of the DIFFTEST (Muthén and Muthén, 2010); however, this option is not available with multiply imputed data. Therefore, we examined the global fit indices (i.e., RMSEA, CFI, TLI) when making model comparisons, but recognize that there is no standard for examining changes in these fit indices. The fit indices for the configural, metric, and scalar measurement invariance models are presented in Table 4.

3.4.1. Primary diagnosis invariance—Factorial invariance was first studied with respect to primary psychiatric diagnosis, which was a four-level variable. The four groups were schizophrenia-spectrum, bipolar disorder, depression, and other. The global fit indices generally improved when moving to higher levels of invariance (e.g., scalar), suggesting that the same factors measured in the same scale were present in each group. In the scalar invariance model, the fit was adequate based on typically used cut-offs for the RMSEA (i.e., <0.08) and TLI (>0.90). Table 5 presents the estimated factor means by participant characteristics. Compared with the schizophrenia-spectrum group, all other groups had, on average, elevated *Affective* factor scores; other mean differences were non-significant.

3.4.2. Hospitalization status invariance—In the sample, 2,692 participants had not been recently hospitalized and 1,772 participants had been recently hospitalized. The fit of the three invariance models were adequate and the metric and scalar invariance models were generally preferred compared to the configural invariance model based on absolute fit indices. The fit of the scalar invariance model was slightly degraded from the metric invariance model based on the CFI, but the TLI and RMSEA were nearly identical suggesting the move from metric to scalar invariance did not deteriorate model fit. Thus, the four factors have the same meaning in the same metric across hospitalization status.

3.4.3. Sex invariance—Factorial invariance was then examined with respect to sex and as before, the model fit generally improved when moving to higher levels of invariance and the fit of the scalar invariance model was adequate. Thus, there is support for the same factors measured in the same metric across sex.

3.4.4. Race/ethnicity invariance—Race/ethnicity was a three-level variable with participants identified as white, African American, and Hispanic. The fit statistics all favored the scalar invariance and the overall fit of the scalar invariance model was good supporting the idea that the same factors measured in the same scale were present across race/ ethnicity.

3.4.5. Age invariance—Age was split at 40 years, with 1,979 participants who were older than 40 years of age and 2,485 participants who were 40 years of age or younger. The fit statistics favored the metric and scalar invariance over the configural invariance model and the TLI and RMSEA favored the scalar invariance model over the metric invariance model. Thus, we interpret the scalar invariance model, which supports the notion that the four factors have the same meaning in the same metric across these age groups.

4. Discussion

We identified a four-factor (*Affective, Positive, Negative, Disorganized Cognitive Processing*) model through a split half EFA/CFA that retained all items. We had no primary item loadings less than 0.300, few between-factor cross-loadings, and no between-factor correlations suggesting factor overextraction. As suggested by prior research, our results demonstrated that positive and negative factors alone are not suitable representations of illness states—indeed, over half of the items loaded onto other factors. Still, our factor model differed from extant models in some respects. For instance, our *Disorganized Cognitive Processing* factor included items (i.e., poor impulse control, excitement, mannerisms and

posturing, tension) that have loaded across a range of factors in other studies, including *Excited, Hostile, Depressed, Anxious, Disorganized, Concrete, or Cognitive* latent structures (Wallwork et al., 2012). Together, the items that load onto this factor involve cognitive processes (e.g., conceptual disorganization) and overt expressions or behaviors (e.g., tension), both of which have been shown to be related to executive functioning (Johnson-Selfridge and Zalewski, 2001) and more general ‘real-world’ functioning and behavior (Bowie et al., 2006). Additionally, our *Affective* factor, which shares similarities in structure to the affect factor identified by Mueser and colleagues (1997), contained both internalizing (e.g., anxiety) and externalizing (e.g., hostility) items; this mix of items has usually loaded on separate factors. However, our affective factor, like Mueser and colleagues’, makes clinical sense when considered, for example, from the perspective of post-traumatic responses and the interrelationship with violent events. That is, it is well established that adults with mental illness are involved in both historical (Swanson et al., 2002) and recent (Desmarais et al., 2014; Van Dorn et al., 2012) violent events, including suicide attempts (Johnson et al., 2015), at rates higher than found in the general population, and that shared risk factors underlie these events. Moreover, a key factor in the higher risk of violent events among those with mental illness is hypothesized to be increased affective symptoms (Van Dorn et al., 2015a, 2015b), and underlying the relationship between violent events and affective symptoms is likely trauma, posttraumatic stress disorder, substance use, and other exacerbated symptomatology (Mueser et al., 2002b).

Importantly, our results were obtained without the statistical and methodological limitations present in some prior factor analytic studies on psychiatric symptom data. For example, we tested the fits of two extant BPRS (Overall et al., 1967; Shafer, 2005) and two PANSS (van der Gaag et al., 2006; White et al., 1997) models using CFA on our data. These extant models demonstrated only poor to adequate fit in our data. Furthermore, some of these prior models had eliminated poor fitting items from their published solutions, which increased their model-data fit, but also removed important sources of information about psychiatric symptoms. Beyond the issue of removing poorly fitting items, however, other limitations associated with these prior solutions were avoided in our analyses. For example, White et al.’s (1997) fit a CFA to the same split half upon which they had run the EFA and found that model fit remained poor. Multiple items were allowed to have dual loadings or allowed to have correlated unique factors before adequate data-model fit was obtained. As another example, van der Gaag et al.’s (2006) cross-validation approach likely violated the original nature of the approach (Efron and Tibshirani, 1993), making it exploratory rather than a computationally intensive validation method. In efforts to modify their CFA, they freed factor loadings and unique covariances in both forward and backward approaches, which capitalized on chance. They also conducted a follow-up CFA on the full sample based on the model *derived*, and not *estimated*, in an earlier step. Finally, the majority of existing psychiatric symptom latent structures have been identified from data incorrectly specified as continuous (Grimm et al., 2015). However, response options for psychiatric symptom assessment instruments comprise ordered categorical variables, which tend to produce skewed data; emerging research supports the importance of treating ordinal data as such (Grimm et al., 2015), especially when data have few categories or are highly skewed (Rhemtulla et al., 2012).

We also tested the *configural*, *metric*, and *scalar* measurement invariance of our model across participant characteristics, which to our knowledge has not been done in prior research on mixed-diagnosis samples. Results indicated that the latent variables had the same meaning and were measured on the same scale across a variety of patient characteristics. We note that the fit of our recommended factor model showed slight differential fit across various groupings, especially with respect to the TLI and CFI (e.g., model fit was slightly worse for hospitalization status and psychiatric disorder based on the TLI and CFI). These fit indices are generally worse when correlations among observed variables are smaller and certain groupings of participants create more homogenous groups. Still, our study advances research through a systematic exploration and identification of a generalizable factor structure of core psychiatric symptom severity as measured with the BPRS-18 and PANSS, which holds implications for both practice and research.

A generalizable factor structure may afford clinicians the opportunity to monitor treatment effectiveness and patients' illness trajectories over time. Building on research that has examined the relationship between psychological symptoms and clinical global impression ratings (Leucht et al., 2005), our factor structure could be used to evaluate clinically significant changes in the underlying dimensions of functioning (Kazdin, 1999). Specifically, factor scores may be obtained by summing the individual items (Rhoades and Overall, 1988) in any given factor to create a factor-specific total score. In clinical practice, the amount of missing items should be minimal, compared to for example, research studies, where missing data may be more prevalent. If there are larger amounts of missing data (i.e., greater than 20% of items per factor), the factor should be omitted; practically speaking, this means more than one item missing from the *Affective*, *Positive*, or *Negative* factors, and more than two items missing from the *Disorganized Cognitive Processing* factor. Our identified factors may provide a more nuanced and meaningful picture of patient functioning than afforded by reliance on total scores and may allow for the targeting and evaluation of treatments across disorders and dimensions of functioning. As such, future research should test the fit of our model in other diverse samples.

We also believe that research would benefit from a stronger focus on pooling data (Curran, 2009). Even though there is an abundance of research on psychiatric symptoms in adults with mental illness, conclusions are typically based on single-study and single-diagnosis designs that are often underpowered with limited generalizability (MacCallum et al., 1999). Because of a longstanding focus on single-study designs that are frequently underpowered, it has been argued that the majority of published research findings are false (Ioannidis, 2005); and even 'true' associations are frequently inflated, which affects subsequent studies when powered to the original study (Ioannidis, 2008). So even though there is an abundance of research on psychiatric symptoms, the majority of our current knowledge has been gleaned from these single-study designs with few efforts to pool smaller samples into larger integrated data sources (Grimm et al., 2015). Pooled data approaches are viewed as one way to minimize false research findings (Ioannidis, 2005) and advance a field's cumulative knowledge (Curran, 2009). By integrating data, allowing for diagnostic heterogeneity in the pooled sample, and focusing on dimensions of functioning, researchers will be better positioned to understand how various domains are expressed across disorders—for example, from genes to self-reports as identified in the RDoC (Cuthbert and Insel, 2010). To our

knowledge, this study is the first effort to pool raw data from studies using multiple instruments to assess psychiatric symptoms across multiple diagnoses.

Still, this study has limitations. First, data on interrater reliability was not available in the parent studies, though descriptions of interviewer training are provided elsewhere (Steadman et al., 1998; Stroup et al., 2003). Second, we multiply imputed data. However, across our 20 imputations, our percent efficiency was near 100 (Schafer and Olsen, 1998) given the low amount of incomplete data in the parent studies and our number of imputations. Specifically, only 23% of all 30 items had missing data. Our approach to imputing data has been shown to be valid with up to 60% of data missing (Barzi and Woodward, 2004). Moreover, we argue that our use of the multiply imputed datasets increases the validity of the data on which our findings were based. That is, the sparseness of certain response categories, particularly towards the more severe end of the scale, and which given the distribution of psychiatric symptoms is likely present in all data sources, substantially impacts the stability and validity of the estimated polychoric correlation matrix, which can then result in unstable and non-replicable factor solutions that create downward biases on and variability of model fit, particularly as sample size decreases (Grimm et al., 2015). Our analysis of multiply imputed data minimized this likelihood. Third, while there was heterogeneity across patients' primary mental health diagnoses, almost two-thirds of participants were diagnosed with schizophrenia; a more balanced distribution of diagnoses should be explored in future research. That is, given the ordinal nature of psychiatric symptom data, the number of items contained in each assessment, and number of factors extracted, adequate numbers of "cases" are needed in each response category to test invariance across patient characteristics. The current paper represents, to our knowledge, the first effort to evaluate the configural, metric, and scalar invariance of psychiatric symptom data in a pooled and mixed-diagnosis sample of adults with mental illnesses. Still, more balance, with a suitably large sample, across primary diagnoses may allow for the examination of other patient characteristics, like stage of illness (e.g., prodromal, transitional, chronic). Fourth, while we selected four extant models to evaluate in our initial CFA, there are numerous other models that could have been evaluated. Still, our selection of these prior models was based on their identification by the instrument authors (Overall et al., 1967) and in the case of Overall and colleagues' solution, it is the most widespread sub-scale structure associated with the BPRS (cf., Shafer, 2005). The remaining extant models are a recognized scoring system for the instrument (White et al., 1997) and were identified through large-scale research, and thus not likely impacted by the small sample size concerns noted earlier (Shafer, 2005; van der Gaag et al., 2006). Fifth, and finally, we only included data from the BPRS-18 and PANSS. As such, our findings should be considered in light of any weaknesses intrinsic to these two scales generally (e.g., imbalance in the number of items assessing each latent construct) and their items more specifically (e.g., lack of suicidality item). While the 18 items shared between the two instruments, and the 12 additional items contained within the PANSS, provide a broad pool of items, a larger pool of items from which to draw might provide even more nuance about latent psychiatric symptomatology. For example, expanded versions of the BPRS are increasingly used by clinicians and researchers and include additional items such as suicidality and self-neglect (Lukoff et al., 1986).

4.1. Conclusions

Invariant psychiatric symptoms across patient subgroups are necessary for results to be comparable across studies and for the between-diagnosis evaluation of treatment outcomes. We believe the current research, along with other efforts, for example, that have modeled the latent structure of posttraumatic symptoms as being model- or population-dependent (Shevlin and Elklit, 2012), are an important step in the direction of between-study and between-disorder comparability and are in-line with the RDoC's goal of developing valid (Sanislow et al., 2010), non-nominally measured (Cuthbert and Insel, 2013) indicators of the dimensions of functioning underlying mental illnesses. To the extent that clinical (e.g., substance use), social (e.g., role functioning), and interpersonal (e.g., violence) outcomes are significantly affected by or significantly affect psychiatric symptoms, the relevance of symptom identification and management across mental disorders becomes clear. Findings from the current study can be used to inform this important and ongoing work.

Acknowledgments

Funding for this study was provided by the National Institute of Mental Health (NIMH), Award Number R01MH093426 (PI: Dr. Van Dorn).

This paper was based on results from the Facilitated Psychiatric Advance Directive (F-PAD) project, supported with Federal funds from the NIMH through research grant R01MH063949 and also was supported by the John D. and Catherine T. MacArthur Foundation Research Network on Mandated Community Treatment (PI: Jeffrey W. Swanson, Ph.D.); results from the MacArthur Mental Disorder and Violence Risk (MacRisk) project, supported with funds from the Research Network on Mental Health and the Law of the John D. and Catherine T. MacArthur Foundation, Chicago, Ill, and by NIMH grant R0149696 (PI: John Monahan, Ph.D.); results from the Schizophrenia Care and Assessment Program (SCAP) project, supported with funds from Eli Lilly, Inc., through a contract with the MedStat Group (PI: Jeffrey W. Swanson, Ph.D.); results from the MacArthur Mandated Community Treatment (MacMandate) project, supported with funds from the John D. and Catherine T. MacArthur Foundation Research Network on Mandated Community Treatment (PI: John Monahan, Ph.D.); and results from the Clinical Antipsychotic Trials of Intervention Effectiveness (CATIE) project, supported with Federal funds from the National Institute of Mental Health under contract NO1MH90001.

References

- Asparouhov T, Muthén B. Multiple Imputation with Mplus. Mplus Web Notes. 2010
- Barch DM, Bustillo J, Gaebel W, Gur R, Heckers S, Malaspina D, Owen MJ, Schultz S, Tandon R, Tsuang M. Logic and justification for dimensional assessment of symptoms and related clinical phenomena in psychosis: relevance to DSM-5. *Schizophr Res.* 2013; 150(1):15–20. [PubMed: 23706415]
- Barzi F, Woodward M. Imputations of missing values in practice: results from imputations of serum cholesterol in 28 cohort studies. *Am J Epidemiol.* 2004; 160(1):34–45. [PubMed: 15229115]
- Biancosino B, Picardi A, Marmai L, Biondi M, Grassi L. Factor structure of the Brief Psychiatric Rating Scale in unipolar depression. *J Affect Disord.* 2010; 124(3):329–334. [PubMed: 20053458]
- Bowie CR, Reichenberg A, Patterson TL, Heaton RK, Harvey PD. Determinants of real-world functional performance in schizophrenia subjects: correlations with cognition, functional capacity, and symptoms. *Am J Psychiatry.* 2006; 163(3):418–425. [PubMed: 16513862]
- Brandon NJ, Millar JK, Korth C, Sive H, Singh KK, Sawa A. Understanding the role of DISC1 in psychiatric disease and during normal development. *J Neurosci.* 2009; 29(41):12768–12775. [PubMed: 19828788]
- Curran PJ. The seemingly quixotic pursuit of a cumulative psychological science: introduction to the special issue. *Psychol Methods.* 2009; 14(2):77–80. [PubMed: 19485622]
- Cuthbert BN, Insel TR. Toward new approaches to psychotic disorders: the NIMH Research Domain Criteria project. *Schizophr Bull.* 2010; 36(6):1061–1062. [PubMed: 20929969]

- Cuthbert BN, Insel TR. Toward the future of psychiatric diagnosis: the seven pillars of RDoC. *BMC Med.* 2013; 11(1):126. [PubMed: 23672542]
- Desmarais SL, Van Dorn RA, Johnson KL, Grimm KJ, Douglas KS, Swartz MS. Community violence perpetration and victimization among adults with mental illnesses. *Am J Public Health.* 2014; 0:e1–e8.
- Efron, B.; Tibshirani, RJ. *An Introduction to the Bootstrap.* Chapman & Hall; New York: 1993.
- Grimm, KJ.; Tueller, SJ.; Sellers, BG.; Desmarais, SL.; Swartz, MS.; Van Dorn, RA. The latent structure of psychiatric symptoms and the implications of sample size and distributional assumptions. Proceedings of Symposium presented at the American Psychology-Law Society Conference; San Diego, CA. 2015.
- Guy, W. *ECDEU Assessment Manual for Psychopharmacology*, revised. U.S. Department of Health and Human Services; Rockville, MD: 1976.
- Horn JL. A rationale and test for the number of factors in factor analysis. *Psychometrika.* 1965; 30(2): 179–185. [PubMed: 14306381]
- Huang J, Perlis RH, Lee PH, Rush AJ, Fava M, Sachs GS, Lieberman J, Ha-milton SP, Sullivan P, Sklar P. Cross-disorder genomewide analysis of schizophrenia, bipolar disorder, and depression. *Am J Psychiatry.* 2010; 167(10):1254–1263. [PubMed: 20713499]
- Insel T, Cuthbert B, Garvey M, Heinssen R, Pine DS, Quinn K, Sanislow C, Wang P. Research domain criteria (RDoC): toward a new classification framework for research on mental disorders. *Am J Psychiatry.* 2010; 167(7):748–751. [PubMed: 20595427]
- Ioannidis JP. Why most published research findings are false. *PLoS Med.* 2005; 2(8):e124. [PubMed: 16060722]
- Ioannidis JP. Why most discovered true associations are inflated. *Epidemiology.* 2008; 19(5):640–648. [PubMed: 18633328]
- Johnson-Selfridge M, Zalewski C. Moderator variables of executive functioning in schizophrenia: Meta-analytic findings. *Schizophr Bull.* 2001; 27(2):305. [PubMed: 11354597]
- Johnson, KL.; Desmarais, SL.; Tueller, SJ.; Grimm, KJ.; Swartz, MS.; Van Dorn, RA. Longitudinal typologies of violence and victimization in adults with mental illnesses: a latent transition analysis. Proceedings of Symposium presented at the American Psychology-Law Society Conference; San Diego, CA. 2015.
- Kane J, Honigfeld G, Singer J, Meltzer H. Clozapine for the treatment-resistant schizophrenic: a double-blind comparison with chlorpromazine. *Arch Gen Psychiatry.* 1988; 45(9):789. [PubMed: 3046553]
- Kay SR, Flszbein A, Opfer LA. The positive and negative syndrome scale (PANSS) for schizophrenia. *Schizophr Bull.* 1987; 13(2):261. [PubMed: 3616518]
- Kazdin AE. The meanings and measurement of clinical significance. *J Consult Clin Psychol.* 1999; 67(3):332–339. [PubMed: 10369053]
- Leucht S, Kane JM, Kissling W, Hamann J, Etschel E, Engel RR. What does the PANSS mean? *Schizophr Res.* 2005; 79(2):231–238. [PubMed: 15982856]
- Lieberman JA, Stroup TS, McEvoy JP, Swartz MS, Rosenheck RA, Perkins DO, Keefe RS, Davis SM, Davis CE, Lebowitz BD. Effectiveness of anti-psychotic drugs in patients with chronic schizophrenia. *N Engl J Med.* 2005; 353(12):1209–1223. [PubMed: 16172203]
- Lukoff D, Nuechterlein K, Ventura J. Appendix A: manual for the expanded BPRS. *Schizophr Bull.* 1986; 12(4):594–602.
- Lyne JP, Kinsella A, O'Donoghue B. Can we combine symptom scales for collaborative research projects? *J Psychiatr Res.* 2012; 46(2):233–238. [PubMed: 22056401]
- MacCallum RC, Widaman KF, Zhang S, Hong S. Sample size in factor analysis. *Psychol Methods.* 1999; 4(1):84–99.
- McArdle JJ. Structural factor analysis experiments with incomplete data. *Multivar Behav Res.* 1994; 29(4):409–454.
- McEvoy J, Lieberman J, Stroup T, Davis S, Meltzer H, Rosenheck R, Swartz M, Perkins D, Keefe R, Davis C. Effectiveness of clozapine versus olanzapine, quetiapine, and risperidone in patients with chronic schizophrenia who did not respond to prior atypical antipsychotic treatment. *Am J Psychiatry.* 2006; 163(4):600–610. [PubMed: 16585434]

- Miller DD, McEvoy JP, Davis SM, Caroff SN, Saltz BL, Chakos MH, Swartz MS, Keefe RS, Rosenheck RA, Stroup TS. Clinical correlates of tardive dyskinesia in schizophrenia: baseline data from the CATIE schizophrenia trial. *Schizophr Res.* 2005; 80(1):33–43. [PubMed: 16171976]
- Monahan J, Redlich AD, Swanson J, Robbins PC, Appelbaum PS, Petrila J, Steadman HJ, Swartz M, Angell B, McNeil DE. Use of leverage to improve adherence to psychiatric treatment in the community. *Psychiatr Serv.* 2005; 56(1):37–44. [PubMed: 15637190]
- Mueser KT, Corrigan PW, Hilton DW, Tanzman B, Schaub A, Gingerich S, Essock SM, Tarrier N, Morey B, Vogel-Scibilia S. Illness management and recovery: a review of the research. *Psychiatr Serv.* 2002a; 53(10):1272–1284. [PubMed: 12364675]
- Mueser KT, Curran PJ, McHugo GJ. Factor structure of the Brief Psychiatric Rating Scale in schizophrenia. *Psychol Assess.* 1997; 9(3):196.
- Mueser KT, Rosenberg SD, Goodman LA, Trumbetta SL. Trauma, PTSD, and the course of severe mental illness: an interactive model. *Schizophr Res.* 2002b; 53(1):123–143. [PubMed: 11728845]
- Muthén, L.K.; Muthén, B.O. *Mplus: Statistical Analysis with Latent Variables: User's guide.* Muthén & Muthén; 2010.
- Overall, JE. The Brief Psychiatric Rating Scale in psychopharmacology research. In: Pichot, P.; Olivier-Martin, R., editors. *Psychological Measurements in Psychopharmacology: Modern problems in Psychopharmacology.* Karger; Oxford, England: 1974. p. 67-78.
- Overall JE, Hollister LE, Pichot P. Major psychiatric disorders: a four-dimensional model. *Arch Gen Psychiatry.* 1967; 16(2):146. [PubMed: 6019329]
- Pacchiarotti I, Nivoli A, Mazzarini L, Kotzalidis GD, Sani G, Koukopoulos A, Scott J, Strejilevich S, Sánchez-Moreno J, Murru A. The symptom structure of bipolar acute episodes: In search for the mixing link. *J Affect Disord.* 2013; 149(1):56–66. [PubMed: 23394711]
- Park SC, Jang EY, Kim D, Jun TY, Lee MS, Kim JM, Kim JB, Jo SJ, Park YC. Dimensional approach to symptom factors of major depressive disorder in Koreans, using the Brief Psychiatric Rating Scale: the Clinical Research Center for Depression of South Korea Study. *Kaohsiung J Med Sci.* 2015; 31(1):47–54. [PubMed: 25600920]
- Peralta V, Cuesta MJ. Dimensional structure of psychotic symptoms: an item-level analysis of SAPS and SANS symptoms in psychotic disorders. *Schizophr Res.* 1999; 38(1):13–26. [PubMed: 10427607]
- Purcell SM, Wray NR, Stone JL, Visscher PM, O'Donovan MC, Sullivan PF, Sklar P, Ruderfer DM, McQuillin A, Morris DW. Common polygenic variation contributes to risk of schizophrenia and bipolar disorder. *Nature.* 2009; 460(7256):748–752. [PubMed: 19571811]
- Reininghaus U, Priebe S, Bentall RP. Testing the psychopathology of psychosis: evidence for a general psychosis dimension. *Schizophr Bull.* 2013; 39(4):884–895. [PubMed: 22258881]
- Rhemtulla M, Brosseau-Liard PE, Savalei V. When can categorical variables be treated as continuous? A comparison of robust continuous and categorical SEM estimation methods under suboptimal conditions. *Psychol Methods.* 2012; 17(3):354–373. [PubMed: 22799625]
- Rhoades H, Overall J. The semistructured BPRS interview and rating guide. *Psychopharmacol Bull.* 1988; 24(1):101. [PubMed: 3290934]
- Rubin, DB. *Multiple Imputation for Nonresponse in Surveys.* John Wiley & Sons; Hoboken, New Jersey: 2004.
- Sanislow CA, Pine DS, Quinn KJ, Kozak MJ, Garvey MA, Heinssen RK, Wang PSE, Cuthbert BN. Developing constructs for psychopathology research: research domain criteria. *J Abnorm Psychol.* 2010; 119(4):631–639. [PubMed: 20939653]
- Schafer, JL. *Analysis of Incomplete Multivariate Data.* CRC press; Boca Raton, Florida: 1997.
- Schafer JL, Olsen MK. Multiple imputation for multivariate missing-data problems: a data analyst's perspective. *Multivar Behav Res.* 1998; 33(4):545–571.
- Shafer A. Meta-analysis of the brief psychiatric rating scale factor structure. *Psychol Assess.* 2005; 17(3):324–335. [PubMed: 16262458]
- Shevlin M, Elklit A. The latent structure of posttraumatic stress disorder: different models or different populations? *J Abnorm Psychol.* 2012; 121(3):610–615. [PubMed: 22686869]
- Singh MM, Kay SR. A comparative study of haloperidol and chlorpromazine in terms of clinical effects and therapeutic reversal with benztropine in schizophrenia. Theoretical implications for

- potency differences among neuroleptics. *Psychopharmacologia*. 1975; 43(2):103–113. [PubMed: 1103205]
- Steadman HJ, Mulvey EP, Monahan J, Robbins PC, Appelbaum PS, Grisso T, Roth LH, Silver E. Violence by people discharged from acute psychiatric inpatient facilities and by others in the same neighborhoods. *Arch Gen Psychiatry*. 1998; 55(5):393–401. [PubMed: 9596041]
- Stroup TS, McEvoy JP, Swartz MS, Byerly MJ, Glick ID, Canive JM, McGee MF, Simpson GM, Stevens MC, Lieberman JA. The national institute of mental health clinical antipsychotic trials of intervention effectiveness (CATIE) project. *Schizophr Bull*. 2003; 29(1):15–31. [PubMed: 12908658]
- Swanson J, Swartz M, Elbogen E, Van Dorn R, Ferron J, Wagner H, McCauley B, Kim M. Facilitated psychiatric advance directives: a randomized trial of an intervention to foster advance treatment planning among persons with severe mental illness. *Am J Psychiatry*. 2006; 163(11):1943–1951. [PubMed: 17074946]
- Swanson JW, Swartz MS, Elbogen EB. Effectiveness of atypical anti-psychotic medications in reducing violent behavior among persons with schizophrenia in community-based treatment. *Schizophr Bull*. 2004; 30(1):3. [PubMed: 15176758]
- Swanson JW, Swartz MS, Essock SM, Osher FC, Wagner HR, Goodman LA, Rosenberg SD, Meador KG. The social-environmental context of violent behavior in persons treated for severe mental illness. *Am J Public Health*. 2002; 92(9):1523–1531. [PubMed: 12197987]
- Thomas A, Donnell AJ, Young TR. Factor structure and differential validity of the expanded Brief Psychiatric Rating Scale. *Assessment*. 2004; 11(2):177–187. [PubMed: 15171466]
- van der Gaag M, Hoffman T, Remijnsen M, Hijman R, de Haan L, van Meijel B, van Harten PN, Valmaggia L, De Hert M, Cuijpers A. The five-factor model of the Positive and Negative Syndrome Scale II: a ten-fold cross-validation of a revised model. *Schizophr Res*. 2006; 85(1):280–287. [PubMed: 16730429]
- Van Dorn R, Volavka J, Johnson N. Mental disorder and violence: is there a relationship beyond substance use? *Soc Psychiatry Psychiatr Epidemiol*. 2012; 47(3):487–503. [PubMed: 21359532]
- Van Dorn, RA.; Desmarais, SL.; Grimm, KJ.; Tueller, SJ.; Swartz, MS. The role of psychopharmacological medication and routine outpatient care in the reduction of violent encounters among adults with mental illnesses. *Proceedings of Paper Presented at the International Association of Forensic Mental Health Services Conference; Manchester, England*. 2015a.
- Van Dorn, RA.; Grimm, KJ.; Desmarais, SL.; Tueller, SJ.; Johnson, KL.; Swartz, MS. Cross-lagged relationships between violent behaviors, substance use, and psychiatric symptoms in adults with mental illnesses. *Symposium presented at the American Psychology-Law Society Conference; San Diego, CA*. 2015b.
- van Os J, Gilvarry C, Bale R, Van Horn E, Tattan T, White I, MURRAY ON. BEHALF OF THE UK 700 GROUP R. A comparison of the utility of dimensional and categorical representations of psychosis. *Psychol Med*. 1999; 29(3):595–606. [PubMed: 10405080]
- Wallwork R, Fortgang R, Hashimoto R, Weinberger D, Dickinson D. Searching for a consensus five-factor model of the positive and negative syndrome scale for schizophrenia. *Schizophr Res*. 2012; 137(1):246–250. [PubMed: 22356801]
- White L, Harvey PD, Opler L, Lindenmayer J. Empirical assessment of the factorial structure of clinical symptoms in schizophrenia. *Psychopathology*. 1997; 30(5):263–274. [PubMed: 9353855]
- Widaman, KF.; Reise, SP. Exploring the measurement invariance of psychological instruments: Applications in the substance use domain. In: Bryant, KJ.; Windle, M.; West, SG., editors. *The Science of prevention: Methodological Advances from Alcohol and Substance Abuse Research*. American Psychological Association; Washington, DC: 1997. p. 281–324.

Table 1

Tests of extant factor models in integrated data.

White et al. (1997)	
$\chi^2(df)$	9,155(258)
CFI	0.909
TLI	0.894
RMSEA	0.088
van der Gaag et al. (2006)	
$\chi^2(df)$	11,922(380)
CFI	0.909
TLI	0.896
RMSEA	0.082
Overall et al. (1967)	
$\chi^2(df)$	3,130(48)
CFI	0.889
TLI	0.848
RMSEA	0.120
Shafer (2005)	
$\chi^2(df)$	5,033(109)
CFI	0.869
TLI	0.836
RMSEA	0.101

Notes. CFI=Comparative Fit Index; TLI=Tucker Lewis Index; RMSEA=Root Mean Square Error of Approximation.

Table 2

Factor structure from exploratory factor analysis of PANSS and BPRS.

Factor Loading Pattern	Factors			
	Affective	Positive	Negative	Disorganized Cognitive Processing
Items				
Anxiety	0.693	0.041	0.035	0.041
Depression	0.710	−0.020	0.178	−0.056
Guilt Feelings	0.558	0.043	0.036	0.051
Somatic Concern	0.329	0.112	−0.110	0.048
Hostility	0.542	−0.095	−0.175	0.374
Poor Impulse Control	0.469	0.009	−0.143	0.618
Delusions	0.045	0.954	−0.011	−0.048
Suspiciousness/ Persecution	0.259	0.653	0.169	0.013
Grandiosity	−0.124	0.600	−0.212	0.158
Hallucinatory Behavior	0.115	0.566	0.140	0.062
Unusual Thought Content	−0.051	0.824	−0.060	0.114
Lack of Judgment and Insight	−0.260	0.379	0.143	0.278
Active Social Avoidance	0.323	0.395	0.625	−0.049
Passive/Apathetic Social Withdrawal	0.175	0.257	0.755	0.000
Blunted Affect	−0.040	0.042	0.660	0.232
Emotional Withdrawal	0.060	0.145	0.668	0.263
Motor Retardation	0.016	−0.083	0.633	0.210
Lack of Spontaneity and Flow of Conversation	−0.158	−0.177	0.694	0.361
Disorientation	−0.123	0.117	0.256	0.311
Difficulty in Abstract Thinking	−0.196	0.117	0.277	0.309
Poor Rapport	−0.058	−0.087	0.635	0.413
Excitement	0.087	0.147	−0.229	0.644
Conceptual Disorganization	−0.138	0.266	0.055	0.579
Poor Attention	−0.022	0.070	0.179	0.655
Mannerisms and Posturing	−0.040	0.059	0.178	0.503
Tension	0.229	0.049	0.066	0.483
Preoccupation	0.071	0.313	0.078	0.579
Stereotyped Thinking	−0.037	0.311	0.113	0.525
Uncooperativeness	0.123	−0.083	0.182	0.587
Disturbance of Volition	0.026	0.118	0.244	0.587
Factor Intercorrelations				
Positive	0.131			
Negative	−0.105	0.201		
Disorganized Cognitive Processing	−0.053	0.342	0.154	

Note. The bolded values indicate that the factor loading was greater than 0.300.

Table 3

Factor structure from confirmatory factor analysis of PANSS and BPRS.

Factor Loading Pattern	Factors			
	Affective	Positive	Negative	Disorganized Cognitive Processing
Items				
Anxiety	0.699	=0	=0	=0
Depression	0.706	=0	=0	=0
Guilt Feelings	0.591	=0	=0	=0
Somatic Concern	0.379	=0	=0	=0
Hostility	0.563	=0	=0	0.044
Poor Impulse Control	0.506	=0	=0	0.376
Delusions	=0	0.874	=0	=0
Suspiciousness/ Persecution	=0	0.751	=0	=0
Grandiosity	=0	0.602	=0	=0
Hallucinatory Behavior	=0	0.706	=0	=0
Unusual Thought Content	=0	0.894	=0	=0
Lack of Judgment and Insight	=0	0.756	=0	=0
Active Social Avoidance	0.312	0.188	0.666	=0
Passive/Apathetic Social Withdrawal	=0	=0	0.840	=0
Blunted Affect	=0	=0	0.812	=0
Emotional Withdrawal	=0	=0	0.903	=0
Motor Retardation	=0	=0	0.698	=0
Lack of Spontaneity and Flow of Conversation	=0	=0	0.882	-0.030
Disorientation	=0	=0	0.221	0.344
Difficulty in Abstract Thinking	=0	=0	0.290	0.349
Poor Rapport	=0	=0	0.814	0.065
Excitement	=0	=0	=0	0.520
Conceptual Disorganization	=0	=0	=0	0.856
Poor Attention	=0	=0	=0	0.804
Mannerisms and Posturing	=0	=0	=0	0.684
Tension	=0	=0	=0	0.497
Preoccupation	=0	0.259	=0	0.607
Stereotyped Thinking	=0	0.206	=0	0.662
Uncooperativeness	=0	=0	=0	0.589
Disturbance of Volition	=0	=0	=0	0.831
Factor Intercorrelations				
Positive	0.041			
Negative	-0.147	0.515		
Disorganized Cognitive Processing	-0.116	0.710	0.690	

Note. '=0' indicates that the factor loading was constrained to 0.

Table 4

Tests of measurement invariance.

Participant Characteristics	Invariance		
	Configural	Metric	Scalar
Psychiatric Diagnoses			
$\chi^2(df)$	11,955(1,568)	10,419(1,667)	12,488(2,039)
CFI	0.885	0.903	0.884
TLI	0.872	0.899	0.901
RMSEA	0.077	0.069	0.068
Hospitalization Status			
$\chi^2(df)$	12,879(784)	10,749(817)	12,617(954)
CFI	0.906	0.923	0.909
TLI	0.896	0.918	0.917
RMSEA	0.083	0.074	0.074
Sex			
$\chi^2(df)$	11,506(784)	9,703(821)	10,028(954)
CFI	0.913	0.928	0.926
TLI	0.903	0.923	0.933
RMSEA	0.078	0.070	0.065
Race/Ethnicity			
$\chi^2(df)$	11,260(1176)	9,136(1242)	9,714(1514)
CFI	0.912	0.931	0.929
TLI	0.903	0.928	0.927
RMSEA	0.077	0.067	0.062
Age			
$\chi^2(df)$	12,353(784)	10,281(817)	11,414(954)
CFI	0.908	0.925	0.917
TLI	0.898	0.920	0.924
RMSEA	0.081	0.072	0.070

Notes. CFI=Comparative Fit Index; TLI=Tucker Lewis Index; RMSEA=Root Mean Square Error of Approximation.

Table 5

Estimated factor means by participant characteristics.

	Factors			
	Affective	Positive	Negative	Disorganized Cognitive Processing
Participant Characteristics	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>	<i>M (SD)</i>
Primary Diagnosis				
Schizophrenia-spectrum	0.11 (0.80)	0.39 (0.89)	0.22 (0.91)	0.29 (0.88)
Bipolar disorder	0.18 (0.91)	−0.26 (0.87)	−0.63 (0.66)	−0.38 (0.69)
Depression	0.73 (0.96)	−0.44 (0.73)	−0.52 (0.70)	−0.64 (0.53)
Substance use disorder	0.58 (0.97)	−0.64 (0.66)	−0.72 (0.64)	−0.64 (0.48)
Other	0.29 (0.88)	−0.31 (0.76)	−0.44 (0.66)	−0.35 (0.61)
Hospitalization Status				
Non-hospitalized	0.13 (0.83)	0.10 (0.86)	−0.03 (0.91)	0.04 (0.88)
Hospitalized	0.46 (0.94)	0.09 (1.03)	−0.13 (0.93)	−0.11 (0.89)
Sex				
Female	0.34 (0.95)	−0.05 (0.91)	−0.18 (0.90)	−0.16 (0.87)
Male	0.21 (0.85)	0.19 (0.94)	0.00 (0.92)	0.08 (0.88)
Race/Ethnicity				
White	0.32 (0.90)	0.00 (0.96)	−0.13 (0.91)	−0.10 (0.87)
African-American	0.20 (0.91)	0.21 (0.90)	−0.03 (0.93)	0.05 (0.89)
Hispanic	0.19 (0.74)	0.15 (0.84)	0.19 (0.88)	0.20 (0.89)
Age				
40 years	0.38 (0.92)	0.07 (0.98)	−0.13 (0.92)	−0.11 (0.86)
>40 years	0.11 (0.84)	0.12 (0.87)	0.00 (0.91)	0.09 (0.90)