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Categorical vs dimensional classifications of psychotic disorders

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Abstract

Objective—Both categorical and dimensional methods appear relevant to classifying psychotic disorders; however, there is no clear consensus on the most appropriate categories and dimensions or on the best approach for constructing nosologic criteria that integrate these 2 methods. This review examines the evidence on specific dimensions and categories that would best characterize psychoses.

Method—Entries in the MEDLINE database between 1980 and 2011 were searched for studies of the dimensional and/or categorical structure of psychosis. Studies were included if samples represented a spectrum of psychotic disorders and dimensions/categories were empirically derived using principal components analysis, factor analysis, or latent class analysis.

Results—Most dimensional studies observed 4 or 5 dimensions within psychosis, with positive, negative, disorganization, and affective symptom domains most frequently reported. Substance abuse, anxiety, early onset/developmental, insight, cognition, hostility, and behavioral/social disturbance dimensions appeared in some studies. Categorical studies suggested 3 to 7 major classes within psychosis, including a class similar to Kraepelin's dementia praecox and one or more classes with significant mood components. Only 2 studies compared the relative fit of empirically derived dimensions and categories within the same data set, and each had significant limitations.

Conclusion—There is relatively consistent evidence on appropriate categories and dimensions for characterizing psychoses. However, the lack of studies directly comparing or combining these approaches provides insufficient evidence for definitive conclusions about their relative merits and integration. The authors provide specific recommendations for designing future studies to identify valid dimensions and/or categories of the psychoses and investigate hybrid approaches to model the structure of the underlying illnesses.

1. Introduction

Current diagnostic systems for psychiatric disorders, including the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*), use signs and symptoms of illness to assign individuals to distinct, nonoverlapping categories. This approach was taken in part

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so that the validity and utility of the criteria and categories could be tested. In practice, explicit categorical criteria have improved reliability; however, the validity of current nosological systems remains under debate. Do these systems accurately reflect the complex underlying etiological and pathophysiologic structure of the illnesses observed in patients? Categorization of psychiatric disorders attempts to "carve nature at its joints." However, it is not clear if there are "joints" between psychiatric disorders; and dimensional (as opposed to categorical) approaches, characterizing patients based on their most prominent symptoms, have been proposed. In drafting the *DSM, Fifth Edition* (*DSM-V*), criteria (www.dsm5.org), vigorous discussion is under way about the relative roles of categorical and dimensional measures [1–4]. Specifically, in response to the *DSM* research planning conference on dimensional approaches [2], the *DSM-V* developers have proposed the incorporation of dimensional assessments, alongside the categorical diagnostic criteria, which are currently being tested in *DSM-V* field trials. The National Institute of Mental Health has contributed by incorporating into their 2007 Strategic Plan the need to "develop, for research purposes, new ways of classifying mental disorders based on dimensions of observable behavior and neurobiological measures" (Strategy 1.4) [5]. In response to this goal, the Research Domain Criteria project was initiated in 2009 (http://www.nimh.nih.gov/research-funding/rdoc/index.shtml) to organize directed research efforts to advance our understanding of the etiology and underlying mechanisms of psychopathology through a dimensional approach, "agnostic with respect to contemporary diagnostic classifications," using different units of analysis (eg, genes, cells, behavior) [6].

This long-standing debate largely reflects the fact that the evidence available on illness comes from assessment of high-level features: observed behaviors and self-report of problems. Diagnoses remain similar to those made 100 years ago because there are no accepted alternatives, such as genetic or other biological markers, although overwhelming evidence suggests that such factors underlie illness risk and expression. Kraepelin's dichotomy of dementia praecox and manic-depressive illness has persisted because course and treatment outcome can be roughly predicted from his distinctions and some patients fit within its strictures. Although perhaps not the best measure, absolute boundaries between discrete diagnostic categories do lead to many patients being classified as "not otherwise specified" (NOS); following a careful evaluation, they do not fit into the *DSM* or related diagnosis buckets. In the current *DSM* nosology, the checklist approach to diagnosis, based on the presence or absence of symptoms, has led to grouping cases of varying severity under one category, with subclinical cases classified as not ill. This results in a sharp line between individuals meeting criteria for a disorder and those not meeting criteria, who may nonetheless have a form of illness. Clinicians and investigators acknowledge limitations in the current psychotic diagnoses and agree that a redefined classification system, incorporating dimensional elements, could be beneficial for better exploring the etiology of psychosis and improving the choice of treatments. However, to construct better nosologic criteria, one needs evidence on exactly what dimensions and categories characterize patients with psychotic disorders and how they should be combined in a model that best fits this population.

Despite the controversy surrounding the relative merits, and possible complementarities, of categorical and dimensional approaches to diagnosis, little attention has been given to directly comparing the alternatives using evidence-based strategies or to investigating the utility of combined approaches. Herein, we review findings from a comprehensive literature search of published studies exploring the dimensional and/or categorical structure of psychosis. We conclude with recommendations for future studies needed to compare classification systems for use in clinical care and research.

2. Method

We searched entries in MEDLINE from January 1, 1980, to January 1, 2011, for articles that met the following criteria: contained search words in title or abstract (* denotes truncated): (*a*) psychosis, psychotic or psychoses; (*b*) dimension*, categor*, latent class, or latent factor; and (*c*) diagnosis, classification, or nosology. This search identified 439 primary articles; title/abstracts were read, and relevant publications were selected for in-depth review. In addition, we screened citations for possible inclusion of relevant articles.

Studies were included if they met the following criteria: (*a*) The study sample contained more than one type of psychotic disorder. We excluded studies conducted with a mainly schizophrenia [7] or bipolar sample [8] and those with nonclinical samples [9] because they did not address differential classification schemes for the broad spectrum of psychotic disorders, the question we were reviewing. The studies included in our review focus on idiopathic psychotic disorders in large part because they are the most common causes of psychosis and for which the causes and relationships of different presentations are still unknown. (*b*) Reported dimensions and/or categories were empirically derived to describe the symptom structure and/or subgroups with shared symptom profiles within the sample. We excluded studies that empirically examined the factor structure of varying definitions of schizophrenia from different diagnostic systems [10,11]. (*c*) The statistical methods used to derive dimensions were principal components analysis (PCA) or factor analysis, and the method used to derive empirical categories was latent class analysis. We excluded studies using multidimensional scaling [12], which could not be compared with the overwhelming majority of studies using PCA or factor analysis.

Of note, there are many studies before 1980 that attempted to empirically derive psychotic syndromes (dimensions) and types (clusters), such as the work performed by Lorr and colleagues in 1963 [13] and the World Health Organization's International Pilot Study of Schizophrenia in 1974 [14]. Although these and other important studies are relevant, we included only those performed after 1980 to coincide with the introduction of the *DSM, Third Edition* (*DSM-III*). Studies using the more reliable and consensually based diagnostic criteria after this date are more easily compared with one another, which was an explicit point of introducing *DSM-III*.

Using the criteria outlined above, we identified 41 primary articles addressing aspects of dimensional vs categorical criteria as the preferred nosology of psychotic disorders. The findings of these studies are discussed below and summarized in the Table. To our knowledge, a literature review examining this issue has not been previously published. Linscott et al [15] systematically reviewed studies to evaluate whether criterion symptoms of schizophrenia are categorical, but did not review dimensional approaches.

3. Results

3.1. Dimensional studies

All studies of symptom dimensions in psychotic disorders used factor analysis or a closely related method. In 39 studies that examined dimensional structure in patients with a broad spectrum of psychotic disorders, the number of empirically derived factors/dimensions ranged from 2 to 11 (Table). The majority of the studies agreed that either 4 or 5 dimensions describe the psychosis construct, with positive, negative, disorganization, and affective symptom dimensions most frequently reported. Additional dimensions and clustering of symptoms within dimensions were unique to individual studies.

All studies found a dimension that encompassed positive symptoms, although they named this dimension differently, eg, *Schneiderian*, *reality distortion*, *delusions*, and *psychotic*. The symptoms loading highly on this dimension varied based on the instrument(s) used in each study, but largely consisted of specific delusions and hallucinations as well as, in some studies, bizarre behavior and thought disorder. Several studies [16–24] reported 2 or more independent positive dimensions. Peralta et al [20] suggested that more complex dimensional models, subdividing broad symptom dimensions into ones that represent specific psychopathology, may shed light on the neurobiology of psychoses (Table).

All studies observed key negative symptoms, as a combined symptom dimension [16–19,22,24–48], as multiple specific negative symptom dimensions [20,21], or as part of a disorganization or Bleulerian dimension [23,49–54]. When negative symptoms loaded together, the items most often found were restricted/blunted/flat affect, restricted/retarded thinking, alogia, and slowed activity. Two studies selecting complex factor solutions reported a higher number of dimensions and found that negative symptoms were distributed among other dimensions instead of forming an independent dimension [20,21]. McGorry et al [52] and Salvatore et al [51] reported a dimension encompassing negative, catatonic/motor, and disorganization symptoms, consistent with Bleuler's early conceptualization of schizophrenias. Twenty-two studies [16,18–22,24,27–35,37,39,44,46–48] reported independent disorganization and negative dimensions. Symptoms most often loading on the disorganization dimension were incoherence, inappropriate affect, tangentiality, circumstantial thinking/speech, illogicality, rumination, bizarre behavior, and derailment. One potential confounding factor in determining whether negative and disorganization symptoms are independent or combined dimensions is that rating scales used by the studies do not clearly differentiate between primary and secondary negative symptoms. Perhaps future studies, making use of improved negative symptom scales—such as the Clinical Assessment Interview for Negative Symptoms currently under development—will clarify this issue [55].

Thirty-one of the 39 studies reported an affective symptom dimension. Five studies that did not report this dimension used the Scale for the Assessment of Positive Symptoms (SAPS) and Scale for the Assessment of Negative Symptoms (SANS) as the only assessments [16,19,20,34,35], which may not include enough items covering affective symptoms to observe a separate dimension. Three other studies not reporting an affective dimension chose to focus on nonaffective symptoms in their analyses [17,37,39]. Of the studies reporting affective dimensions, all but 7 found separate manic and depressive dimensions [31,33,38,41–43,45]. McGrath et al [31] included limited coverage of affective symptoms, which resulted in a single inclusive affective dimension. Ehmann et al [33] used the Routine Assessment of Patient Progress, which does not include items specific to depression or mania and reported anxiety/somatization and aggression dimensions. In fact, the item "mood/affect" fell under the aggression dimension. Bell et al [38] reported that affective symptoms subdivided into 2 dimensions: an "emotional discomfort" dimension, which included anxiety, depression, and guilt items from the Positive and Negative Syndrome Scale (PANSS), and a "hostility" dimension, which included hostility, poor impulse control, uncooperativeness, and excitement items from the PANSS. These may be analogous to depressed and manic dimensions. Daneluzzo et al [41] and Rapado-Castro et al [43] used the PANSS as well and did not report a separate manic dimension.

Twelve studies reported dimensions not found in other studies or reported in only a small number of studies. Rosenman et al [25] found that substance abuse was common in their population and included it in their analysis. Most studies chose to view substance abuse as a comorbid condition instead of a potential dimension of psychoses. McGrath et al [31] reported an early onset/developmental dimension, which was not examined in any other

studies. This unique finding is attributed to inclusion of items specific to characterization of onset and course/chronicity of illness, such as poor premorbid functioning, school deterioration, prodromal signs, psychosis onset less than 16, and remitting course. Several studies reported a lack of insight dimension [18,21,22]. Van Os et al [18] acknowledged that this may not be a "true dimension of symptomatology" because it loaded on only one item from their chosen assessment. Cuesta et al [21,22] reported an insight dimension, which included 3 items with high factor loadings but obvious overlap: lack of feeling of illness, lack of insight, and refusal of treatment. Two studies reported an independent anxiety dimension [22,33], whereas other studies either have found anxiety symptoms to load under a depression or mania dimension or did not address anxiety in their assessments. Several studies reported dimensions typically characterized as nonspecific symptoms: (*a*) cognitive functioning or cognition [36,38,43], (*b*) hostility [38,40,43], and (*c*) behavioral/social disturbance [20,36,42].

Methodological differences, particularly choice of assessments and symptoms included in the analyses, likely explain much of the variation in findings. Peralta and Cuesta [56] suggested that "item selection is perhaps the most important decision in the whole process." Ten studies used the Operational Criteria Checklist for Psychotic Illness (OPCRIT or OCCPI) checklist as their only assessment [18,23,24,27,30,48–50,53,54], which has incomplete coverage of negative symptoms. Five studies used only the SAPS/SANS assessments, which do not specifically assess affective symptoms [16,19,20,34,35]. When multiple items covering overlapping aspects of psychopathology were available for analysis, selected items were often chosen in an effort to prevent overrepresentation of individual symptoms (eg, restricted vs blunted affect). Three studies [27,49,50] excluded items endorsed by only a small percentage of their sample and items that did not seem directly related to psychopathology. These choices, unique to each analysis, complicate comparison across studies.

Variation in findings may also be explained by the choice of statistical methods. Most studies used PCA, which some researchers equate with exploratory factor analysis (EFA) [57]. However, the motivations underlying the 2 approaches differ substantially; PCA is a data reduction technique, whereas EFA explains the correlation structure of observed items as a result of their associations with underlying latent (unobserved) factors [57]. Although the 2 approaches often lead to similar conclusions, the choice between them can substantially impact results. Even among studies using PCA or EFA, choices such as criteria for determining the number of factors/components and the rotation method used to obtain solutions vary [57]. Researchers using factor analysis can further choose between EFA, which avoids prior assumptions about the number of underlying factors and the items which contribute to those factors, and confirmatory factor analysis (CFA), which requires those prior assumptions [57,58]. Confirmatory factor analysis can be useful for replicating or extending results of a prior EFA using an independent sample. Six studies used CFA either following PCA in a split-half design (or in an independent sample) to validate results of the PCA performed on the first half of their sample [28,38,44,49] or alone to compare goodness of fit in their samples with competing factor models reported in the literature [27,37]. Methods relaxing distributional assumptions required for most implementations of factor analysis are available, although only one study used them [31].

Although use of multiple and varied assessments across studies provides evidence that some robust findings (such as a positive symptom dimension) are not sensitive to choice of instrument(s), findings on the dimensional structure of psychosis would be strengthened by replication of results using the same instruments and methods in different populations. Comparison of different assessment tools across studies is also necessary before consensus can be achieved on the optimal assessment of symptom dimensions. One study [38]

performed a CFA comparing factor solutions resulting from PANSS assessment of their sample (schizophrenia and schizoaffective disorder patients) with the sample of Kay et al [59] (only schizophrenia patients). Bell et al [38] reported similar dimensions for each sample: negative, positive, cognitive, emotional discomfort, and hostility; however, the amount of variance explained by each factor varied between samples. Meta-analyses combining data across studies [60,61] have the potential to yield insights, although variation in items and assessments used limits their application.

Studies designed to investigate factor structure, using comprehensive assessments of a wide variety of symptoms, should lead to the most accurate dimensional model. The optimal number of dimensions may depend on the intended purpose. For example, a model endorsing a large number of symptom dimensions may be untenable for use in routine clinical practice but may be useful in seeking constructs for research. Cuesta et al [21], who presented a hierarchical model of psychosis, discussed the possibility of incorporating lower- or higher-order levels of dimensionality based on the focus of study. The setting in which competing models are applied will ultimately determine usefulness in each instance.

3.2. Categorical studies

Empirically derived categories within psychotic disorders have been studied less than dimensions, presumably because current nosologic systems are already categorical. Ironically, the most widely used diagnostic system, *DSM-III*, and its successor, *DSM-IV*, were explicitly designed with well-defined sign and symptom items and syndromic groupings intended to be tested for validity. We encountered 7 studies that investigated whether empirically derived categories within psychotic disorders differ from current operational classification systems (ie, *DSM-IV* and *International Classification of Diseases, 10th Revision* [*ICD-10*] [62]). The statistical method in these studies is typically latent class analysis (LCA). Latent class analysis, in this application, categorizes individuals based on responses to items from instruments that assess symptoms. Latent class analysis does not prove the existence of classes but rather provides a model for subgroups of the sample that must be independently replicated [63]. Some studies initially performed factor analysis of symptoms in their sample and then applied the resulting factor scores for each individual in the LCA [44–46]. This enabled the authors to investigate the association of dimensional score distribution within the resulting latent classes.

The number of classes identified ranged from 3 to 7; however, composition of classes varied among studies (Table). All but one study agreed on a class reminiscent of Kraepelin's description of *dementia praecox*, although the nomenclature of this empirically derived class varied among studies: *classic schizophrenia* [44,63,64]; *Kraepelinian schizophrenia* [46]; *prominent delusions, flat affect, thought disorder* [45]; and *mixed psychotic* [47]. This class was characterized by poor outcome and high levels of positive and negative symptoms, whereas varying levels of disorganization and affective symptoms were observed among studies. All studies reported one or more classes with a significant mood component and agreed that mood symptoms play an important role in delineating classes of psychotic patients. Five studies agreed on a class characterized by moderate to high levels of positive, depressive, and manic symptoms, and low to moderate levels of negative symptoms, named differently across studies: *bipolar-schizomania* [44,63], *schizobipolar* [64], *affective psychosis* [46], and *schizoaffective* [45]. Four studies [44,47,63,64] identified a class, agreeing on the name *schizodepression*, with high levels of depressive and negative symptoms and moderate to high levels of positive symptoms. Two studies found a class, *schizomania*, comprising high levels of manic and positive symptoms, low levels of negative symptoms, and variable levels of disorganization [47,64]. Four studies [44,46,53,63] reported a class with high levels of depressive symptoms and almost no other symptoms, resembling the *DSM-IV* diagnosis of major depression. The *deficit nonpsychosis* class

described by Derks et al [46] resembles the *disorganization* class reported by Murray et al [53] in that both were marked by high levels of negative and disorganization symptoms. Two studies [47,64] reported a *psychosis* class exhibiting primarily positive symptoms, resembling the *reality distortion/depression* class found by Murray et al [53]. Two studies [44,63] identified a *hebephrenia* class with moderate to high levels of positive, negative, and disorganization symptoms. However, Kendler et al [63] reported high levels of manic symptoms in this class, whereas Boks et al [44] reported very low levels. Two of the studies included nonpsychotic patients; and both reported the presence of a *nonpsychotic* [44] or *healthy* class [46], defined by low scores on each of the dimensions of psychopathology.

Four studies attempted to compare their empirically derived classes with diagnostic categories from existing nosological systems (eg, *DSM-IV*, *ICD-10*). Kendler et al [63] and Murray et al [53] found that their classes exhibited high concordance with *DSM, Revised Third Edition* (*DSM-III-R*), categories, demonstrated by a high percentage of subjects within each class meeting criteria for a single *DSM-III-R* diagnosis. For example, of subjects belonging to the *classic schizophrenia* class in Kendler's study [63], 84% met criteria for *DSM-III-R* schizophrenia; and 96% of subjects in the *major depression* class met criteria for *DSM-III-R* major depression. In the study of Murray et al [53], 79% of those diagnosed with *DSM-III-R* depression with psychosis fell under the *depression* latent class; and more than 90% of those diagnosed with *DSM-III-R* mania, mania with psychosis, or bipolar with psychosis fell under the *bipolar* latent class. In contrast, Derks et al [46] reported that the empirically derived classes in their study "cut across traditional *DSM* diagnosis" and may represent an alternative depiction of psychoses. Peralta et al [64] reported that their empirically derived classes demonstrated poor concordance with both *DSM-IV* and *ICD-10* classifications overall, including only moderate concordance for schizophrenia. The authors describe a "vicious circle in that we do not possess robust extraclinical markers for disentangling the nosological structure of psychotic illness, and at the same time the blurred boundaries between disorders hinder the physiopathologic and etiologic research." Of note, diagnostic interviews used in research are often lists of items from *DSM* and *ICD* or based on the structure of *DSM* or *ICD* nosology; so they may tautologically return answers validating those structures.

3.3. Studies comparing categorical vs dimensional classification

Direct comparisons of the fit of alternative models and external validation of the models are lacking among studies exploring dimensional and categorical approaches. Of all the studies reviewed, only 2 [47,53] fit both dimensional and categorical models to the same data set. Murray et al [53] noted concordance between PCA and LCA results applied to the same data, but did not attempt to compare the fit of the 2 models. Peralta et al [47] studied 3 different time frames (index episode, lifetime course, and interepisode symptoms) in comparing dimensional and categorical approaches and found that their factor solution (dimensions) explained a greater proportion of the variance in a chosen set of external clinical variables than their latent classes (categories), irrespective of time frame. Significant limitations of this unique and interesting study are the relatively small sample size (110 patients) and the limited number of symptoms in the analysis. These parameters can have a large impact on the resulting factor structure. Using instruments that cover a broader range of symptoms could improve the complexity and validity of derived classifications.

Several studies compared the predictive ability of empirically derived dimensions with existing diagnostic categories (ie, *DSM-IV*, *ICD*-10, Research Diagnostic Criteria (RDC) [65]) using clinical/outcome measures as external validators [18,23,29,30,32,66]. However, these comparisons may place well-established categories at a disadvantage because only the dimensions, and not the categories, were derived using data from the same samples used for external validation. As exploratory "bottom-up approaches" for empirically deriving

dimensions or categories are dependent on the chosen sample population and statistical methods/assumptions used, Helzer et al [3] emphasize the importance of well-chosen external validators for assessing clinical validity. Van Os and colleagues found stronger associations of derived dimensions than of *DSM-III, ICD-10* [18], and RDC [32] diagnostic categories with outcome measures, such as quality of life, social disability, duration of hospitalization, and treatment history. Demjaha et al [29] and Dikeos et al [30] found that empirically derived dimensions, in conjunction with traditional diagnostic categories, explained significantly more variability in clinical measures, such as mode of onset, neurological soft signs, duration of untreated psychosis, poor premorbid work and social adjustment, and course, than diagnostic categories alone. However, the converse was not true, in that diagnostic categories alone did not explain more variability in clinical measures than the information provided when categories and empirically derived dimensions were used together [30]. Similarly, Rosenman et al [66] found that empirically derived dimensions explained significantly more variability in clinical measures than categories alone. Allardyce et al [23] examined similar clinical characteristics but found less consistent results in favor of either dimensional or categorical approaches. However, all of these authors agree that a complementary approach incorporating both dimensions and categories may provide the best system of classification.

4. Discussion

The majority of dimensional studies agree that 4 or 5 dimensions describe the psychosis construct, with positive, negative, disorganization, and affective symptoms most frequently reported. Of studies reporting an affective dimension(s), manic and depressive symptoms were frequently found to comprise this dimension(s). It remains to be determined if other less frequently reported dimensions can be considered useful: substance abuse, early onset/developmental, lack of insight, anxiety, cognitive functioning/cognition, hostility, and behavioral/social disturbance.

Categorical studies suggest that 3 to 7 major classes can be found within the spectrum of psychosis. Six of 7 studies reported a class characterized by high levels of positive and negative symptoms and poor outcome, similar to Kraepelin's dementia praecox. All of the studies agree that there are one or more classes involving a significant mood component, with or without cooccurring positive and negative symptoms.

The 2 studies comparing the fit of dimensional and categorical models within the same data set support the value of dimensions. However, we were unable to find published studies investigating specific hybrid approaches. The field needs explicit guidance on how categorical or dimensional classification, or their combination, best explains the naturally occurring variance in clinical presentations.

4.1. Future studies

Research is needed to provide evidence for dimensions and categories that best characterize patients with psychotic disorders and to validate combined models that best fit this population. A key design element in evaluating categorical and dimensional approaches is instrument selection. Many questionnaires and symptom scales are available, but each was designed for specific purposes that may not fit the needs of a nosological study. It may be necessary to add questions not included in standard interviews for *DSM* diagnoses; for example, one could consider course, comorbidities, cultural background, and sex. Because we do not know where to draw diagnostic lines, both core and peripheral symptoms must be considered. For example, many patients with psychotic disorders exhibit comorbid anxiety and substance use disorders. It should be questioned whether these symptoms are best conceptualized as categorically different from psychosis or, rather, as a related dimension.

Another important factor is time frame of the study, which can greatly impact the results. There are characteristics and symptoms unique to a first-episode population that will not be present in a chronically ill population, and vice versa. A cross-sectional design may reveal very different results from a longitudinal design. Whereas future longitudinal studies can best address changes in symptom profiles over the course of illness, cross-sectional studies can account for chronicity of illness and compare symptom dimensions or classes among groups of patients of different age and symptom duration.

Illness severity must be considered. Evaluating only severe, tertiary care hospitalized patients can limit generalizability of the results to community-based samples, or vice versa. However, it is rarely feasible to study a population of subjects representing the full spectrum of severity from “healthy” controls to those with minor symptoms, those requiring minimal outpatient care, and those requiring inpatient or custodial care. Ultimately, a comparison of results between studies using different subject populations is necessary. Similar issues of heterogeneity apply to many other aspects of interindividual variation, such as ethnicity, education, and past and current treatment, all of which can affect symptoms and course of illness. For this reason, the most valuable epidemiologic studies usually have very large sample sizes.

Further research should directly compare the performance of dimensional and categorical approaches in the same patient population and make specific recommendations for hybrid approaches. In addition to comparing the predictive validity of empirically derived dimensions and categories, this research should take advantage of modern statistical techniques, such as latent class factor analysis and factor mixture modeling, which combine aspects of dimensional and categorical modeling [67] and of methods for comparing the relative goodness of fit of dimensional, categorical, and hybrid models applied to the same data sets [68]. Hybrid modeling approaches provide a specific framework for combining dimensions and categories within the same data set. Factor mixture modeling, for example, assumes individuals fall into distinct classes but allows individuals within classes to differ along dimensional continua. Standard and well-established statistics can be used to compare the fits of alternative models (eg, FA model vs factor mixture modeling model vs LCA model) to the same data set to help select the approach providing the best fit [68]. Hybrid strategies have been applied successfully to support established or alternative classification systems for other psychiatric disorders, including alcohol and substance use disorders [69,70], attention-deficit/hyperactivity disorder [71], and posttraumatic stress disorder [72]. Although the most useful data for investigating hybrid approaches are likely to come from studies designed specifically for that purpose, the reanalysis of existing data could provide a starting point for suggesting promising models at relatively little cost. Cooperation among researchers in sharing data to allow the testing of alternate models in different populations could facilitate the development and validation of candidate models. The evaluation of these candidate hybrid models should be accomplished by developing them in one sample and then ensuring that they are tested in other, independent, samples.

If results from initial studies suggest that dimensional or hybrid approaches provide superior fit to empirical data and have superior external validity compared to categories alone, subsequent work must propose and validate specific strategies for incorporating dimensional aspects of psychotic disorders into standard clinical and research practice. To be practically useful, a classification approach must be general enough to be applied across a range of clinical or research settings and simple enough to be applied routinely. This requires the identification or development of scales to assess the categories or dimensions identified in research, guidelines for their use, and validation in subpopulations. These steps will provide concrete and empirically validated means for integrating dimensional and categorical aspects of psychotic symptomatology into clinical and research practice.

Few would deny that our psychiatric nosology could be improved. It will not be easy to identify the right dimensional and categorical elements. Nevertheless, even small advances may lead to improved research and treatment. Better models of psychiatric classification may suggest new mechanisms to explore in research on pathophysiology and new targets for research on improved treatments. In addition, better models might allow researchers to classify patients into more homogeneous syndromic groups, which should improve signal to noise for measurements of etiology or pathology. Better models may similarly allow more accurate testing of whether particular treatments target certain dimensions or categories of illness, reducing the variance that arises from mixing different populations and outcomes. Someday, we may be able to rely on clearer evidence of psychopathologic distinctions from biomarkers; but current technology is not yet adequate to that task. Continuing to study dimensions and categories of illness may appear “low tech”; but signs and symptoms are how we tell people are ill, and better syndromic models of these illnesses may strengthen the signals observed in “high tech” studies of etiology and pathophysiology.

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Table

Summary of studies included in review

Source	Sample	Symptoms included	Analysis	Main results
Dimensional studies of psychosis				
Allardyce et al. [23]	n = 464 psychosis 1st episode	28 OPCRIT items	PFA	5 factors: mania, disorganization/ bizarre, depression, nonbizarre/ nonmood congruent delusions, auditory hallucinations
Bassett et al. [17]	n = 72 members (5 families) with broad-spectrum psychopathology	8 PANSS items and 1 item created—inappropriate affect	PCA	3 factors: (1) negative; (2) delusions/ hallucinations, thought disorder, and inappropriate affect; (3) suspiciousness and stereotyped thinking
Bell et al. [38]	n = 146 SZ & SZA	30 PANSS items	PCA then CFA of present and Kay et al. [59] samples	PCA: 5 factors: negative, positive, cognitive, emotional discomfort, hostility CFA: Poor fit between 2 samples; although similar dimensions
Brekke et al. [37]	n = 193 SZ & SZA	11 BPRS items, 2 CAF items, 4 QLS items	CFA—goodness of fit assessed for 6 models	3-factor model best fit: positive, negative, disorganized
Bunk et al. [36]	n = 44 SZ, SZA, schizophreniform, affective illness	30 PANSS items at onset of illness then 42 y later	PCA at onset and follow-up	Onset: 5 factors: cognitive, social withdrawal, antisocial behavior, excitement, reality distortion Follow-up: 5 factors: excitement, cognitive/motor-restriction/rigidity, positive, negative, anxiety/depression
Cardno et al. [39]	n = 109 SZ or SZA sibling pairs	7 SANS/SAPS items 22 OPCRIT items	PCA	SANS/SAPS: 3 factors: disorganization, negative, positive OPCRIT: 4 factors: positive, disorganization, negative, 1st-rank delusions
Cardno et al. [24]	n = 224 psychosis twin pairs	18 OPCRIT items analyzed then 16 OPCRIT items	PCA of 18 items PCA of 16 items	18 items (psychotic symptoms): 6 factors: disorganized, negative, 1st-rank delusions, paranoid, other hallucinations, 1st-rank hallucinations 16 items (psychotic + affective symptoms): 3 factors: manic, general psychotic, depressive
Cuesta et al. [21]	n = 660 psychosis	64 AMDP items	PCA	10 factors: pure paranoid, mania, negative catatonia, depression, dysphoria, disorganization, Schneiderian, insight, psychomotor poverty, positive catatonia (hierarchical representation of factors)
Cuesta et al. [22]	n = 94 psychosis 1st episode	70 AMDP items	PCA	Hierarchical system with up to 10 factors: mania, disorganization/ dysphoria, insight, depression, anxiety/ guilt, psychomotor poverty, Schneiderian hallucinations, depersonalization/ derealization, other disorders of ego integrity, paranoid
Daneluzzo et al. [41]	n = 234 BP & SZ	3 PANSS scales 6 PANSS cluster scores	PCA of PANSS scales + clusters	PCA: SZ: 3 factors: positive, negative, depressive PCA: BP: 3 factors: positive, negative, mixed
Demjaha et al. [29]	n = 536 psychosis 1st episode	28 SCAN items	PAF	5 factors: mania, reality distortion, negative, depression, disorganization
Dikeos et al. [30]	n = 191 psychosis	51 OPCRIT items	PCA	5 factors: mania, reality distortion, depression, disorganization, negative

Source	Sample	Symptoms included	Analysis	Main results
Ehmann et al. [33]	n = 165 psychosis	21 RAPP items	PCA	5 factors: aggression, positive, negative, organic/disorganization, anxiety/somatization
Kitamura et al. [26]	n = 584 psychosis	Semistructured interview	Factor analysis	5 factors: (1) manic, (2) depressive, (3) negative symptoms and formal thought disorder, (4) positive, (5) catatonic
McClellan et al. [42]	n = 69 SZ, BP, psychosis NOS (early-onset)	7 BPRS-C items 4 SAPS items 5 SANS items	PCA	4 factors: negative, positive, behavioral problems, dysphoria
McGorry et al. [52]	n = 509 psychosis 1st episode	92 RPMIP items	PAF	4 factors: mania, depression, Bleulerian (negative-disorganization), Schneiderian (positive)
McGrath et al. [31]	n = 1043 SZ, SZA	44 items from Diagnostic Checklist for *DSM-IV*	LCFA	5 factors: positive, affective, disorganized, negative, early onset/ developmental
McIntosh et al. [54]	n = 204 psychosis	33 OPCRIT items	PCA performed separately at 4 consecutive inpatient admissions	4 factors: manic, depressive, disorganization, reality distortion (stable over time)
Minas et al. [16]	n = 114 psychosis	35 SAPS/SANS items	PCA	3 factors: negative, thought disorder, delusions/hallucinations
Peralta et al. [28]	n = 314 psychosis	11 AMDP items 8 SANS/SAPS global ratings	PCA AMDP PCA SANS/SAPS CFA SANS/SAPS	AMDP items: 3 factors: catatonic, manic, depressive SANS/SAPS: 3 factors: psychosis (positive), disorganization, negative CFA results support PCA results
Peralta et al. [20]	n = 660 psychosis	50 SAPS/SANS items	PCA 1st order then 2nd order	11 1st-order factors: poverty of affect/ speech, thought disorder/inappropriate affect, bizarre delusions, social dysfunction, other delusions, paranoid delusions, bizarre behavior, non-auditory hallucinations, auditory hallucinations, manic thought disorder, attention 3 2nd-order factors: psychosis, disorganization, negative
Rapado-Castro et al. [43]	n = 99 psychosis 1st episode, early onset	30 PANSS items baseline, 4 wk, 6 mo	PCA at each time point	5 factors: positive, negative, depression, cognitive, hostility Dimensions stable over time but predominance differed: negative predominant baseline/4 wk; depression predominant at 6 mo
Ratakonda et al. [35]	n = 412 SZ & non-SZ	9 SAPS/SANS global ratings	PCA performed separately for SZ and non-SZ	3 factors similar for both SZ and non-SZ: positive, negative, disorganization
Rosenman et al. [25]	n = 978 psychosis	64 SCAN items	PFA	5 factors: dysphoria, positive, negative/incoherence, mania, substance abuse
Salvatore et al. [51]	n = 377 psychosis 1st episode	78 AMDP items 34 BSABS items	PCA	4 factors: pure mania with psychosis, depressive-excited mixed state, excited-hallucinatory-delusional state, disorganized-catatonic-autistic state
Serretti et al. [49]	n = 1004 SZ spectrum & mood disorder	38 OPCRIT items	PCA on half of sample CFA on other half	4 factors: excitement, depression, disorganization, delusion CFA showed good fit of model
Serretti et al. [50]	n = 2241 psychosis	46 OPCRIT items	PCA	4 factors: excitement, psychotic, depression, disorganization
Serretti et al. [27]	n = 1294 SZ, BP, delusional disorder	29 OPCRIT items	CFA of 6 factor models	5 factor best fit: positive, negative, depressive, manic, disorganized

Source	Sample	Symptoms included	Analysis	Main results
Toomey et al. [19]	n = 630 psychoses global-level PCA n = 549 psychoses item-level PCA	9 SAPS/SANS global ratings 50 SAPS/SANS items	PCA on global ratings FA on global ratings then again separately on individual items	PCA: replicated 3 factors found in other studies: positive, negative, disorganization FA global ratings: 2 factors: positive (SAPS), negative (SANS) FA individual items: 5 factors: diminished expression, disorganization, disordered relating, bizarre delusions, auditory hallucinations
Toomey et al. [34]	n = 369 SZ, MDD, BP	9 SAPS/SANS global ratings	PCA performed separately for each diagnosis	SZ: 3 factors: negative, disorganization, positive MDD: 4 factors: diminished expression, diminished instrumental behavior, positive, disorganization BP: 2 factors: negative, positive MDD + BP: negative, positive, disorganization Psychotic (SZ + MDD + BP): 3 factors: negative, disorganization, positive Nonpsychotic (MDD + BP): 3 factors: (1) affective flattening/alogia/ attention; (2) apathy/anhedonia/ thought disorder; (3) disorganization
van Os et al. [18]	n = 166 psychosis recent onset	20 OCCPI items	PCA	7 factors: inappropriate-catatonia, delusions-hallucinations, mania, insidious-blunting, depression, lack of insight, paranoid delusions
van Os et al. [32]	n = 706 psychosis	65 CPRS items 46 OPCRIT items	PCA on CPRS then OPCRIT items	CPRS 4 factors: depressive, manic, negative, positive OPCRIT 5 factors: manic, depressive, negative, positive, disorganization
Ventura et al. [40]	n = 141 SZ, SZA, bipolar manic	18 BPRS items 24 BPRS items	PCA on 18 items then 24 items	18 item: 4 factors: negative, depression-anxiety, hostile-uncooperativeness, positive 24 item: 4 factors: manic-excitement, negative, positive, depression-anxiety
Wickham et al. [48]	n = 155 SZ, SZA, psychosis NOS (61 families)	53 OPCRIT items	PCA	5 factors: depressive, manic, reality distortion, disorganization, psychomotor poverty
Categorical studies of psychosis				
Boks et al. [44]	n = 1056 psychosis (after examination, some proved not to be psychotic but left in analysis)	52 CASH items	EFA then CFA LCA of factor scores	5 factors: disorganization, negative, positive, depression, mania 6 classes: bipolar-schizomania, schizodepressive, hebephrenia, classic schizophrenia, non-psychotic, major depression
Derks et al. [46]	n = 4286 psychosis (SZ, SZA, BPI, BPII, BP NOS, MDD, healthy, other)	79 CASH items	EFA LCA of factor scores	EFA 5 factors: disorganization, negative, mania, positive, depression LCA 7 classes: schizophrenia, affective psychosis, manic-depression, deficit non-psychosis, depression, healthy, no symptoms
Kendler et al. [45]	n = 256 siblings w/ SZ n = 457 siblings with nonaffective psychoses	11 MSSS items + 2 additional variables: age at onset, sex	Factor analysis 11 MSSS items LCA of factor scores using 11 MSSS items, age at onset, and gender	3 factors SZ pairs: negative, positive, affective/manic 3 factors nonaffective pairs: negative, positive, affective/good prognosis LCA 5 classes: (1) SZA, (2) negative symptom SZ, (3) prominent delusions, flat affect, thought disorder SZ, (4) paranoid SZ, (5) remitting/relapsing catatonic SZ
Kendler et al. [63]	n = 343 SZ and affective disorders	21 items: 19 from OPCRIT, 2 items from MSSS	LCA	6 classes: classic schizophrenia, major depression, schizophreniform, bipolar-

Source	Sample	Symptoms included	Analysis	Main results
				schizomania, schizodepression, hebephrenia
Peralta et al. [64]	n = 660 psychosis	16 MAS items	LCA	5 classes index episode: schizophrenia, psychosis, schizomania, schizodepression, cycloid 5 classes lifetime: schizophrenia, atypical schizophrenia, psychosis, schizobipolar, schizodepression
Studies comparing categorical vs. dimensional classification				
Murray et al. [53]	n = 387 psychosis	62 OPCRIT items	PCA LCA	PCA: 4 factors: mania, reality distortion, depression, disorganization LCA: 4 classes: depression, disorganization, bipolar, reality distortion/depression
Peralta et al. [47]	n = 110 psychosis	12 subscale global ratings and inappropriate affect from CASH 3 time frames: index, lifetime, interepisode	LCA then factor analysis for each time frame	Index 4 classes: psychotic, mixed positive-negative, schizomanic, schizodepressive Lifetime 4 classes: mixed psychotic, psychotic, schizobipolar, schizodepressive Interepisode 3 classes: remitting psychosis, chronic psychosis, defect psychosis Index 4 factors: depression-motor poverty, negative, disorganization, psychosis Lifetime 4 factors: negative, mania, depression, psychosis Interepisode 3 factors: negative-disorganization, psychosis, depression-motor poverty

SZ, schizophrenia; SZA, schizoaffective; BPRS, Brief Psychiatric Rating Scale; CAF, Community Adjustment Form; QLS, Quality of Life Scale; AMDP, Manual for the Assessment and Documentation of Psychopathology; BP, bipolar; SCAN, Schedules for Clinical Assessment in Neuropsychiatry; PAF, principal axis factoring; RAPP, Routine Assessment of Patient Progress; RPMIP, Royal Park Multidiagnostic Instrument for Psychosis; PFA, principal factor analysis; LCFA, latent class factor analysis; BSABS, Bonn Scale for Assessment of Basic Symptoms; FA, factor analysis; MDD, major depressive disorder; CPRS, Comprehensive Psychopathological Rating Scale; CASH, Comprehensive Assessment of Symptoms and History; BPI, bipolar I; BPII, bipolar II; BP NOS, bipolar not otherwise specified; RMSEA, root mean square error of approximation; MSSS, Major Symptoms of Schizophrenia Scale; MAS, Manual for the Assessment of Schizophrenia.