CHAPTER 8

How does dimensional diagnosis change psychopathology research?

When mental health problems are assumed to be categorical, a natural approach in experimental psychopathology is to distinguish people with different diagnoses from controls to identify the mechanisms underlying their problems. However, if mental health problems are assumed to be dimensional in terms of distinguishing both clinical from nonclinical ranges of functioning and different kinds of problems, how valid is this approach? In this section, we asked experts to answer three questions:

What is the role of case-control studies in psychopathology?

How does dimensional diagnosis affect the way we sample participants for psychopathology research?

How will research methods change in the era of dimensional diagnosis?

Conway advocates for a clean departure from approaches to psychopathology research based on the categorical model and in favor of approaches based on a hierarchical dimensional model. He is critical of case-control studies, emphasizes the advantages of using hierarchical models to sample based on the specificity of research questions, and argues that reformulating psychopathology theories based on syndromes would improve research. Baskin-Sommers and colleagues take a more conservative position, highlighting how statistical covariance models can be used to arrange psychopathology indicators into

dimensions, categories, or combinations of the two. They reserve room for the utility of case-control designs and argue that research designs vary across but can be appropriate for either categorical or dimensional approaches. They also draw attention to broader issues in sampling for clinical research, such as the importance of increasing generalizability by recruiting participants from broader, more representative, and more diverse samples.

PART I
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Dimensional diagnosis can improve theory building and testing in psychopathology research

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My goal in this chapter is to describe how multidimensional diagnostic systems, particularly the hierarchical taxonomy of psychopathology (HiTOP; Kotov et al., 2021), *function as research frameworks* and enable new insights into the origins and outcomes of mental health problems.

Two distinctive properties of the HiTOP model account for its utility as a research tool: hierarchy and dimensionality. HiTOP is hierarchical because, much like accepted models of personality and cognitive ability domains, it organizes mental health conditions at different levels of breadth (Figure 8.1). All levels, ranging from broad to specific, are equally valid representations of psychopathology. For instance, sleep difficulties could be understood by referring to narrow homogeneous constructs near the base of the hierarchy (e.g., "early morning awakening" is located at the symptom level, where the various basic units of psychopathology are too numerous to list in Figure 8.1; "insomnia" is a symptom component that aggregates various specific expressions of insomnia, including early morning awakening), intermediate constructs ("vegetative depression" syndrome, "distress" subfactor), or broad, heterogeneous constructs near the top of the hierarchy ("internalizing spectrum," "general-factor superspectrum").

HiTOP is dimensional because it recognizes that, according to the available data, individual differences on virtually all psychopathology constructs are a matter of degree, not kind (Haslam et al., 2020). Therefore, the model attempts to locate people at some level of, say, the insomnia dimension rather than positing separate populations of people who do versus do not have clinically significant insomnia.
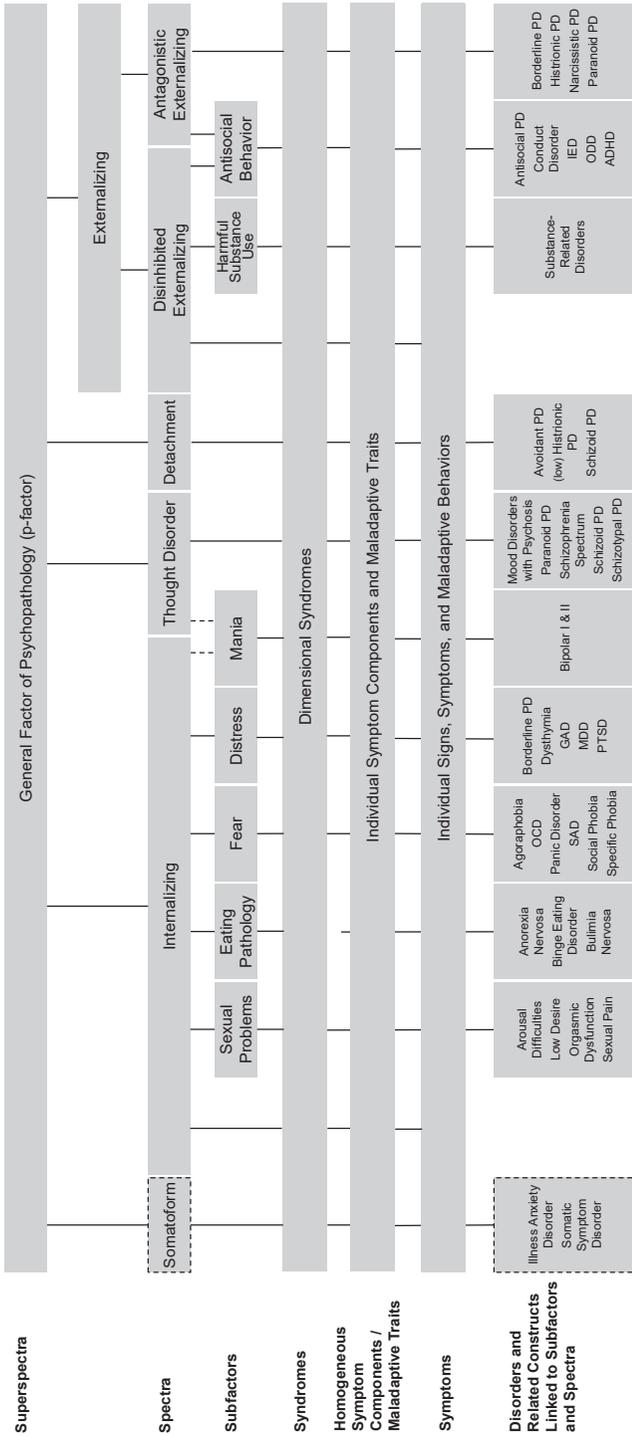
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FIGURE 8.1. HiTOP model. Dashed lines indicate dimensions included as provisional aspects of the framework. Abbreviations: ADHD, attention-deficit/hyperactivity disorder; GAD, generalized anxiety disorder; IED, intermittent explosive disorder; MDD, major depressive disorder; OCD, obsessive–compulsive disorder; ODD, oppositional defiant disorder; PD, personality disorder; PTSD, posttraumatic stress disorder; SAD, separation anxiety disorder.

Below I address the implications of a hierarchical dimensional conceptualization of psychopathology for prominent questions in mental health research.

What Is the Role of Case-Control Studies in Psychopathology?

There are a few ways in which frameworks like HiTOP are out of sync with a case-control design. First, if psychological problems are continuously distributed in the population, then imposing a dividing line between cases and controls binarizes what is naturally continuous information. I am unaware of robust evidence for a categorical (or categorical–dimensional hybrid) model for any mental health problem. Whereas one can always fit a categorical model to observed symptom data and often get interpretable results, this is not evidence that the categorical model is a better representation of the symptoms (on conceptual or empirical grounds) than a dimensional model.

Assuming a dimensional structure to psychopathology, creating binary diagnoses essentially discards information, which usually dilutes a construct's "signal" in relation to the outcome of interest (MacCallum et al., 2002). For example, there are almost always meaningful differences among cases in disorder severity. We can probably all think of clinical examples of people who were especially extreme cases of some diagnosis. But analysis of case-control data assumes that all cases have the same degree of disorder (e.g., all cases are coded as 1 in the dataset, and all controls as 0). Along these same lines, the case-control design misses the fact that there will be cases who have more in common with the typical control than they have in common with the typical case.

Second, whereas HiTOP attempts to model comorbidity (i.e., diagnostic co-occurrence) with higher level dimensions near the top of the hierarchy, case-control studies generally ignore comorbidity. But this comes at an interpretative cost. Comorbidity means that in a study of generalized anxiety disorder (GAD) cases who are compared with healthy (i.e., no GAD diagnosis) controls, other diagnoses might account for GAD's effects. Panic disorder, social phobia, and many other conditions tend to co-occur with GAD (e.g., Brown et al., 2001). Any of these might be driving the observed effects. This threat of confounding makes it almost impossible to draw clear conclusions.

Some studies have tried to sidestep the problem by recruiting samples of cases with only one disorder and comparing them with healthy controls. But these "pure" cases are not representative of the general population or patient populations. Again, comorbidity is ubiquitous.

Therefore, this workaround generally does not improve the quality of inferences in case-control designs.

Third, case-control studies overlook heterogeneity within categorical diagnoses. Virtually all categorical diagnoses are multidimensional in the sense that they comprise lower level components that are meaningfully different. Borderline personality disorder, for example, includes symptoms that reflect concerns ranging from identity disturbance to affective instability to recklessness. In theory, these different narrow features have distinct patterns of association with clinical outcomes. Yet the case-control design collapses them into a single binary concept, obscuring the reason(s) for any observed case-control differences.

How Does Dimensional Diagnosis Affect the Way We Sample Participants for Psychopathology Research?

One implication of a hierarchical perspective on psychopathology is that investigators can recruit participants based on their standing on broad, intermediate, or narrow psychopathology dimensions. Thinking about sampling this way enforces extra precision in a researcher's theory of the etiological factor or outcome they intend to study. For example, if you plan to study the correlates of sleep difficulties, you could sample people based on early insomnia; a composite of early, middle, and late insomnia; distress; or internalizing. This decision-making process will presumably help you clarify the exact component(s) of categorical disorders that theoretically generates associations with the outcomes under study.

I present two illustrative examples. First, Edershile and Wright (2021) sampled adults with respect to vulnerable narcissism, a lower-level characteristic of the externalizing domain. They planned to study interpersonal dynamics among people who tend to have exaggerated affective responses to perceived criticism and slights, which are part of the clinical profile in vulnerable narcissism. Therefore, enriching the sample for this condition increased the chances of capturing the sorts of problematic interpersonal patterns they were targeting.

Second, Craske et al. (2019) created a psychotherapy meant to address low positive affect (anhedonia), a feature primarily associated in categorical nosologies with major depressive disorder (MDD), social phobia, posttraumatic stress disorder (PTSD), and schizophrenia-spectrum disorders. They recruited participants who were very low on positive affect because this was the psychological problem they intended their treatment to reach. They could have recruited based on a categorical MDD, but this group would probably have included people who were not especially low on positive affect. (Again, categorical diagnoses are

multidimensional and anhedonia is not required for a DSM depression diagnosis.) Their clinical theory operated at this lower order level, and sampling on the anhedonia dimension ensured their study design was a good match to their theory.

How Will Research Methods Change in the Era of Dimensional Diagnosis?

If we do enter an era of dimensional diagnosis, the biggest change I expect for applied research is that we will realize that examining the validity (with respect to causes, correlates, and outcomes) of any one syndrome (categorically or dimensionally defined) in isolation is unnecessarily limiting. The bivariate correlation between syndrome and outcome collapses a lot of information that we could separate, if we considered the syndrome's location within a hierarchy of psychopathology dimensions.

As mentioned, syndromes are multifaceted, and normally we are unaware which facets are contributing most to the correlation between syndrome and outcome. Syndromes represent variance from higher-order dimensions in the hierarchy, too. It could be that a syndrome's correlation with some outcome primarily reflects the relationship that some higher-order dimension has with the outcome. Deconstructing traditional syndromes into constituent dimensions across levels of the hierarchy will help to discover from where in the hierarchy predictive information (i.e., validity) comes (Conway et al., 2019). This approach will pinpoint what part or parts of a mental health condition matter most in a given research context. It may be the case that for some outcomes in some research settings, "traditional" syndromes (e.g., MDD, PTSD) will be the optimal level of analysis. The main point is that we will be able to empirically test that idea instead of just assuming it as we do now when working with categorical disorders.

One implication of this perspective is that virtually any theory of psychopathology that is based on a categorical diagnosis can—and maybe should—be reformulated through a hierarchical dimensional lens. For the past few decades, many theories of the origins, outcomes, and treatment of psychopathology have been framed by categorical DSM entities. One example from my own research field involves the concept of "stress generation." The original theory behind stress generation was oriented around MDD (Hammen, 1991). The idea was that people who were diagnosed with MDD were more likely than those who were not to encounter future stressful life events, particularly those that they had a hand in creating. The theory calls this sort of event "dependent stress."

For example, the theory holds that people with an MDD diagnosis are more likely than their peers to get fired from work because of absenteeism, break up with romantic partners over major disagreements, and get suspended from school for disciplinary problems.

The theory was formulated around MDD because this was considered by most investigators at the time (and probably still is) to be the most valid way of describing people who struggle with depressed mood and associated cognitive, physical, and interpersonal problems. However, as you can see in Figure 8.1, MDD is a heterogeneous mixture of internalizing problems. Dimensional systems like HiTOP urge researchers to consider which aspects of the condition—at higher and lower levels of granularity—are most closely linked with the target outcome.

With some coworkers, I attempted an expanded test of the stress generation phenomenon in a group of 800 young adults, many of whom were at high risk for depression due to maternal history of depression (Conway et al., 2012). All respondents completed interview assessments of psychopathology and stressors at ages 15 and 20. MDD did indeed have a prospective link, on a bivariate level, to dependent stressors. So, the traditional stress generation hypothesis was supported. Then, we used a latent-variable model to parse the pathology that was common to all the emotional disorders we assessed (i.e., a higher-order dimension) from the pathology that was unique to each of the disorders in our study (i.e., a lower order dimension). We found that the broad internalizing dimension had a moderate prospective association with dependent stress. We also saw that the unique part of MDD had an independent association, albeit a relatively small one, with dependent stress. Also, the unique part of panic disorder had an *inverse* relation to dependent stress, an effect we named "stress inhibition" to contrast with stress generation.

We used these findings to reformulate the stress generation theory from a dimensional diagnosis perspective. We argued that stress generation is not best conceptualized as an outcome of MDD per se. The pattern of results was not that simple. Instead, it seems that between-person variation on the dimension that cuts across all emotional disorders is the strongest predictor of who encounters more dependent stressors. And the unique pieces of MDD and panic disorder—which were not measured directly in this study so remain unknown—contribute too in different ways. In other words, we learned that the original theory is incomplete and that the predictive validity is distributed across relatively broad and narrow levels of the internalizing domain, at least in this population.

In conclusion, I think the major lesson from this one study is that all theories can become more refined and more versatile if rethought from a hierarchical dimensional perspective. With enough testing along these lines, investigators will be able to home in on the psychopathology

dimensions that should take center stage in their theories. And, if there is compelling evidence that a dimensional perspective enhances theories' utility (e.g., better prediction, more complete explanation), people will be motivated to generate new theories that are oriented around psychopathology dimensions rather than categories.

This perspective is progressive, and there may be a cost here in terms of continuity with prior research guided by categorical diagnoses (sacrificing "replication and extension"). But I see this as a healthy paradigm shift that is unequivocally worth exploring. A multidimensional research framework, like HiTOP, takes what we know about the organization of psychopathology symptoms and sets up a more informative theory-advancing approach to studying mental disorders.

PART II
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Exploring the strengths and weaknesses of different models used in psychopathology classification

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In recent years, there has been a growing tension in clinical psychology regarding the appropriate ways to classify psychopathology. On the one hand, proponents of categorical classification suggest that there are distinct groups that separate people based on levels of psychopathology (e.g., *Diagnostic Statistical Manual of Mental Disorders* [DSM] diagnosis vs. no diagnosis, Zachar, 2000). However, critics suggest that there is little empirical evidence for discrete cutoffs between people who have or do not have psychopathology (Haslam et al., 2020). On the other hand, proponents of dimensional classification believe that psychopathology is reflected in continuously distributed symptoms (Conway et al., 2019). However, the dimensional approach has been criticized for not having been compared with more data-driven categorical models (Van Dam et al., 2017) and for having substantial practical limitations in real-world clinics (Haeffel et al., 2022; Weinberger et al., 2015). Here, we suggest that the tension can be resolved by improving the accuracy and transparency of methods used in this area. We provide a brief primer on the strengths and weaknesses of different statistical models: factor-analytic (which identify dimensions), latent-class (which identify categories), and factor mixture models (which identify categories and dimensions). We highlight examples of appropriate applications and potential misapplications of these models, which has muddied the waters in terms of identifying accurate classifications of psychopathology. Based on the extant research, we do not believe that the tension has been resolved: some studies support hybrid dimensional–categorical models (e.g., Muthén, 2006), whereas others support dimensions (e.g., McBride et al., 2011).

We then discuss other methodological considerations including whether to treat psychopathology as a categorical or dimensional variable, sampling, and case-control design for research on psychopathology classification. We believe that research methods in this area should balance efforts to replicate effects, leverage inclusive sampling approaches, and select a design that reflects the literature and addresses the core research question.

A Brief Primer on Relevant Statistical Methods

Dimensional, Categorical, and Hybrid Latent Variable Models

Two of the most common types of models used in research on the classification of psychopathology are factor analysis and latent class analysis. Factor analysis is a purely dimensional model and is the main method used in the hierarchical taxonomy of psychopathology (HiTOP) system (Waszczuk et al., 2017). Factor analysis explains symptoms using latent variables (factors) that are distributed continuously throughout the population, and each factor reflects a subset of correlated symptoms. In contrast, latent class analysis is a purely categorical model. It divides people into categories (latent classes), and each latent class has a different set of symptom probabilities. These two methods have different limitations in representing symptom correlations: factor analysis assumes that correlations are uniform across the population, whereas latent class analysis explains the correlations among symptoms solely in terms of classes differences, where symptoms are not correlated within each latent class.

Factor mixture models (Clark et al., 2013; Muthén, 2006) are a hybrid of dimensional and categorical models. Like factor analysis, symptom probabilities are determined by continuous latent factors (dimensions). However, individuals also belong to latent classes (categories) and specific parameters vary across latent classes (which parameters vary depends on the type of model, see Clark et al., 2013). We will focus on what we term "proper" factor mixture models—that is, those that allow individuals in the same latent class to have different factor scores. Proper factor mixture models have two primary properties: (1) symptoms are correlated within latent classes (unlike latent class analysis), and (2) symptom correlations differ across the population (unlike factor analysis).

Before concluding this section, we want to comment on latent class factor analysis (Muthén, 2006). This model can be viewed as a factor mixture model in which everyone in a latent-classes class has the exact same factor score (Clark et al., 2013). However, this is distinct from the proper factor mixture models, which allow within-class variation

in factor scores. Thus, mathematically, latent class factor analysis is merely a more parsimonious reparameterization of latent class analysis: both models (unlike proper factor mixtures) assume that symptoms are uncorrelated within each latent class. Latent class factor analysis, then, is not an accurate representation of a hybrid model (e.g., Conway et al., 2012).

Deciding among Dimensional, Categorical, and Hybrid Models

There are two main methods for deciding among dimensional, categorical, and hybrid models of psychopathology: (1) comparing latent variable models using fit statistics (e.g., Bayesian Information Criterion; Clark et al., 2013; Muthén, 2006), and (2) taxometric analysis (Meehl, 1992). The advantage of the former approach is that multiple dimensions of symptoms (factor analysis), multiple categories with different symptom patterns (latent class analysis), and different patterns of correlation within categories (proper factor mixture models) can be compared. However, this approach requires distributional assumptions (e.g., normality). The advantage of the latter approach is that it uses nonparametric methods to compare highly categorical and dimensional models. However, it assumes that there are at most only two categories (e.g., depressed and not depressed) and that all indicator variables (symptoms) represent the same type of psychopathology (i.e., all symptoms are higher in one category than in the other if the categorical hypothesis is true or are all positively correlated if the dimensional hypothesis is true). In some simulations, reviewing fit statistics for latent variable model comparison performs better than taxometric analysis in detecting categorical structure and correctly assigning participants to latent profiles (Lubke & Tueller, 2010). Thus, at this time researchers may want to start with using fit statistics to compare latent variable models and perhaps use taxometric methods as a secondary analysis.

Evidence for Dimensional, Categorical, and Hybrid Models of Psychopathology

The findings from comparing models of psychopathology symptoms are equivocal. Studies using taxometric analysis show that many forms of psychopathology are dimensional (Haslam et al., 2020). That being said, given the limitations of the method noted above, we should be cautious in viewing the tension between dimensional and categorical classifications as resolved. Other studies that use fit statistics to compare latent variable models show mixed support for different models: Muthén

(2006) found that a proper factor mixture model (hybrid) provided the best description of alcohol use disorder symptoms, but McBride et al. (2011) reported that a factor analysis model (dimensional) provided the best fit. Conflicting results also have been reported in other areas of psychopathology, including depression (Lubke & Tueller, 2010; Sunderland et al., 2013) and borderline personality disorder (Conway et al., 2012; Johnson & Levy, 2020). Thus, given the mixed evidence we believe that whether various forms of psychopathology are purely dimensional or include categories is still an open question.

Research Methods Considerations

Whether one views psychopathology as dimensional or categorical influences various aspects of research methods. Advocates of dimensional diagnosis argue that psychopathology should only be treated as a continuous rather than discrete variable in statistical analyses, that it is imperative to use less restrictive criteria for sampling participants, and that the case-control design should be abandoned (Conway et al., 2019). Based on the extant literature, we do not believe that the dimensional-versus-categorical question has been definitively settled and worry about prescribing all the shifts in methods encouraged by proponents of the dimensional approach. We do not believe sufficient data supports a move to always analyze psychopathology as a continuous variable or to not use case-control designs; however, we certainly agree that inclusive sampling is critical.

Treating Psychopathology as a Discrete or Continuous Variable

Consider research on the relationship between delay discounting (represented as a continuous variable) and attention-deficit/hyperactivity disorder (ADHD). A categorical analysis would first sort participants into discrete groups based on ADHD symptoms and then look for group differences in delay discounting. A dimensional analysis would use regression to relate delay discounting to a continuous measure of ADHD symptoms. Which is the correct approach?

As noted above, some (but not all) studies support a hybrid model with both categories and dimensions for certain forms of psychopathology (e.g., Clark et al., 2013; Muthén, 2006). Additionally, in the ADHD example much of the literature on ADHD and delay discounting uses DSM diagnoses (e.g., Jackson & MacKillop, 2016), providing a pragmatic reason to do similar analyses for the sake of comparison. Thus, there are at least two cases where researchers could treat psychopathology

as categorical: (1) when analysis of symptom data supports data-driven categories and (2) when using DSM diagnoses is needed for replication and extension from previous research. This does not preclude the use of dimensional analyses, but the rationale should be stated (or better yet, tested) rather than presumed.

Sampling

Sampling is a fundamental aspect of the research process. To date, sampling strategies are often too restrictive in terms of eligible target populations and comorbidities. Historically, there have been many reasons given for restrictions in sampling. Often, researchers have excluded particular individuals to either reduce the effects of confounding from other variables or because it was not practical to recruit a diverse sample (Ellard-Gray et al., 2015). However, it is important that the sample include a wide range of individuals with diverse backgrounds and levels of psychopathology (Haeffel et al., 2022; Kaiser & Weaver, 2019).

One way in which samples have been restricted is through the excess use of exclusion criteria (Charlson & Wells, 2022; Newman et al., 1998). To illustrate the point, we look at some research on substance use disorders. Many studies on alcohol treatment exclude people with neurological impairment and problems with drugs (Monahan & Finney, 1996). However, approximately 50–80% of those with alcohol use disorder show neurological impairments (Maillard et al., 2020; Oscar-Berman et al., 2014) and approximately 38% have another comorbid substance disorder (Saha et al., 2018). Furthermore, Humphreys and Weisner (2000) found that common exclusion criteria (e.g., serious medical problems, neurological impairment, other substance use problems) result in samples that miss those with more severe alcohol use whose backgrounds and experiences may hold significant clues as to the efficacy of treatment and to the factors related to initiation, maintenance, or desistance from alcohol misuse. In research on the classification of psychopathology, which ultimately seeks to identify the true structure of and relationships among symptoms, it therefore becomes imperative to have a sample that represents the characteristics of the population with these symptoms (Haeffel et al., 2022; Humphreys & Weisner, 2000; Shen et al., 2011; Steinley & Brusco, 2008). Almost any restriction due to exclusion criteria undermines external validity and runs the risk of studying participants whose etiopathogenesis and symptom structure differ from those of the population of interest.

It also is crucial to consider the range of psychopathology severity in a sample. Clinical scientists continue to overrely on college students and other samples of convenience (Roberts & Ilardi, 2008). Although this

may allow for larger sample sizes, these samples often do not include a sufficiently broad range of severity levels of psychopathology and do not resemble the clinical population of interest.

As a result, researchers may not be able to distinguish between categories and dimensions reliably and the factor loading estimation in factor analysis may be biased (Franco-Martínez et al., 2023). For example, Steppan et al. (2014) found that including versus excluding people with at least one criterion for alcohol abuse and dependence (from DSM-IV) changed the dimensionality of factor-analytic models. As another example, sampling on the low range of alcohol use resulted in a dimensional structure when, in reality, high levels of alcohol increased the likelihood of other symptoms (e.g., use of other substances), which then resulted in different symptoms and a different structure of high alcohol use (Helle et al., 2020). Thus, who, how, and, where participants are sampled from can affect the levels of observed severity, which can influence findings on the structure of psychopathology.

Design

Some researchers who advocate for dimensions suggest that case-control designs no longer have a place in research (Conway et al., 2019). However, as we have argued, categories may play an important role in understanding the structure of psychopathology as well as other clinically relevant features (e.g., biological sex, race/ethnicity, or specific experiences [e.g., combat trauma vs. other types of traumas]). Some research supports the existence of categories in certain forms of psychopathology (e.g., Clark et al., 2013), which allows for the comparison of different groups in a case-control design. In a study on anxiety sensitivity, Volarov and colleagues (2020) identified a three-class structure, and if this research is replicated, then a case-control design based on anxiety sensitivity levels may be appropriate. Of note, factor mixture models typically require large sample sizes (Wang et al., 2021), making it difficult to test whether groups should be formed in a specific study. Thus, researchers may have to rely on previous research that has extracted latent categories of psychopathology to decide whether a case-control design is appropriate for a given research question.

Case-control designs may also be justified when participants can be divided into groups based on a clinically relevant categorical variable. For instance, Galovski and colleagues (2013) were interested in whether biological males and females with posttraumatic stress disorder differed in their response to cognitive-processing therapy. Therefore, a case-control design with groups stratified by biological sex was appropriate. Case-control designs can also be used to test theories that posit

the existence of discrete groups. For example, Moffitt (1993) hypothesized that there are two trajectories of antisocial behavior in youth: (1) an "adolescent-limited" group in which antisocial behavior occurs in teenage years and decreases afterwards and (2) a "life-course persistent" in which antisocial behavior starts early in life and persists into adulthood. To adequately test and understand this developmental taxonomy, researchers need to categorize youth into these two groups and assess the extent to which they differ on other variables (e.g., family interactions, brain structure) or even the structure of their symptoms. Ultimately, the choice of a research design should be decided by the research question and no design should be eliminated solely based on its use of categories.

Summary

We urge researchers to be open-minded about the use of both categories and dimensions as classifications of psychopathology. Rather than assuming one model of psychopathology is incorrect, we think there are many opportunities to uncover the structure of psychopathology with appropriate statistical and research methods while keeping in mind practical considerations and the people affected by psychopathology.

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