From Research to Practice: Clinical Utility of Quantitative Nosology

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Author Note

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Abstract

Despite the rising number of evidence-based practices, many practitioners favor personal clinical judgment over evidence for treatment selection. Recommendations to resolve this situation have focused on knowledge translation, a process of moving from what has been learned through research to the actual applications of that knowledge. Here, we additionally suggest establishing a framework wherein research directly aims to facilitate clinicians' decision-making at different stages of treatment for individual clients. To establish such a framework, we revisit the foundation that has guided our understanding of mental illness—psychiatric nosology. This article first compares the conventional categorical nosology (e.g., DSM categories) to two types of modern quantitative nosology—the dimensional (e.g., HiTOP) and network approach—which emerged to overcome the shortcomings of categorical nosology. We then review the current state of these two types of quantitative nosology regarding their clinical utility in assessment, explanation of functional impairment, prognosis prediction, treatment selection, and outcome monitoring. Lastly, we suggest future directions for each approach considering their unique methodological advantages and recommend unifying the dimensional and network approaches to establish a comprehensive framework that can inform clinicians at different treatment stages.

Keywords: science-practice gap, nosology, classification, diagnostic system, dimensions, HiTOP, network

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There has been growing urgency in bridging the gap between researchers and practitioners. In 2005, with the hope to better integrate diverse perspectives, the APA appointed a wide range of scientists and practitioners to serve on the Presidential Task Force on Evidence-Based Practice and urged for its funding priorities (APA Presidential Task Force on Evidence-Based Practice, 2006). The task force defined evidence-based practice (EBP) in psychology as “the integration of the best available *research* with *clinical expertise* in the context of patient characteristics, culture, and preferences (p. 273).” In the past few decades, more than 500 interventions that fall broadly into 86 EBPs have been generated (Williams & Beidas, 2019). However, mental health services in the community rarely incorporate these practices; instead, sizeable clinicians hold negative attitudes toward EBPs and favor personal clinical judgment over evidence for treatment selection (Allen & Armstrong, 2014; Nelson et al., 2006; Rye et al., 2019).

The EBP movement did not promote communications across roles, but dichotomized individuals as either “for” or “against” EBPs. Practitioners’ lingering doubts on EBPs may be due to several factors, such as mischaracterization of EBPs, naïve realism, misconceptions of human nature, lack of knowledge and training resources (Lilienfeld et al., 2013). However, their skepticism may also result from valid criticism of EBPs (see Weisz, Ng, & Bearman, 2014). On the other hand, researchers and EBP advocates often dismiss the negative attitudes against EBP as either (educable) ignorance or (ineducable) anti-intellectualism (Lilienfeld et al., 2013). In line with the view of many researchers, health institutes and organizations often assumed the culprit of low treatment effectiveness lies in a leaking pipeline of information dissemination and

explicitly called for a focus on translating research findings to practice (Collins et al., 2011; National Institute of Mental Health, 2000).

Implementation science emerged in response to the call for accelerating knowledge translation. Implementation studies focus on the implementation process of EBP and examine strategies at the provider, organization, and policy level to increase the rates and quality of the use of EBP (see Bauer, Damschroder, Hagedorn, Smith, & Kilbourne, 2015). Hitherto, researchers have identified abundant clinician-, organization-, and policy-level determinants of implementation outcomes, and the field aims to advance on integrated, multilevel, causal theories (Williams & Beidas, 2019). With fruitful outcomes in the past few years, implementation science has become a priority area for research funders such as the National Institutes of Health (2019).

Despite the valuable contributions of implementation science, it lies at the end of the translational spectrum of applied science (Lomas, 1993) and serves as a one-way (i.e., researchers to practitioners) bridge. Results from implementation studies may inform how to educate EBP on clinicians (Bauer et al., 2015; Proctor et al., 2009) but rarely impact the knowledge and treatment development. For example, clinicians rated the beneficial features of EBPs, such as their effectiveness and adaptivity for complicated cases, as the *least* changeable factor. Further, they viewed it as their (instead of researchers') responsibilities for EBP modification and refinement to achieve individual client needs and better clinical utility (Green & Aarons, 2011). The survey results demonstrate that the current implementation framework has imposed an unnecessary burden on clinicians without empowering them to express their needs to researchers.

A two-way bridge (i.e., researchers to practitioners and vice versa) that allows clinicians' voice to inform research designs is a requisite, considering the current EBP is nowhere close to satisfactory (see Weisz et al., 2014 for the implementation cliff). This statement above is not an innovative thought. In 2014, Goldfried and colleagues proposed the same approach to this vexing problem. They argued that merely disseminating research findings to practitioners (as has typically been the case) is a one-way solution insufficient to close the researcher-practitioner gap. They suggested a two-way bridge with which practitioners can also disseminate their clinical experiences to researchers for joint consensus. Practice-oriented research, anchored in clinical routines and based on the collaboration among researchers and clinicians, has been proposed as the opposite bridge lane (Castonguay et al., 2013). It has been conducted in many natural clinical settings with different types of partnerships and serves as an excellent collaboration framework. (Castonguay, Youn, et al., 2015; Castonguay & Muran, 2014). However, despite its emphasis on equality among different roles, researchers' knowledge about research methods may put clinicians at a disadvantage to initiate research ideas.

Therefore, before collaboration, it is crucial to recognize the fundamental distinction between researchers' and practitioners' epistemic needs (Cha & DiVasto, 2017; Lilienfeld et al., 2013; McFall et al., 2015). Researchers pursue a nomothetic understanding (i.e., relating to the discovery of general rules) of human behaviors across settings. For example, the core focus of treatment development in the past 40 years has been "the creation and evaluation of well-specified treatment manuals focused on well-defined syndromal categories (Hayes, Long, Levin, & Follette, 2013, p. 871)." On the other hand, practitioners require idiographic comprehension (i.e., considering individual differences) for personalized treatment, given that differential treatment responses are the rule, not the exception (e.g., Bagby et al., 2008; Owens, Hinshaw,

McBurnett, & Pfiffner, 2018; Vittengl, Clark, Thase, & Jarrett, 2013). To solve idiographic problems with nomothetic EBPs, practitioners can only seek supervisors, colleagues, and case studies, instead of researchers and empirical outcomes, for further guidance (Allen & Armstrong, 2014; Nelson et al., 2006).

Idiographic research designs are a possible solution to the therapist's dilemma of treating individual problems with group-level information and are more executable today than ever. Dating back to the late 20th century, the desire to evaluate individual treatment processes and effects has led researchers and practitioners to advocate for an increased idiographic focus in psychotherapy research (Howard et al., 1996). Idiographic methods have existed for decades (for a review, see Russell, Jones, & Miller, 2007). However, due to limitations in data collection (e.g., a lack of large longitudinal and comprehensive study) and complexity of analytic techniques (e.g., conventional methods has limited ability in processing high-dimensional data), idiographic methods have not been commonly used within a research or clinical setting in the past.

Nevertheless, we observed clear signs indicating the increasing accessibility and feasibility of idiographic methods. The government has launched nationwide longitudinal studies in the past few years, such as the Adolescent Brain Cognitive Development (ABCD) Study (<https://abcdstudy.org/>), with widened scopes and increased frequency in the assessment. Another sign is the increasing availability of dynamic data collection methods via smartphones, such as the ecological momentary assessment, which enhances our understanding of individual processes during psychotherapy (Fisher & Boswell, 2016; Myin-Germeys et al., 2009). Researchers in Penn State University also pioneered the transformation of a graduate training clinic into a practice research network, where individual treatment outcome data can be collected

via the Treatment Outcome Package (Kraus, Seligman, & Jordan, 2005) repeatedly within the course of treatment (Castonguay, Pincus, et al., 2015). Innovative statistical methods (e.g., dynamic structural equation modeling, network analysis, autoregressive integrated moving average models, Bayesian time-series analysis) can better capture complicated individual processes. We can now conduct these advanced modeling with free and open-source software programs, such as the *R* language and environment (R Core Team, 2015), accompanied by *R* packages with user-friendly guides (e.g., *bsts*, Scott, 2014; *forecast*, Hyndman et al., 2020; *graphicalVAR*, Epskamp, 2018; *gimme*, Lane, 2020; *lavaan*, Rosseel et al., 2020).

The previous statement often entices scholars to pursue complex analyses; however, the real question is not what analysis shall we use, but where shall we start with idiographic research? We cannot grow a garden of Eden by planting random seeds. Moderator studies have investigated various idiographic factors that result in differential responses to treatment (e.g., personalities; Bagby et al., 2008; demographic variables and symptom clusters; Owens et al., 2018). Mediator studies have investigated individual symptom trajectories and causal chains within the course of treatment (Bosley et al., 2019). Despite progress in the past few decades, we lack a concrete framework wherein idiographic research aims directly to facilitate clinicians' decision-making at different stages of treatment for individual clients. One potential starting point for establishing such a framework is *psychiatric* nosology, a foundation that guides our conceptualization, communication, investigation, and implementation.

Three Overarching Frameworks of Psychiatric Nosology

Categorical Nosology

The categorical view of psychiatric nosology originated from the medical field. Kraepelin, known as the founder of modern scientific psychiatry, believed that psychiatric

diseases originated from *separate* biological processes and advocated for a categorical view of psychiatric nosology (Kraepelin & Diefendorf, 1915). Although Kraepelin recognized that there was no concrete evidence to construct a final classification, he classified mental problems into several syndromic categories based on the common medical assumption that similar disease processes should result from identical etiology and would produce identical symptom profiles. Kraepelin's categorical view and classification system paved the way for the *medical disease model*—characterized by distinct pathology that manifests as a series of symptoms that guide the diagnosis and treatment of the *disease* (Tinetti & Fried, 2004)—to enter the mental health field.

To treat the “disease,” the field requires an official classification system. Recognizing the lack of consensus among mental health professionals, the World Health Organization (WHO) sponsored a comprehensive review of diagnostic issues (Stengel, 1959). Stengel considered *operational definitions* as a means to reliable clinical diagnoses and a solution to the lack of knowledge regarding pathology and etiology. The demand for operational definitions contributed to the sharp boundaries among diagnoses and between normality and pathology. The WHO and the American Psychiatric Association (APA) have endorsed Stengel's suggestion. They worked closely to compile a series of explicit criteria for each mental disorder as a categorical concept, published as the *International Classification of Diseases* (ICD) and *Diagnostic and Statistical Manual of Mental Disorders* (DSM), respectively and developed assessment instruments according to their diagnostic algorithms (see APA, 2016; Stein et al., 2020; WHO, 2004 for reviews on the history).

The ICD and DSM classification systems have shaped our conceptualization of mental disorders. The ICD and DSM diagnostic algorithms impose sharp cutoffs between normality and pathology. The public tends to picture “normality” to be qualitatively different from

“abnormality.” Even many studies on psychopathology abided by the dichotomous labels (i.e., with or without a diagnosis) from diagnostic instruments. Although the classification systems picture each disorder as a distinct category, the DSM workgroup acknowledged that the current categories are heterogeneous in etiology and symptom profiles (APA, 2013). Due to the arbitrary cutoffs between disorders, comorbidity is the norm rather than the exception (Widiger & Samuel, 2005). In response to the criticisms on arbitrary cutoffs, the latest revision made the boundaries between disorders more “fluid (APA, 2013, p. 5)” by loosening exclusion criteria and allowing more overlapping diagnoses. However, the revision process paid little attention to diagnostic specificity, with the apparent evidence that multiple diagnoses share the same symptom criteria (e.g., concentration problems in depression, PTSD, and ADHD). The systems also had a limited focus on depicting the relationships between disorders. The higher-order classifications in the current systems are not a direct reflection of comorbidity (e.g., generalized anxiety disorder is grouped with other anxiety disorders while it has higher comorbidity with depression). Quantification of inter-disorder relationships was mostly carried out to split or merge existing disorders (e.g., Grant et al., 2006; Hasin et al., 2013). In sum, the ICD and DSM classification systems have shaped our understanding of mental disorders as categorical entities with perplexing intra- and inter-diagnostic features (Clark, Watson, & Reynolds, 1995; Hasler, Drevets, Manji, & Charney, 2004; Zimmerman, Ellison, Young, Chelminski, & Dalrymple, 2015).

Despite its imperfections, the categorical nosology has been widely accepted through generations for their perceived utility. Categorical labels fit with human nature in prototypical thinking (Rosch, 2002) and are thus easy to be used in conversation. Diagnostic labels are convenient in research design and conventional statistical methods in psychology (e.g.,

ANOVA). Health, school, and social systems mostly require definitive diagnoses for service delivery. Most importantly, the ICD and DSM have endeavored to strike a balance between novel proposals and continuity across versions to ensure the accessibility of prolific epidemiological data in the past and to maintain health policy coherence (Reed, 2018).

However, researchers and clinicians have repeatedly voiced their dissatisfaction with the categorical paradigm. There is no empirical evidence supporting the categorical view of mental disorders or the sharp boundaries between normality and pathology (see Kotov et al., 2017). Many patients may fall short for diagnostic criteria despite manifesting significant distress and impairment, while the current health, school, and social systems have limited capability providing services to subclinical patients. The within-disorder heterogeneity and comorbidity render the current diagnoses with limited reliability, research progress, and clinical utilities. The DSM-5 Field Trials found that 40% of diagnoses did not meet a cutoff for acceptable reliability (Regier et al., 2013). The diagnostic categories are the primary units in clinical research and treatment development. Heterogenous units may distort research findings, hinder treatment development, and thus decrease clinicians' adherence to treatment manuals (Francke et al., 2008; Goldberg, 2011; Milaneschi et al., 2016; Stewart et al., 2012; Weisz et al., 2014).

In sum, categorical nosology has an important historical position and unique contributions to the development of modern mental health. The ICD and DSM systems feature dichotomous cutoffs between normality and pathology, allow comorbidity, and are prone to within-disorder heterogeneity. These categorical classification systems have been accepted widely due to its perceived utility in communication, research design, epidemiological data accessibility, and policymaking. However, within-disorder heterogeneity and comorbidity may hinder research development and service delivery.

Quantitative Nosology

Dimensional approach. A potential solution to the shortcomings of traditional categorical classification emerged with the quantitative movement in the form of a dimensional approach (see Kotov et al., 2017). The quantitative movement began with the application of factor analysis on psychiatric patients' characteristics to identify empirical symptom dimensions (Eysenck, 1944; McNair & Lorr, 1964; Moore, 1930; Overall & Gorham, 1962; Wittenborn, 1951). Symptom dimensions of children and adolescents remain widely used in child psychopathology and pediatric clinic (Achenbach, 1985), while the DSM categorical nosology has dominated the adult mental health field since the 80s. Still, a group of researchers continued with the dimensional approach to comorbidity among adult mental disorders (Krueger, 1999; Krueger et al., 1998; Wolf et al., 1988) and maladaptive personality traits (e.g., Clark, 2005; Saulsman & Page, 2004). Their findings on higher-order dimensions in psychopathology have inspired a growing and diverse literature and led to the formation of the Hierarchical Taxonomy of Psychopathology (HiTOP) consortium.

The HiTOP consortium aimed to integrate empirical evidence from psychopathology to outline a *hierarchical* system featuring the following characteristics. In contrast to a categorical view, a dimensional nosology defines psychopathology as *dimensions* of psychological function that range from normal to abnormal without arbitrary cutoffs. The identification of dimensions is based on observed *covariations* among symptoms, maladaptive behaviors, and personality traits. Primary dimensions can be further combined into higher-order factors, resulting in a hierarchical structure (see Fig. 2 in Kotov, Waszczuk, et al., 2017). The HiTOP model consists of six levels, namely (from lowest to highest): (1) symptoms/signs/maladaptive behaviors, (2) symptom components (e.g., insomnia) and maladaptive traits (e.g., separation insecurity), (3) dimensional

syndromes (e.g., separation anxiety disorder), (4) subfactors (e.g., fear dimension), (5) broad spectra (e.g., internalizing spectra), and (6) super-spectra (e.g., the general factor of psychopathology).

The HiTOP model has demonstrated great advantages in reliability, validity, and practicality. The dimensional results are more stable across the lifespan and replicable than a categorical approach (e.g., Eaton, Krueger, & Oltmanns, 2011; Kotov et al., 2020; Snyder, Young, & Hankin, 2017). The inclusion of maladaptive behaviors and personality traits broadens the symptom criteria of psychopathology and better captures the relationships between mental and personality disorders (Bender, 2019; Bornstein, 2019; James & Taylor, 2008; Kendell, 2002). The hierarchical structure accounts for comorbidity and can be tailored to focus on any level depending on the desired degree of specificity. The consortium also arranged a list of evidence-based dimensional measures relevant to the HiTOP model for research and practical use (Kotov et al., 2017). Importantly, the HiTOP model provides a framework for knowledge integration with six workgroups focusing on a wide range of topics, ranging from neurobiological studies to clinical translation (<https://renaissance.stonybrookmedicine.edu/HITOP/workgroups>).

However, the HiTOP model is not exempt from limitations. Factor analysis assumes that the latent factor (e.g., a higher-order spectrum) is the *cause* of the observed covariation among items (e.g., symptoms). Thus, the HiTOP model derived from factor analysis is incapable of depicting direct relationships among lower-order items. For example, the unidirectional transition from generalized anxiety to depression (Schoevers, Deeg, van Tilburg, & Beekman, 2005) cannot be captured by the model. Despite a broad inclusion of symptoms, maladaptive behaviors, and personalities to estimate psychopathological dimensions, idiographic factors that

are not a direct representation of mental illness (e.g., low social support, stress, SES, family environment) are excluded from the model. Although higher-order spectra are associated with impairment and early adversity, the practical meanings of these dimensions are debatable (Bender, 2019; Caspi et al., 2014). Hierarchical models are often the *best* model compared to models with alternative structures based on model indices. However, recent research showed that model indices are biased toward hierarchical models (particularly, bifactor models) over other model structures (Greene et al., 2019), leading us to question the evidential meaning of previous studies on the structure of psychopathology.

In sum, dimensional nosology emerged to address the shortcomings of traditional categorical nosology. The recent HiTOP model features a hierarchical structure with dimensions derived from symptoms, maladaptive behaviors, and personalities. The HiTOP model demonstrates excellent research and practical advantages and serves as a framework for information integration. However, the HiTOP model falls short of capturing intra-level item relationships (e.g., symptom relationships) or reflect environmental influences. Additionally, the meanings of the higher-order dimensions remain unsettled.

Network approach. Clinicians commonly considered mental problems as complex causal networks of psychological and environmental components. Beck's (1995) Cognitive Conceptualization Diagram provided therapists with boxes and arrows displaying the causal relationships among relevant childhood data, core beliefs, conditional beliefs, compensatory strategies, and overt difficulties. Contemporary case conceptualization in Cognitive Behavioral Therapy (CBT) follows a similar framework of Beck's and incorporates additional links with behavioral, biological, psychosocial, and environmental factors (Zubernis & Snyder, 2016). Individuals' situational reactions can also be universally illustrated as reciprocal links among

situations, thoughts, affects, intentions, responses, consequences, and self-evaluation (Goldfried, 2010). In addition to CBT, other schools of thoughts, including interpersonal psychotherapy, psychodynamic approaches, and emotion-focused therapy, also consider mental illness as causal links among a set of situational, affective, cognitive, and behavioral factors with a stronger emphasis on interpersonal effectiveness (Jacobson & Mufson, 2012), defensive mechanisms (Eells & Lombart, 2003), and emotional experiences (Timulak & Pascual-Leone, 2015), respectively.

Despite the widespread use of causal network diagrams in case conceptualization, only recently did quantitative models for complex networks enter psychological science. These models are referred to as “network models” derived from “network analysis.” Network analysis has been developed and applied in various scientific fields (Barabási, 2012). Borsboom and Cramer (2013) introduced network analysis to the mental health field as “the new game in town (p. 93)” with the potential to match the complexity of mental disorders. Network researchers suggest conceptualizing and studying mental disorders as networks of interacting symptoms. To portray the interactions of symptoms, researchers formulate psychological networks that consist of nodes representing observed symptoms, connected by edges representing statistical relationships among these symptoms (Borsboom & Cramer, 2013; Jones, Heeren, & McNally, 2017; Nijten, Deserno, Cramer, & Borsboom, 2016; Schmittmann et al., 2013). The network approach may not be intuitively considered as a branch of nosology because it lacks concrete boundaries among clusters. However, the relationships among syndromic clusters and the likelihood of comorbidity can be easily measured with the number and strength of symptom connections (Cramer, Waldorp, van der Maas, & Borsboom, 2010; Wigman et al., 2015). Clustering methods can also be applied to network models for cutoffs between disorders (e.g.,

Saxena et al., 2017), albeit not recommended for clinical research where little evidence supports mental disorders as distinct categories.

The number of network studies has been exponentially increased (see Fried et al., 2017, for a review) for apparent reasons. The network framework provides compelling rationales in line with clinical case formulation. Like a dimensional nosology, the network approach can well capture comorbidity and explain relationships among clusters. Additionally, network methods evolve quickly in response to constructive criticism with detailed tutorial papers and user-friendly statistical tools in the *R* programming environment (e.g., Epskamp, Borsboom, & Fried, 2017; Epskamp, Cramer, Waldorp, Schmittmann, & Borsboom, 2012; Jones, Mair, & McNally, 2018). Idiographic factors other than symptoms can be easily incorporated into a network model as nodes. Further, with time-series data, network models can depict complex dynamics among symptoms (and with other risk factors) at an individual level.

The network approach also has limitations. Despite the rapid improvement in network methods, models for high-dimensional data (i.e., models consisting of a large number of variables) are often sensitive to noise and measurement errors (Forbes et al., 2017). Network researchers must conduct sensitivity and stability analyses in every study, while many researchers may struggle with the complexity of these analyses. Current network models can accommodate multiple types of variables (Haslbeck & Waldorp, 2015); however, the robustness of network estimation with variables skewed from a Poisson or Gaussian distribution is relatively unclear. The implication of commonly used network indices (e.g., centrality) in psychopathology requires further investigation (Bringmann et al., 2019). Lastly, studies of network research lack an overarching framework for knowledge integration.

The network approach is an emerging framework in clinical psychology. Within this framework, mental problems are conceptualized as complex interactions among symptoms and other psychological/risk factors. A network model consists of observed variables (e.g., symptom) as nodes, connected with edges representing their statistical relationships. The network approach has attracted substantial attention in the past few years with its compelling rationale, flexibility in variable selection, and ability to depict individual dynamical changes. However, network analysis is complicated and requires further attention in its stability/replicability and investigation in its statistical properties.

Toward Individualized Treatment with Quantitative Nosology

Current State of Quantitative Nosology

Dimensional Approach. The HiTOP consortium has developed a consensual hierarchical dimensional model that better aligns with the natural organization of psychopathology. The HiTOP model covers the majority of psychopathology forms, including transient symptoms and stable maladaptive traits. It addresses comorbidity by identifying higher-order dimensions that reflect associations among variables (e.g., symptoms) or lower-order dimensions, allowing researchers to study shared characteristics among mental problems at different levels. Further, the dimensional approach in psychiatric nosology has been found with greater reliability and stronger associations with validators (e.g., shared genetic risk factors, biomarkers, shared environmental risk factors) than the categorical nosology (Andrews et al., 2009; Keyes et al., 2012; Kotov et al., 2017; Markon et al., 2011).

The HiTOP dimensions outperform categorical diagnoses in accounting for long-term chronicity and functional impairment. Longitudinal studies have demonstrated long-term stability of the HiTOP structure in early adolescence, young adults, middle-aged adults, and

older adults (Eaton et al., 2011; Reitz et al., 2005; Vollebergh et al., 2001). Higher-order dimensions in the HiTOP model (e.g., the internalizing and externalizing spectra and the general factor) can better predict future pathology than disorder-specific variance (Kim & Eaton, 2015). The internalizing spectrum (includes phenomena such as depression, anxiety, and phobias) predicts future suicide attempts and a set of medical conditions (Eaton et al., 2013) and fully accounts for functional impairment associated with mood and anxiety symptoms. (Markon, 2010; Waszczuk et al., 2017). The externalizing spectrum (including phenomena such as conduct problems, substance use, and antisocial personality traits) has excellent validity in capturing characteristics associated with criminal offenses (Venables & Patrick, 2012) and jointly explains marital distress with the internalizing spectrum (South et al., 2011). Additionally, in children, the severity of externalizing spectrum is associated with within-family change of parental warmth and family conflicts, supporting the family-based treatment approach in child externalizing problems (Lin et al., 2021).

The thought disorder spectrum (including phenomena such as schizophrenia, schizotypal, and paranoid personality traits) fully accounts for impairment associated with psychosis (Jonas & Markon, 2013). The general psychopathology factor is associated with higher levels of life impairment, childhood adversity, compromised brain integrity (Caspi et al., 2014), and predicts prospective school functioning (Lahey et al., 2015).

The HiTOP model can also inform and facilitate clinical practice. Available HiTOP-related measures (see Table 1 in Kotov et al., 2017) allow practitioners to implement quality assessment in an efficient stepwise manner (Krueger et al., 2018). The stepwise assessment begins with a brief measure of the higher-order spectra, followed by lengthier measures to characterize lower dimensions within the elevated spectrum. Clinicians can obtain an

individual's profile of relevant dimensions that are potentially more informative than categorical diagnoses in clinical decision-making (e.g., Morey, Skodol, & Oldham, 2014; Verheul, 2005). Hopwood and colleagues (2019) have demonstrated the procedure of case formulation and treatment selection based on a HiTOP profile, in which the high-order dimensions can guide transdiagnostic treatment selection for a comorbid case. Further, HiTOP has demonstrated its utilities in transdiagnostic treatment development, such as the unified protocol for emotional disorders (Barlow et al., 2020).

In sum, the dimensional approach with the HiTOP model can better explain and predict chronic mental health conditions and functional impairment. The HiTOP suggests a stepwise assessment protocol that returns a dimensional profile with rich personal information. Such a profile can inform initial case formulation and transdiagnostic treatment selection. Further, increasing transdiagnostic treatments have been developed accordant with the HiTOP framework.

Network Approach. Researchers have applied a network approach to various mental disorders (see Contreras, Nieto, Valiente, Espinosa, & Vazquez, 2019; Fried et al., 2017; Robinaugh, Hoekstra, Toner, & Borsboom, 2020 for reviews). Most network studies are exploratory, in which mood disorders, post-traumatic stress disorder, psychosis, and comorbidity are the most studied areas (Contreras et al., 2019). Network research initially focused on identifying central (i.e., the most interconnected) symptoms in the network. A prospective study found that central depressive symptoms (e.g., anhedonia, depressed mood, fatigue, and concentration problems) could better predict the onset of future MDD than non-central symptoms. Weighted severity scores based on symptom centrality outperformed the traditional severity scores based on symptom counts (Boschloo et al., 2016). However, the clinical

implication of symptom centrality requires further investigation. Central symptoms are meaningful for intervention only if they are upstream determinants in the causal path. Further, the meaning of centrality may not be universal across disorders or situations (see Bringmann et al., 2019).

Another important feature in a network model is the connectivity among symptoms, which provides an alternative view to disorder boundaries and prognosis. A simulation study suggests that the boundary between health and pathology varies as a function of network connectivity (Borsboom et al., 2016). In a weakly connected network, activation within the network spreads slowly to other nodes, resulting in continuous (i.e., dimensional) states. Contrarily, in a strongly connected network, any activation within the system rapidly cascades into a severe pathological state (i.e., all symptoms are activated), yielding a sharp boundary between normality and pathology. Further, a highly connected network may shift from a trigger-determinant state to a self-maintained state after the initial activation, resulting in an onset of a disorder episode or chronic mental illness. For example, an individual with depressive tendencies may show excessive responses to a stressor (e.g., being criticized for a work mistake) and remain in a negative state for a prolonged period after the initial trigger disappears. In line with such conceptualization, empirical studies showed that connectivity of temporal emotional networks in patients with major depression and psychosis is stronger than those of healthy controls (Pe et al., 2015; Wigman et al., 2015). Higher levels of connectivity in depressed patients at baseline also predicted worse prognosis at a 2-year follow-up even after controlling for severity (van Borkulo et al., 2015).

Network researchers later expanded their focus from inter-symptom relationships to the complex interplays among symptoms and other risk or environmental factors. For example,

researchers have studied the role of attentional bias in social anxiety symptom networks (Heeren & McNally, 2016), biomarkers (Santos et al., 2017) and resilience (Hoorelbeke et al., 2016) in depressive symptom networks, and screen time behaviors in mood symptom networks (Lin, Eaton, et al., 2020). Most studies included risk or environmental factors as nodes in the network, whereas a few studies treated them as categorical (Cramer, Borsboom, Aggen, & Kendler, 2012) or continuous (Lin, Fried, et al., 2020) variables associated with network connectivity. The inclusion of risk and environmental factors in network models can improve our understanding of complex psychopathological phenomena with multiple etiologies or maintaining factors and facilitate individualized prognosis predictions.

Another emerging research trend is the estimation of individual networks with time-series data, which offers a promising gateway to the understanding of complex psychological dynamics at the individual level (Bringmann et al., 2017; Epskamp et al., 2018). Technological advances permit the collection of intensive time-series measures of symptoms, emotions, and other daily fluctuating factors with the experience sampling methods or ecological momentary assessment (Piccirillo, Beck, & Rodebaugh, 2019). With time-series data, researchers can estimate personalized symptom networks and monitor dynamical changes among clinically relevant variables in various natural settings. Several single case studies have estimated symptom or emotion networks of patients with anxiety, depression, or psychosis. Some studies have gathered more than 1000 measures of a single person. (Bak et al., 2016; Kroeze et al., 2017; Wichers & Groot, 2016). Fisher and colleagues (2017) expanded their research scale to 40 patients and presented the study as an exemplar for translating such methods into routine clinical assessment and psychotherapy. Such personalized knowledge can be used for dynamic treatment selection

(allowing flexible treatment selection based on a client's weekly status), progress monitoring, and detection of early signs for remission or relapse.

In sum, the network approach has been applied to various mental disorders. Network models allow us to identify central symptoms that are potentially effective treatment targets (pending for clinical trials). Symptom connectivity provides us an alternative way to think of continuity versus discrete mental states between normality and pathology. Highly connected symptom networks may be an indicator of severity and a predictor of worse prognosis. With the inclusion of risk and environmental factors, we can approach psychopathological phenomena as complex interactions among multiple etiological and maintaining factors. Lastly, individual networks based on time-series data provide promising potential to reveal complex interplays among daily fluctuating variables and psychopathology at the individual level.

A Comparison Between the Dimensional (HiTOP) and Network Approaches

Both approaches aim to overcome shortcomings of the categorical nosology but differ in theories. To unveil the natural structure of psychopathology, the HiTOP model extracts common variance from symptoms, maladaptive behaviors, and personality traits as hierarchically arranged latent psychopathological factors. The network model depicts causal, dynamical relationships among symptoms with the inclusion of other risk factors. These two approaches seem to endorse fundamentally different assumptions. The HiTOP model assumes latent causal relationships, where the relationships among observable variables are explained by a latent causal factor, whereas the network model emphasizes mutual causal relationships among observable variables.

However, the two models can be compatible if we think outside the methodological terms (Bringmann & Eronen, 2018). For example, individuals with depression diathesis may endorse a dysfunctional attributional style. Once exposed to stressors, they tend to exhibit higher levels and

prolonged periods of depressive mood, accompanied by other cognitive (e.g., difficulties in concentration) and somatic symptoms (e.g., interrupted sleep and changes in appetites). These symptoms may be self-sustaining due to a maladaptive attributional style (e.g., blaming self for functional impairment caused by depressive symptoms). When we extract the shared variance among depressive symptoms, we may capture their depression diathesis (e.g., attributional styles) as a latent factor. When we project the depression diathesis to a two-dimensional space, we see a dynamic causal chain among symptoms. Sometimes the diathesis can be treatable (e.g., cognitive treatment on attributional errors), and sometimes the symptoms should be focused first to break the vicious cycle (e.g., behavioral activation for severe depression).

As reviewed above, these two approaches have differential clinical utility. The HiTOP approach provides clinicians with individuals' dimensional profiles that contain rich, personalized information to guide initial treatment selection. The network approach can incorporate ideographic risk factors for an integrated conceptualization that facilitates treatment modification. It can also be applied to monitor dynamical changes along with treatment and provide instant feedback to clinicians. The marriage of these two approaches may potentially provide clinicians a holistic framework, where they can obtain different kinds of information that guides their decision-making at any desired level of focus.

Future Steps toward Better Clinical Utilities

Individualized treatment is required in natural clinical settings. Some clinicians are against evidence-based practices (EBPs) because many of EBPs are designed for categorical diagnostic labels with limited flexibility for comorbidity and complicated cases (Lilienfeld et al., 2013; Weisz et al., 2014). Even for EBP advocates, they need to tailor EBPs for clients' idiographic needs with limited empirical evidence guiding their decisions. In the following

paragraphs, we would discuss how we can improve clinical utilities of future research based on the dimensional and network frameworks to facilitate clinicians' decision-making at different treatment stages.

Dimensional Approach. Clinically, we would expect an individual's assessment scores to reflect the degree of functional impairment, prognosis, and treatment responses. Functional impairment is an important clinical index for service allocation. A few studies showed that higher-order spectra in the HiTOP model could fully explain functional impairment associated with lower-order diagnoses or symptoms (e.g., Jonas & Markon, 2013; Waszczuk et al., 2017). However, when taking a closer look, the higher-order spectra only explained half of the functional impairment variance. Some proposed that functional impairment in self and interpersonal aspects (i.e., the A criterion for personality disorders) may be captured by the general psychopathology factor in the HiTOP model (see Bender, 2019; Widiger et al., 2019), pending for further empirical support.

Additionally, the previous HiTOP studies on functional impairment were conducted at the population level with cross-sectional data. If we hope to incorporate the HiTOP assessment into clinical routines, we urgently need to obtain the *predictability* of HiTOP profiles on functional impairment at the *individual* level. Depending on the obtained predictability, we may want to investigate other risk factors for functional impairment and the interplays among HiTOP dimensions and these factors. Further, if the predictability cannot reach a clinically meaningful level, we may want to consider incorporating direct functional impairment assessment into the HiTOP assessment protocol.

The prognosis is another critical information for clinicians to decide the types, length, and dosage of services for a particular individual, and for the individual to obtain a realist

expectation. Although a study showed that the HiTOP dimensions could better predict future pathology than specific disorder variance (Kim & Eaton, 2015), we are still far from the required precision in clinical settings. To achieve better clinical utility, we encourage researchers utilizing longitudinal data to construct predictive models of HiTOP dimensions on prognostic indices (e.g., length of an episode, probability of remission and relapse) while controlling for treatment histories.

Undoubtedly, we would hope to predict individuals' treatment responses based on their assessment profiles. We currently have a transdiagnostic treatment for mood problems with substantial support for efficacy (Barlow et al., 2020). However, if we want to move toward individualized treatment, we need further investigation of the relationships between different levels of dimensions and treatment responses. We have little evidence on whether higher scores of a broad spectrum predict worse treatment responses. Previous studies have shown that symptom severity, but not comorbidity, was the determinant of treatment response (Mennin et al., 2000). We have no clinical trials investigating if higher scores indicate a need for stronger dosage, longer length, or different types of treatment for better therapeutic effects. We have limited knowledge about which level of dimensions is a better indicator of treatment responses given different symptoms profiles. For example, behavioral activation (targeting anhedonia, a lower-level symptom) is shown to be more effective than a cognitive approach (targeting general cognitive distortions shared by clients with depression and anxiety) as an initial step for clients with severe depression (Dimidjian et al., 2006). Empirical studies of treatment responses based on HiTOP profiles and can further facilitate initial treatment selection and formulation of subsequent treatment plans.

We also need to identify intervenable transdiagnostic factors and link them with relevant treatment modules. Some, especially trainees, may appreciate having a heavy manual called “an integrated therapy of X” containing all potentially relevant treatment modules for a set of mental problems (which is becoming a trend in treatment development; see Hayes et al., 2013) as a tool book. We certainly value such type of information and agree it comes handy in clinical training. However, for licensed clinicians with more complicated cases, heavier caseloads, higher demands in quick decision-making, and limited time in continuous training, such a book may not provide much help. Imagining if transdiagnostic therapy for the internalizing spectrum means conducting all treatments that we used to apply on depression and anxiety (which belong to the internalizing spectrum) to a single client, this certainly does not transcend what we already have in hands. Thus, it is critical to identify intervenable transdiagnostic factors (e.g., attribution errors, cognitive fallacies, assertiveness, a fixed mindset) associated with each higher-order dimension. Then we need to conduct clinical trials to examine specific treatment effects on these high-order dimensions. Network analysis is an excellent statistical method that can be combined with latent dimensions (as nodes) to examine an individual’s dynamical treatment effects on these higher-order dimensions.

As we emphasized previously, HiTOP is an effective framework for information integration and knowledge translation. Embracing a new framework does not mean to abandon previous research findings. We have fruitful research results based on categorical labels that can be easily incorporated with the current HiTOP framework and inform future HiTOP studies (e.g., what may be a potential transdiagnostic factor?). We expect the HiTOP measures to become the first-line clinical assessment and hope the HiTOP field continues research on functional impairment, prognosis, treatment responses, and the identification of intervenable transdiagnostic

factors. We hope that with the integration of the current literature and future findings in the same program, we can automatically output detailed treatment recommendations (and links to relevant resources) for both transdiagnostic and subfactors.

Network approach. The network approach offers the potential to inform individualized treatment but is still in an early stage of development and application. The network analysis field directly borrowed theories and estimation methods from other fields and has minimal insight to the plausibility of these other fields' assumptions on modeling psychopathological phenomena (Bringmann et al., 2019; Robinaugh et al., 2020). For example, we commonly use centrality measures derived from social network theories to detect central symptoms. However, it is unclear if symptom relationships share the same characteristics as those of interpersonal relationships in a social network. Researchers also commonly assume that higher levels of network connectivity would indicate a worse prognosis. However, the only evidence of this assumption is from one prospective network study of depression (van Borkulo et al., 2015). We have no evidence that findings related to depression can be applied to other mental problems directly. To avoid misinterpretation, we urge network researchers to investigate the implications and meanings of commonly used network indices in different psychological networks with longitudinal data. Can initial network connectivity predict later prognosis? How is a central symptom involved in the development of a disorder? Research on the meanings of longitudinal prediction in network models can inform the choice of indices and calibrate our interpretations (e.g., Rodebaugh et al., 2018).

Additionally, problems have emerged along with the shift of focus from symptom relationships to symptom-risk factor relationships. Most studies are cross-sectional and exploratory without a precise aim. To ensure our approach matches the research question, we

will differentiate the two concepts packaged with the same term: risk factor (Schooling & Jones, 2018). The first type of risk factor serves as a *predictor* for risk stratification and service allocation. The second type serves as an *explainer* involved in the process or course of a disease. We recommend investigating predictors' predictability on functional impairment, prognosis, and their interactions with higher-order dimensions (instead of symptoms), to guide general service allocation and clinical referral. Contrarily, network analysis with time-series data is ideal for examining causal paths among explainers and symptoms. However, only a handful of labs have resources for time-series measures, whereas most labs only have access to cross-sectional data. It is, therefore, critical to develop methods to select candidate explainers with cross-sectional data.

Additionally, we encourage network researchers to expand the use of individual dynamical networks to treatment process research. Many non-symptom-focused therapeutic factors are considered critical to positive therapeutic changes, such as bringing a sense of hope, therapeutic alliance, clients' awareness of problems and engagement in corrective experiences, and ongoing reality testing (Goldfried, 1980). With network analysis, we can further investigate how these factors interact with symptoms and idiographic traits. We encourage clinical centers to collect weekly data on symptoms and therapy process components, following the framework proposed by Castonguay and colleagues (2015), and collaborate with research sites to further understand treatment processes.

Lastly, the exponentially growing number of network studies is pressing us to develop post-hoc methods and a framework for information integration. Currently, we have no statistical methods to compare the findings of different network studies. Reviews on network research remain descriptive and lack of a consistent framework for knowledge management. Although the network approach aims to address the shortcomings of categorical nosology, network researchers

still mostly communicate using the DSM framework and selected symptom variables based on the DSM criteria. Instead of following the DSM system, we recommend uniting with the HiTOP framework for better knowledge integration (Eaton, 2015).

Summary

1. To bridge the research-practice gap, we suggest establishing a framework in which research directly aims to facilitate clinicians' decision-making at different stages of treatment for individual clients.
2. One potential starting point for establishing such a framework is psychiatric nosology, a foundation that guides our conceptualization, communication, investigation, and implementation.
3. Conventional psychiatric nosology has taken a categorical approach (e.g., the ICD and DSM) with broad acceptance due to its historical legacy and perceived utility. Criticisms of categorical nosology include arbitrary cutoffs between normality and pathology, comorbidity, and within-disorder heterogeneity. These limitations may obscure research findings and impact clinical utility.
4. Two types of quantitative nosology emerged to overcome the shortcomings of categorical nosology, namely the dimensional approach (e.g., HiTOP) and the network approach.
5. The HiTOP dimensional approach conceptualizes mental disorders as hierarchically-arranged dimensional latent factors derived from symptoms, maladaptive behaviors, and personality traits.
6. The network approach conceptualizes mental disorders as complex interplays among symptoms and other risk factors, focusing on identifying central symptoms and examining symptom connectivity.

7. The HiTOP consortium has established a stepwise (i.e., from broad spectra to subdimensions within the elevated spectrum) assessment that returns an individual's dimensional profile. Such a profile can guide clinicians' initial treatment selection for transdiagnostic factors.
8. The network approach can examine complex symptom relationships with idiographic risk factors and estimate individual dynamical changes among symptoms and other daily fluctuating variables with time-series data.
9. We urge HiTOP research to further focus on
 - a. the predictability of higher-order dimensions on functional impairment and prognosis at the individual level
 - b. differential treatment responses of individuals based on their dimensional profiles
 - c. identifying intervenable transdiagnostic factors
 - d. clinical trials investigating individual dynamical changes of therapeutic effects on transdiagnostic factors using network analysis
 - e. treatment suggestions for different levels of dimensions
10. We encourage future network research to investigate
 - a. the meanings of network indices in longitudinal prediction
 - b. the interaction processes of proximal risk factors and symptoms in individual dynamical networks
 - c. the interaction processes of critical therapeutic factors (e.g., alliance) and symptoms in individual dynamical networks
 - d. post-hoc methods for network comparisons across studies
 - e. knowledge management within the HiTOP framework

11. The unification of the HiTOP and network approach may provide a comprehensive framework to inform clinicians' decisions at different treatment stages. HiTOP dimensions can inform initial service allocation and treatment selection, whereas the network analysis can be performed within the HiTOP framework for personalized treatment adjustment considering idiographic risk factors.

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