

Factor Analytic Support for the Five-Factor Model

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Abstract and Keywords

The Five-Factor Model (FFM) has risen to prominence over the past 50 years, and currently represents the most widely used structural model of personality attributes. By definition, the FFM is built upon a foundation of factor-analytic techniques. This chapter is divided into three parts. In the first, a methodological primer is provided for those who may be less familiar with factor analytic techniques. Second, the FFM and factor analysis are understood through a historical review, along with updated exemplars of contemporary techniques and applications to personality. Finally, several new directions in factor analytic research of the FFM are reviewed, including its application to psychiatric disorders.

Keywords: Five-Factor Model, factor analysis, exploratory factor analysis, confirmatory factor analysis, ESEM, personality structure

If determining the structure of personality traits has been the primary métier of personality psychology through much of the twentieth century and the early part of the twenty-first century, then factor analysis has been the primary tool of the trade. The importance of structure in understanding personality traits and the inventories intended to measure those traits is difficult to overstate—from structure flows the framework that facilitates organization and comprehension of an ever-expanding body of research. In this regard, the consensual Big Five or Five-Factor Model (FFM) is often heralded as one of the crowning achievements of psychological science in the past century. As the predominant structural model of personality traits, much has been written on the conceptual and quantitative roots of the FFM. That is not to say, however, that all structural issues in the personality trait domain have been settled. On the contrary, there remain rapidly expanding literatures and ever-more quantitatively sophisticated and complex studies on a variety of germane topics. Therefore, this chapter goes beyond the

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historical factor analytic evidence for the FFM, and considers the contemporary questions motivating a lively (and at times spirited) scientific debate about the structure of personality and the role that factor analysis plays in this discussion.¹

Methodological Underpinnings

To appropriately evaluate the factor analytic evidence for the FFM, it is necessary to keep in mind what factor analysis can and cannot do, and, in a more nuanced way, how factor analyses perform under different conditions. As such, this chapter starts with a nontechnical methodological review of factor analysis (for a more thorough and technical coverage see, e.g., Fabrigar, Wegener, MacCallum, & Strahan, 1999; Mulaik, 2009). Readers with a strong methodological background in factor analytic techniques and latent variable models may prefer to skip this section. The review proceeds chronologically, starting with exploratory factor analysis (EFA), a technique in its second century (Spearman, 1904, 1927), confirmatory factor analysis (CFA), approaching its golden anniversary (Jöreskog, 1969), and exploratory structural equation modeling (ESEM), still in its infancy (Asparouhov & Muthén, 2009).

Exploratory Factor Analysis

The aim of factor analytic techniques is to explain patterns of covariation among *observed* or *manifest* (i.e., directly measured) variables using *unobserved* or *latent* constructs. That is to say, given that responses to some stimuli (e.g., questionnaire items) show patterns of covariation, it is reasonable to hypothesize that there is an explanation for this patterning (e.g., a personality trait). In fact, this was exactly the logic that prompted Spearman to develop factor analysis. He had observed that those individuals who performed well on one mental test tended to perform well on others, which gave rise to his general theory of intelligence and the need for a quantitative method to test it. Factor analysis was thus born. Since then, EFA has been widely applied as a technique to determine the appropriate number of dimensions that can account for observed patterns in a larger set of variables.

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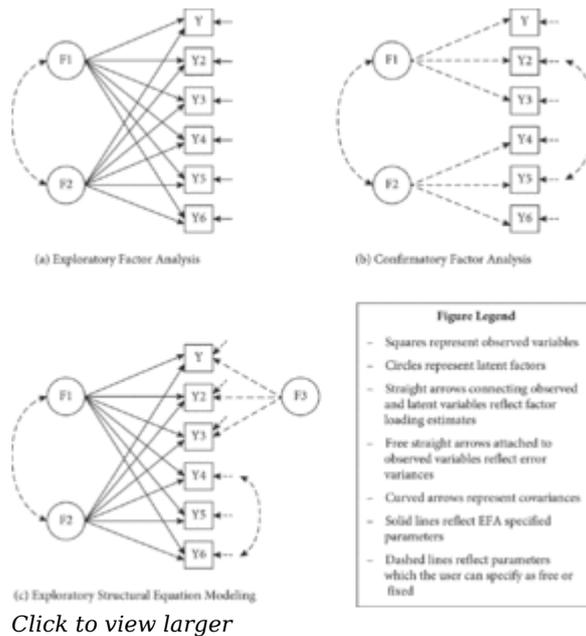


Figure 1. (A) Exploratory factor analysis. (B) Confirmatory factor analysis. (C) Exploratory structural equation modeling.

The hallmark of EFA is that the investigator does not specify the estimated parameters and the patterning of items loading on factors, and instead these are determined by the analysis. Figure 1A provides a graphic representation of EFA. Square boxes represent observed variables, circles represent latent variables or factors, straight arrows connecting circles and squares represent factor loadings, arrows only pointing toward squares represent observed variable uniqueness (i.e., variability not accounted for by the latent factors, which includes both unique variance and error variance), and curved arrows represent covariances/correlations. Additionally, solid lines represent model specified parameters, whereas dashed lines represent parameters that can be specified by the investigator. In this example there are six observed variables and two correlated factors (i.e., an oblique model), and each of the observed variables loads on each of the two factors. This is a basic feature of EFA, and one reason why it is referred to as exploratory—the investigator does not assign observed variables to factors, rather the relationship between each is estimated and the pattern of loadings is evaluated or “interpreted” after the analysis is run.

Some have called EFA an atheoretical data analytic approach, which is a glaring mischaracterization. Many aspects of EFA are theoretically driven. One of the most fundamental theoretical assumptions that can be made in EFA is that underlying dimensions account for patterns of observed responses to stimuli. This is reflected in structural diagrams that represent factor loadings as arrows emanating *from* the latent factors *to* the observed variables.² Furthermore, it is frequently the case that the investigator has a hypothesis about how many factors are needed to account for the

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observed variables (e.g., Spearman's theory of general intelligence would suggest a one-factor model). And, usually, there is a theory about which observed variables serve as markers for the same factors. More generally, modeling decisions should ideally be made based on substantive theory. For instance, factors must be interpreted and labeled, and the emergence of a factor that is uninterpretable may prompt us to select fewer factors, drop some items, or collect more data.

EFA is, however, a very interactive technique, in the sense that several models are often run under different conditions and compared before settling on a final solution. Several considerations are involved in arriving at an acceptable model, but the two primary ones include selecting the number of factors to retain and the rotation for those factors. In each case theoretical considerations should be the primary deciding factor, although quantitative indices have been developed to aid in this process. As powerful desktop computing has become ubiquitous, coarse rules of thumb such as the Kaiser-Guttman rule (i.e., retain only factors with eigenvalues greater than 1.0) and visual tools such as Cattell's (1966) scree plot have given way to more quantitatively rigorous criteria such as Horn's (1965) parallel analysis, Velicer's (1976) minimum average partial test, Ruscio and Roche's (2012) comparison data technique, and fit criteria [e.g., chi-square, root mean square error of approximation (RMSEA)] when available based on the estimator (e.g., maximum likelihood). Regardless of which methods are used, and it is advisable to enlist the aid of at least one of the more rigorous approaches, these are fallible tools that should be weighed in the decision but not followed blindly. The investigator is still required to make careful choices based on all pertinent information, especially theory.

Once the number of factors has been decided on, the next step generally involves selecting a *rotation* for the factors. Rotation refers to adjusting the relationship between the observed variables and latent factors through a linear transformation. In other words, the exact pattern of factor loadings is not fixed, and can be quantitatively adjusted to improve the interpretability of the factors. Many rotation schemes exist (e.g., Varimax, Geomin; see Sass & Schmitt, 2010, for a review) that attempt to maximize specific criteria (e.g., factor or variable simplicity), with a frequent goal of achieving a simple structure (Thurstone, 1947). In a perfect simple structure each observed variable loads strongly and exclusively on a single factor, allowing for easier interpretation. Despite the many options available for factor rotation, the most important distinction is whether it generates *orthogonal* or *oblique* factors. In an orthogonal rotation, the factors are forced to be unrelated to each other, whereas in an oblique rotation factors are allowed to correlate. As will be discussed below, choosing between oblique and orthogonal rotation can have implications that go beyond an individual factor analysis.

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Because all items load on all factors in EFA, rotation of the factors is arbitrary, quantitatively speaking. This is not to say that any single loading can be adjusted to whatever the investigator wants. On the contrary, rotating a factor causes all of its factor loadings to change based on the linear transformation. However, there is no mathematical superiority in selecting one rotation over another, and the decision rests on interpretability. Some have sharply criticized EFA because of this aspect, claiming that because factor rotations are quantitatively arbitrary, factors are therefore conceptually arbitrary and merely conventions of human cognition. Although not a reason to disregard EFA as a useful technique, knowledgeable factor analysts keep in mind that a factor represents a hypothetical latent construct, and neither does it reflect a 1:1 correspondence with any particular natural phenomenon, nor can differing interpretations for a factor be adjudicated quantitatively without external validation.

Several other considerations require attention when conducting or evaluating a factor analysis. Of these, the selection of variables to include is perhaps the most important because it will constrain the resulting factor structure. In some respects this point is so obvious as to not bear mention, but it plays out in subtle ways. Recall that factor analysis seeks to account for patterns of covariation, which follows directly from the included variables. If sufficient measures of a construct are not included, it will not emerge as a factor in the analysis. For instance, if too few measures of a construct are included (e.g., a single openness scale), it is unlikely to emerge as a stand-alone factor, and instead these indicators may join another factor or be orphaned with low loadings on all factors. A reasonable but flexible heuristic is that a factor analysis should include at least three primary indicators of a hypothesized construct. Indeed, much of the early work on personality traits suffered from small sets of variables that could hardly be considered comprehensive, thereby precluding any definitive solution (Digman, 1996). On the flip side of this coin, overloading an analysis with many variables of a very similar nature virtually guarantees that a specific factor will emerge, even if the variables are individually conceptually related to others in the same analysis (i.e., a grouping of variables tightly related relatively speaking, even with marked associations with the other variables, will stand out). As might be apparent, this can cause spurious factors to emerge that better reflect the density of measurement as opposed to substantive distinctions between observed variables. For instance, adding six measures of anxiety disorders to a factor analysis of normative personality traits will likely result in an Internalizing factor separate from neuroticism that accounts for the disorders, even as it correlates highly with neuroticism. When the variables forming a factor are highly redundant it has been termed a “bloated specific” factor, denoting the excess of items used to measure a narrow piece of information.

In sum, EFA seeks to account for shared variance among observed variables with a smaller set of reduced factors. The investigator must choose which variables to include in

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the analysis, and then interpret the resulting factor solution, deciding on how many factors to retain and how to maximize interpretability of the loadings by selecting a rotation. Because of the high degree of investigator decisions, EFA has been criticized as being arbitrary and more art than science. This criticism ignores the principled nature of most decisions and the high degree of investigator decision making in all statistical analysis. A well-conducted factor analysis is no more subjective than any other complex data analytic technique.

Confirmatory Factor Analysis

As the name indicates, unlike EFA, CFA was intended to serve primarily as a hypothesis *testing* analytic approach. CFA shares the major conceptual basis of EFA, in that the goal is to represent patterns of covariation among a set of observed items with a smaller set of unobserved factors. The confirmatory aspects are that (1) the user specifies all³ of the model parameters, and (2) the fit (or, more specifically, the lack of fit) of the specified model to the observed data is tested. Figure 1B illustrates a hypothetical typical two-factor CFA. In this model the observed variables Y1–Y3 serve as indicators of latent factor F1 only, and Y4–Y6 serve as indicators of F2 only. Note that one major distinction from the EFA in Figure 1A is that each factor loading was specified, and not all items load on each estimated factor. Much like the EFA model the factors are allowed to correlate, making it an oblique model. However, there is no rotation to choose, factors are either correlated (oblique) or uncorrelated (orthogonal). Furthermore, each observed variable has a residual variance, reflecting unique variability unaccounted for by the factor plus error. Finally, notice the curved arrow between Y2 and Y5. This reflects an error covariance, indicating that there is shared variance in items Y2 and Y5 unaccounted for by the factors that the investigator is modeling.

Were we to actually test this model, our chosen statistical package would first optimize the values of the parameters in an effort to match the data set we were using with some form of estimator (e.g., maximum likelihood, weighted least squares); it would then compare the fit of the model implied covariance matrix to the observed covariance matrix and generate goodness-of-fit indices based on the degree of match and other criteria. It is worth noting that each model implies a certain pattern of covariation based on its parameterization. For instance, in the case in which there are no free error covariances, the factors must account for *all* of the covariation among the observed variables. Any unaccounted for residual covariation in the actual data will contribute to worse fit.

A detailed discussion of various fit indices goes beyond the purview of this chapter. However, each fit index is specified quantitatively and under certain modeling conditions it may not match *the statistical test the investigator intends*. For instance, the model chi-

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square is often written off because it “performs poorly in large samples.” This is inaccurate; the static is performing exactly as it is intended to do. It is more appropriate to recognize (and state) that the chi-square statistic tests whether the model’s implied covariance matrix fits the data *perfectly*, and in large (i.e., highly powered) samples it is sensitive to very minor sources of ill fit that are unlikely to have practical significance. In studying personality structure we are infrequently interested in the level of precision afforded by the chi-square statistic, but are usually interested in using large (and therefore highly powered) samples and large variable sets that will also contribute to a poorly fitting model as judged by the chi-square test unless large numbers of complex factors are included. Thus, the chi-square test is often at odds with the aims of applied personality researchers. There is nothing dubious about selecting alternative fit indices that more closely match the desired level of precision and account for modeling features that will be encountered in personality structure studies. But the investigator should be making this choice understanding the issues involved.

In CFA strict simple structure can be specified and tested by allowing each observed variable to serve as an indicator for only one factor (e.g., as in Figure 1B). However, this is not a requirement, and variables may serve as indicators for more than one factor. There are important implications for deciding whether to make an indicator simple or complex. Recall that the estimator will attempt to fit the model parameters to the data first. Thus if an indicator is complex, meaning that it is influenced by more than one underlying factor, and it is allowed to load only on a single factor, then this will result in a stronger covariation among the factors. To provide a concrete example, consider depression as an indicator, which is known to be associated with high neuroticism and low extraversion (Clark & Watson, 1991). If depression is allowed to load on neuroticism only in a model that includes other markers and latent factors for both neuroticism and extraversion, this will result in an increased negative correlation among neuroticism and extraversion. Alternatively, if the depression variable is allowed to load on both, it will decrease the latent factor correlation because the patterns of association have now been accounted for at the level of the item loadings. As will be discussed below, this has important implications for the way trait hierarchies are studied and the conclusions that are drawn from them.

Another attractive feature of CFA is that it allows for principled deviation from the assumption of conditional independence. Factor models are often specified such that there is no covariance among the item residuals, the assumption being that the observed variables are independent of each other once the factors are accounted for (i.e., conditional on the factors). Although reasonable given the goal of factor analysis, relaxing this assumption has legitimate uses. For instance, it can be used to account for method variance between specific item sets (e.g., items that share the same stem). However, the

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unprincipled use is to be discouraged, as it can capitalize on chance in any given data set, especially when sample size is large, and result in nonreplicable model complexity.

Though CFA has many advantages (e.g., confirmatory nature, full control in the ability to free and fix parameters), it is unwieldy for use as a purely exploratory tool (i.e., when the latent structure of the data is not well understood or is unknown), especially with large variables sets. Admittedly, many investigators use CFA in a semiexploratory fashion in applied research (e.g., making modifications based on Lagrange multiplier tests, also known as modification indices), but as confidence in the precise structure decreases, and item set size increases, the utility of CFA for exploration declines. Yet there are many situations in which the investigator is most interested in the data-derived structure, or, more frequently, wants to relax the assumption of no cross-loadings, but does not want to go through parameter by parameter testing them.

Exploratory Structural Equation Modeling

Exploratory structural equation modeling (ESEM) is a relatively recent development in latent variable modeling (Asparouhov & Muthén, 2009), and it allows for EFA-derived latent variables to be included within the broader SEM framework. Another way to think about ESEM, especially as it relates to the types of models we are discussing here, is that ESEM blends the features of EFA (i.e., exploratory factors, range of rotations) and CFA (i.e., the ability to specify parameters, user-specified factors, multiple group analysis) allowing for near total flexibility in modeling. A number of considerable advantages are gained by this innovation. These include the ability to add method factors to EFA analyses of multiple scales from different measures, correlated residuals, and adding parameter equalities across two scientifically interesting groups (e.g., genders, patient versus nonpatients). Figure 1C provides a hypothetical example of an ESEM model. In this diagram, in addition to two obliquely rotated EFA-defined factors (F1 and F2), there is a third investigator specified factor (F3) that is orthogonal to the other two. F3 could perhaps represent shared method variance for observed variables Y1–Y3, or the assumption that they are markers for more than one construct. Finally, the residuals for Y4 and Y6 are allowed to correlate. In the modeling of complex personality data that has large item sets, ESEM benefits from the efficiencies of the EFA framework, while allowing the investigator to have control over specific study design features that are afforded with CFA.

Similar to CFA, ESEM relies on estimation methods that ultimately result in an implied covariance matrix that can be compared to an observed matrix in various ways to generate goodness-of-fit indices. The fact that the EFA portion of the structure can model a large number of potentially conceptually negligible but statistically significant cross-

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loadings generally results in considerable improvement in fit over a strict simple structure imposed by many CFAs (see Booth & Hughes, 2014, for a summary). However, it is worth belaboring the point that factor analytic techniques are in large part separable from the estimation approach. Although certain estimation methods (e.g., principle factor analysis) are reserved for EFA, estimations such as maximum likelihood and weighted least squares can be applied to EFA, CFA, or ESEM. This underappreciated fact often results in claims that an ESEM has been conducted, when in reality only an EFA has been conducted with maximum likelihood-generated estimates. Although this produces fit criteria, no additional confirmatory work or alteration of the structure by the user has been done. As noted above, EFA is a legitimate and very useful technique, and the objection with labeling a maximum likelihood EFA as ESEM is related to perceived inflation of the rigor of analysis without having done anything other than a standard EFA. Alternatively, a maximum likelihood-based EFA could be considered one very basic form of an ESEM, but this would seem to muddy the methodological waters. Now armed with the contemporary thinking on factor analysis, both historical and recent studies will be considered.

Factor Analysis of Personality Attributes

The historical development and ongoing research on the FFM are intimately intertwined with factory analysis. The preceding review of the statistical techniques was intended to garner a better appreciation of the model's early fits and starts and the challenges it is facing today.

Historical Foundations: Exploring the Structure of Personality Attributes

Domains that in hindsight are easily interpreted through the lens of the current FFM were identified by factor analysis as far back as 1930s by investigators such as Cattell (1933) and Guilford (Guilford & Guilford, 1934). At the time, however, both the technical and conceptual state of affairs limited the ability of early researchers to arrive at a replicable solution. Considering first the technological capacities available at the time, the earliest factor analyses had to be conducted by hand. Although calculators eventually supplanted longhand calculations, it would be almost two decades before computers were available for routine use. Conducting a factor analysis by hand is an incredibly time-consuming and grueling proposition, thus limiting early efforts to a minority of variables. Early studies were conducted with approximately 20–30 personality variables. Contrast

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this with Goldberg's (1990) definitive analysis of three data sets of trait-descriptive terms. In the first of three studies, he factor analyzed 75 terms (more than twice that of Cattell's 35 scales), using five different extraction methods (e.g., principle axis, maximum likelihood, and principle components) and two different rotations per method. Performing even one analysis with that many terms in the early part of the twentieth century would have been unthinkable, let alone 10, plus two additional studies with variable sets of 100 and 133, respectively. The effect of this early limitation precluded the analysis of anything resembling a comprehensive list of variables, thus requiring more circumscribed and idiosyncratic sets (e.g., Thurstone, 1934). This clearly resulted in some domains being underrepresented [e.g., agreeableness in Guilford & Guilford (1934) and conscientiousness in Thurstone (1951); see Digman (1996) for a detailed review], and other less conspicuous influences were likely in operation as well. Recall that the results of the EFA are driven by the covariation of the included variables—inadequate representation of a construct precludes the emergence of a related factor. As a result, the most convincing and replicable solutions for this type of question will be those that adequately sample from the full domain of personality terms. In the early part of the twentieth century, however, it was as if investigators were attempting to solve the personality puzzle without a full set of pieces.

Another early stumbling block beyond idiosyncrasies in early variable selection was the view, promoted by Thurstone (1947), that “too many factors can do no harm” (p. 509). Offered in the Old Testament of factor analysis, this perspective is apparently responsible for Cattell's decision to extract improbably large numbers of factors from his datasets in the 1940s (Cattell, 1943, 1944, 1945, 1947, 1948). Drawing from Allport and Odbert's (1936) comprehensive list of terms, Cattell factored a set of 35 scales, and across three studies retained 12, 11, and 11 factors, respectively. Surprisingly by today's standards, Cattell decided to bundle all of the factors that emerged across all of his studies in his 16-factor model of personality, despite the fact that only some of these factors replicated. Indeed, one major danger resulting from factor overextraction is that as more and smaller factors are extracted, they are less likely to reflect important, replicable domains, and more likely to reflect dataset-specific variability. This is similar to the principle in CFA described above that we should not blindly free error covariances, even if suggested by modification indices, because it is likely capitalizing on chance variation in a specific sample. These analyses were conducted several decades before modern quantitative procedures were developed to inform the appropriate number of factors to retain (e.g., Parallel Analysis, MAP Test), which would have been much more conservative in their selection of factors. In the context of this chapter, these early studies are worth revisiting because they demonstrate just how closely intertwined the history of the FFM is with the history of factor analysis. Factor analytic methods were in their infancy and their performance was not yet fully understood, and therefore early misses are to be expected.

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Over the next decade there was little advancement, aside from one notable study that found a solution near to the Big Five (Fiske, 1949), which in fact found a familiar four, excluding a clear agreeableness. Some have argued that this is the provenance of the modern structure (see also the chapter by de Raad and Mlačić). However, in the early part of the 1960s, a series of seminal studies hammered out the structure that would ultimately come to form the FFM that is evident today. First, Tupes and colleagues (Tupes & Christal, 1961; Tupes & Kaplan, 1961) settled on five replicable factors in their analyses. Despite the fact that these were mostly obscured from view by being published in U.S. Air Force reports, several researchers (e.g., Borgatta, 1964; Norman, 1963; Smith, 1967) did take notice and followed up with work of their own resulting in very similar structure using different sets of scales rooted in the Allport and Odbert terms (Norman, 1963; Smith, 1967), or as newly generated items (Borgatta, 1964). The fertile grounds laid in the 1960s mostly lay fallow as trait psychology entered its lost decade, ushered in by critics such as Mischel (1968).

However, the seeds had been planted, and they would bloom in the 1980s. Interestingly, among the seminal investigations in this era was a reanalysis of Cattell's and Fiske's earlier scales using more modern factor retention rules. In this study, Digman and Takemoto-Chock (1981) found that when more stringent criteria were employed, five replicable factors emerged across the earlier datasets. These factors conceptually matched those found by Tupes and Christal (1961) and Norman (1963), and are recognizable as the five factors that comprise the FFM of today. At around the same time, Goldberg published two chapters (1981, 1982) summarizing and distilling much of the existing factor analytic evidence of the time, arguing that most contending models could be organized within the framework of Norman's adequate taxonomy (i.e., Norman's five traits). According to Goldberg (1993; see also Digman, 1990), it was based on these writings (Goldberg, 1981, 1982) that he was invited to a conference held in 1983 by Drs. Costa and McCrae. Up to that point, Costa and McCrae had invested their time in studying and developing a measure for a three-factor model of personality comprised of neuroticism (N), extraversion (E), and openness to experience (O). Based on Goldberg's work, they adopted agreeableness (A) and conscientiousness (C) into their model, and the NEO Personality Inventory (NEO PI; Costa & McCrae, 1985) was published with multiscale domains for N, E, and O, and single scale domains for A and C (see also the chapter by Costa and McCrae). By 1992 this structure was expanded to include an equal number of facets—six—per domain in the incomparably popular NEO PI-Revised (NEO PI-R; Costa & McCrae, 1992). Throughout the 1980s and continuing through to today, the Costa and McCrae team produced studies on the FFM with leporine speed. As Goldberg (1993) stated, Costa and McCrae are the "world's most prolific and most influential

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proponents of the five-factor model” (p. 30), and the same has remained true for the more than 20 years since.

Paralleling Costa and McCrae’s work, numerous other investigators contributed to the factor analytic evidence for the FFM during the 1980s in a variety of samples, cultures, and criteria sets (e.g., Amelang & Borkenau, 1982; Digman, 1989; Digman & Inouye, 1986; John, 1989; McCrae, Costa, & Busch, 1986; Peabody & Goldberg, 1989; Trapnell & Wiggins, 1990). The decade culminated with the seminal study by Goldberg (1990) mentioned above, which showed that large sets of scales derived from the Allport and Odbert terms resulted in highly consistent conclusions across factor analytic techniques, rotations, and even across large and diverse sets of items (i.e., 75-133).

The early era of FFM research was based almost exclusively on EFA. Several of the initial stumbling blocks that delayed the arrival of the five-factor structure are easily understood, in retrospect, as emerging from the state of factor analysis and computing technology at the time. As EFA came into its own and the methodology was better understood and its application standardized, results became more consistent, and consensus could be achieved on the structure of broad personality domains. One of the major take home messages of this line of work has less to do with factor analysis per se, and more to do with good science in general: replicate, replicate, replicate.⁴

Model Fit in the Modern Era: Confirming the Structure of the FFM

By the 1990s, with the FFM firmly established, researchers turned away from explorations of basic structure and toward validation of the current model and prediction of external variables (e.g., Ozer & Benet-Martinez, 2006). In many respects, it could be argued that EFAs conducted and replicated in reasonably comprehensive but different sets of trait-relevant variables (e.g., scales, items, ratings) provide the strongest evidence for the FFM as a natural phenomenon. Nevertheless, around this same time, CFA began gaining in popularity and was being widely disseminated via commercial statistical packages (e.g., LISREL), and naturally investigators sought to test the FFM structure in this more stringent confirmatory framework.

To my knowledge, the first study to use CFA to *test* the FFM structure was conducted by Borkenau and Ostendorf (1990). For the primary analyses, Borkenau and Ostendorf (1990) included three sets of FFM scales as observed variables in CFA models: the self-rated NEO PI, self-rated Norman scales, and peer-rated Norman scales. In many ways, this early study was exemplary in its application of CFA. A series of CFA models were estimated that allowed the relevant scale scores from each measure/rater to load on one, and only one, of five corresponding content factors, with three method factors included to

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account for shared variance associated with the measure or rater. For instance, the extraversion factor had as indicators the NEO PI extraversion, self-rated Norman extraversion, and other-rated Norman extraversion, and all NEO PI scales loaded on a single factor accounting for shared method variance. The same was true for the remaining four domains and the Norman self-report and other-report scales.

One variant of this model constrained the factor correlations to 0.0, consistent with the theoretical view that the five factors are orthogonal or close to it, but fared poorly in terms of fit. In contrast, an oblique model did achieve acceptable fit, and was a significant improvement in fit (i.e., change in chi-square) over the orthogonal model. This type of model comparison highlights the attractive features of CFA, providing the researcher with the capacity to test interesting theoretical questions (e.g., completely distinct versus related domains). However, building on these results, the authors then examined a CFA model that included the full set of lower-order markers (or facets) from each of the measures. In contrast to the model based on domain-level scales, the expanded model resulted in an abysmal fit leading to tempered enthusiasm by the authors for the results as a whole.

A detailed review of this initial study is warranted, not only because of its temporal primacy, but because many of the issues with which Borkenau and Ostendorf were grappling have plagued the long string of CFA studies of FFM measures since (e.g., Church & Burke, 1994; Donnellan, Oswald, Baird, & Lucas, 2006; Gignac, Bates, & Jang, 2007; Hopwood & Donnellan, 2010; Lim & Ployhart, 2006; McCrae et al., 1996; Parker, Bagby, & Summerfeldt, 1993; Vassend & Skrandal, 1995, 1997). The major issue was that CFA makes highly restrictive assumptions about the structure of personality, assuming a very strict simple structure, with each item or scale loading on one, and only one, factor. Although this strict simple structure *is not a requirement of CFA models*, it is often how they are taught in introductory structural equation modeling courses and presented in the literature. Furthermore, Borkenau and Ostendorf (1990) rightly pointed out, as many others have since (e.g., DeYoung et al., 2007; Hofstee, De Raad, & Goldberg, 1992; Hopwood & Donnellan, 2010; McCrae et al., 1996), that markers of the FFM, be they individual items or scales, are generally complex, meaning they often reflect more than one domain's content (e.g., NEO PI-R Warmth loads on both extraversion and agreeableness; DeYoung, 2013; McCrae et al., 1996). This leaves investigators interested in CFAs of the FFM faced with somewhat of a Catch-22. Specifically, CFA holds the promise of providing a test of theoretical structure, or the rigorous comparison of structure across important groups (e.g., males versus females, Germans versus French, patients versus nonpatients), and therefore all expected cross-loadings should be modeled. And yet, at the same time, were we to actually consider specifying each reasonable cross-loading manually a priori, it would require a seemingly impossible

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number of predictions that would likely really be revealed only via exploratory work. For instance, take the NEO PI-R scales; for each facet there is one clear prediction associated with the domain it is intended to mark, but for each facet there are also four additional choices to be made for a total of 120 possible secondary loadings—this doubles to 240 for the 60 items of the NEO-Five-Factor Inventory (NEO-FFI). Alternatively, we could allow cross-loadings post hoc based on significant modification indices; but now the structure could hardly be considered confirmatory. This latter practice of allowing error covariances to correlate in CFA, although perfectly allowable quantitatively speaking (i.e., there is no necessity to make the assumption of conditional independence), if done in a post hoc fashion to maximize fit will generally result in many parameters that do not replicate across samples.

Borkenau and Ostendorf (1990) further noted that it was likely possible, moving forward, to create narrow-band scales that maximized within-scale correlations and minimized associations with other scales in such a way that reasonable fit could be achieved in a CFA. But they also immediately discredited this as a solution because this would be an unacceptable prioritizing of statistical fit over the conceptual breadth of each of the five factors (i.e., a poor bandwidth versus fidelity tradeoff). Others have suggested abandoning the enterprise of CFA when considering the FFM, and instead reverting to EFA, and either employing targeted rotations (i.e., Procrustes rotations; McCrae, Zonderman, Costa, Bond, & Paunonen, 1996) or using maximum likelihood estimated EFAs (Hopwood & Donnellan, 2010) that generate the same fit statistics as CFAs. In each case the proponents have emphasized replicability across samples as opposed to statistical fit between the model and the data within one sample, paired with tests of replicability with congruence indices. By this standard, the NEO PI-R measures (McCrae et al., 1996) and other measures of the FFM (and non-FFM personality inventories; Hopwood & Donnellan, 2010) fare quite well.

In contrast to Borkenau and Ostendorf's (1990) early investigation that focused on cross-measure and rater confirmation of the theoretical structure of the FFM, the majority of the CFA studies since have focused primarily on whether a specific measure's item-set or scales conform to the expected structure. This is notable in several respects. In part this reflects the maturing nature of the science, which has moved from unconstrained and, frankly, highly variable criteria sets across research groups to refined and better delineated instruments that are providing consistency of measurement across laboratories. Accordingly, only the most extreme researchers suggested that the results of CFA studies indicted the FFM proper (e.g., Vassend & Skrondal, 1997), and most others limited their questions to suitability of specific measures. Yet others have highlighted the fact that more recently developed measures, those that have been developed in the CFA-dominated modern era, are at a disadvantage because they will be

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judged against criteria that are difficult for any broadband personality inventory to meet (Hopwood & Donnellan, 2010). This is despite the fact that established measures developed earlier also do not meet the CFA standards for fit, generally speaking.

Regardless of any mismatch between the overly restrictive ways in which CFA is customarily applied, the highly sensitive nature of CFA fit indices, and the goals of delineating the broadband structure of personality and developing instruments to measure it, there are many attractive features of a CFA framework that would be a shame to discard. These include the ability to test for measurement invariance across time, groups, and possibly even different item sets. Also, the ability to model additional factors that might influence fit, such as method factors (e.g., Marsh, 1996; Quilty, Oakman, & Risko, 2006), or as will be discussed more below, hierarchical structures (e.g., Digman, 1997), is a desirable quality of CFA. An ideal method would be able to accommodate the attractive features of EFA and CFA within a common framework.

ESEM was developed precisely to facilitate this compromise (Asparouhov & Muthén, 2009). As noted above, ESEM allows for the estimation of exploratory structures while also including researcher-specified constraints, paths, or factors. Among the earliest practical applications of ESEM was the examination of the measurement invariance of the full NEO-FFI's 60 items (Marsh et al., 2010). In a highly detailed exposition, Marsh and colleagues (2010) demonstrated the full capabilities of ESEM for furthering FFM structural research by examining invariance across gender and time and modeling additional sources of shared method variance among items. First, the authors showed, unsurprisingly, that the ESEM model achieved better fit than a strict simple structure CFA. Second, they noted that NEO-FFI uses items that come from different facets to calculate domain scores, which could lead to residual covariation among items. As such, they allowed item residuals to freely covary if they came from the same facet. For those unfamiliar with the NEO item sets, some facets contain highly redundant items (e.g., Impulsiveness), making this a reasonable approach. Allowing these items to correlate resulted in a much better fitting model. Third, they then tested for invariance across genders (using a multigroup approach) and time (using a longitudinal invariance approach), which required the fixing of parameters to equality across groups or time. Although a full summary of the results go beyond this chapter, in brief Marsh and colleagues (2010) found support for partial measurement invariance across gender and time.

This study highlighted just how flexible the ESEM approach can be in practice. Marsh and colleagues (2010) also noted that there has been an artificial schism between research that has investigated the factorial structure of personality using omnibus sets of items and inventories, and research that has studied the measurement invariance of

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scales. These two literatures are not at odds with each other, and are actually interested in the same questions. However, the differences in methodology have kept them apart. ESEM makes invariance testing with larger personality inventories tractable, and could lead to improvements in measurement and the certainty of conclusions drawn in practical research.

Another interesting feature of this study is that the authors chose to use an oblique rotation. In part this choice made it possible to illustrate the fact that going from a CFA with no cross-loadings, to an ESEM framework in which all items can freely cross-load, factor intercorrelations will markedly diminish (although they do not entirely disappear). Booth and Hughes (2014) have since demonstrated a similar decrease in factor intercorrelations with several other FFM measures going from a CFA to a maximum likelihood EFA framework. These observations are not new, and in fact have long been recognized. Indeed, McCrae and colleagues (1996) argued strongly for the use of exploratory solutions as opposed to confirmatory solutions because the five factors are theoretically orthogonal, and this can be specified in EFA without loss of fit. Accordingly, McCrae and like-minded colleagues have tended to view the larger correlations among the FFM factors obtained with CFA as being “inflated” or even “biased upwards.”⁵ It is important to recognize, however, that this is a theoretical argument, and is not based on a quantitative rationale. That is to say, given that items and scales that form the basis of factor analytic models of personality appear to be complex (i.e., share variance not only with other putative markers of the same domain, but also with scales that are presumed to be markers of other domains), factor correlations will be smaller or larger depending on the degree of cross-loadings allowed. The complexity can either be modeled at the level of the loadings of individual items or scales, or it can be modeled at the level of the factor correlations. This has major theoretical implications, both for the FFM, which is often presumed to be composed of orthogonal factors, and because there are those who have posited theories based on the observed patterns of factor correlations (e.g., DeYoung, 2006, 2013; Digman, 1997). However, by reverting to EFA-derived or ESEM-derived factors it becomes difficult, impossible in fact, to adjudicate quantitatively between orthogonal and oblique rotations.

Therefore, investigators should be aware of the implications of choosing a rotation if employing ESEM, just as was necessary in EFA. In general, researchers are faced with three options, orthogonal, oblique, and target rotations. With few exceptions (e.g., exploratory bifactor rotation; Jennrich & Bentler, 2011), the orthogonal and oblique rotations that are generally available are going to be calibrated, in various ways, to maximize simple structure. Given this fact, an orthogonal rotation can be imposed, making the assumption that factors are uncorrelated, but there is no quantitative justification to prefer this solution to one that allows for factor correlations. More

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desirable, Fabrigar and colleagues (1999) argue, is to employ oblique rotations given that if simple structure is maximized by a solution with uncorrelated factors, this will emerge in an oblique rotation. Alternatively, researchers may employ target rotations. Mentioned only briefly above, this allows researchers to rotate ESEM (or EFA) factors to a specific pattern, determined either by prior research or by a theoretical structure. The statistical package will then try to “hit” the target values, and will return a model with values as close as possible to those set as the targets. This can be useful when a specific scale is intended as the primary marker for a domain (i.e., a high target loading is specified) and other scales are intended to be orthogonal (i.e., they would be targeted for a 0.0 loading), and those presumed to have complex structure can be left free to load. Note that regardless of rotation strategy, ESEM (or maximum likelihood EFA) models will all evidence equivalent fit, and therefore the onus remains on the researcher to select and defend a particular solution.

Our understanding of the structure of personality attributes has been deeply influenced by factor analysis in its various forms. Early work relied on EFA, which as a novel method was poorly understood and resulted in solutions that fared poorly on replication. As EFA methods improved, so too did the robustness of personality structure, ultimately arriving at the FFM by the end of the 1980s to early 1990s. Presuming a reasonably consensual final model, a great deal of scientific effort shifted toward validation and examining the implications of the model. At the same time, the FFM was subjected to CFA that seemed to threaten its foundations. However, initial concerns based on rigid applications of CFA gave way to a more nuanced understanding of the issues involved (e.g., complexity of items and scales) and a recognition that the goals of developing and testing a broadband personality structure may be at odds with the highly sensitive nature of CFA. The recent addition of ESEM provides the necessary compromise to broker reconciliation between the practicalities of working with personality data and the desire to use several of the sophisticated features and control of a confirmatory analytic framework. In many respects it would seem that much of what factor analysis can tell us about personality has been exhausted. Nothing could be further from the truth. On the contrary, highly sophisticated factor analytic investigations continue to be used to address complex questions at the cutting edge of personality science. In the next section several of these areas with intensely active literatures will be considered.

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Future Challenges for Factor Analysis in Personality Research and the FFM

By the 1990s the FFM had spurred considerable work on personality traits as predictors, outcomes, developmental constructs, and more. But the story does not end there, and important structural considerations remain even today that go beyond the FFM per se, and include the FFM in the context of a hierarchy of traits and the utility of enlisting the FFM to serve as a broader fundamental psychological structure.

Hierarchical Structure of Personality Traits

Although it should be clear at this point that the FFM represents a robust solution for personality structure, it mostly reflects only one level of abstraction in a larger structural organization of personality that goes both up, toward more general or “meta-traits,” and down, to ever more fine-grained articulations of personality attributes. Since their inception, factor analytic studies of personality have assumed a hierarchical model, with the assumption being that individual behaviors reflect the expression of attributes captured by specific descriptors, specific descriptors combine to form narrow traits, which ultimately coalesce into the broad domains [see, e.g., Guilford (1975) or Costa & McCrae (1995) for a detailed discussion]. For a good example of how this has been operationalized in a contemporary measure, consider the NEO PI-R (Costa & McCrae, 1992): each domain is made up of six facets, which are each made up of eight items. Thus, it could be argued that the NEO PI-R has (at least) three levels of measurement by design.

Going up before going down, it is worth returning to the issue of the factor intercorrelations observed among scales measuring the FFM domains. It was noted earlier that the theoretically orthogonal domains manifested nonignorable, and at times quite sizeable, correlations in real world data. The initial quantitative work on this issue was conducted by Digman (1997) who examined the higher-order structure of the five factors from 14 different studies, finding a replicable structure that had one factor marked by neuroticism (or rather its inverse emotional stability), agreeableness, and conscientiousness, and the other marked by extraversion and openness. Importantly, these structures were tested with CFA models that were generally well-fitting. Digman labeled these factors using neutral terms, alpha and beta, respectively, although he hypothesized links to several grand psychological theories. Since then a number of researchers have explored these two higher-order domains in diverse datasets (e.g., Anusic, Schimmack, Pinkus, & Lockwood, 2009). And although highly replicable, in

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specific datasets they may not emerge or may evidence significant unexpected cross-loadings. These two domains have also motivated theoretical innovation; DeYoung (2006, 2013) has suggested the term “stability” for alpha and has hypothesized that it reflects central serotonergic functioning, whereas he suggested the term “plasticity” for beta, hypothesizing that it reflects dopaminergic functioning (see also the chapter by Allen and DeYoung).

At this point, these two domains appear to be well established from a factor analytic standpoint, and most relevant research moving forward will likely entail further investigation of the external correlates and predictive power of these domains (e.g., it may be that enhanced longitudinal prognostic capacity is afforded by the broader domains relative to the five factors; are the domains indeed reflective of functioning in the neurotransmitter systems?). However, one aspect of this work that deserves greater factor analytic attention is the role of the attenuation in correlations observed when cross-loadings are modeled directly at the lower level of measurement. Significant factor correlations remain when modeling an oblique structure with cross-loadings, but they decrease in magnitude significantly (Booth & Hughes, 2014; Marsh et al., 2010). Testing whether, and if so to what degree, the two higher-order factors survive in a fully hierarchical model using second-order CFAs or ESEMs would be an important confirmation of the robustness of these domains.

The fact that even alpha/stability and beta/plasticity correlate have led some to hypothesize a “general factor of personality” (GFP), analogizing to the “g” of cognitive abilities (Rushton & Irwing, 2008). This proposition has resulted in an incredible amount of research within the past several years, often with acrimonious commentary and critiques. Although it is difficult to guess the motivation behind a given researcher’s decision to conduct a study and/or write a paper with any certainty, it is hard to ignore the fact that Rushton’s writing drew links from the GFP to distasteful explanatory theories of racial inequity in ways that may have motivated criticism (Rushton, Bons, & Hur, 2008). Regardless of the rationale, most of the published critiques have taken supporters of the GFP to task on factor-analytic grounds. For instance, from a very basic perspective, Hopwood, Wright, and Donnellan (2011), using a variety of factor analytic techniques, showed that the GFP from different measures could hardly be considered isomorphic, if even distally related. Pettersson and Turkheimer (2010) demonstrated that the GFP, if representing anything substantive, likely reflected evaluative bias. Finally, Revelle and Wilt (2013) showed that to the extent that the GFP exists, it is of modest statistical prominence, and likely does not warrant considerable attention. Others (e.g., Donnellan, Hopwood, & Wright, 2012), noting problems in the CFA solutions reported (e.g., mismatching degrees of freedom between text and diagrams) in some research supporting the GFP, have also shown that solutions may not replicate across datasets.

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Ultimately, given the strength of the criticism, the GFP has a difficult road ahead should the proponents seek to establish its permanence in the hierarchy of personality traits.

Starting with five variables not much room remains to build upward, but there is probably unlimited space to build downward. Undoubtedly the best-known lower-order set of scales is the NEO PI-R's 30 facets, which were designed to meet several conceptual and statistical criteria. These included suitable factor-analytic features, but also appropriate breadth of measurement, and sufficient prior attention in the research literature. Other promising solutions include the Big-Five Aspects of DeYoung, Quilty, and Peterson (2007), which reflect 10 intermediary constructs, two per domain of the FFM, that sit between the five factors and the facets. The challenge with building downward is identifying sets of scales that "hit" at the same level of abstraction (Guilford, 1975).

Ultimately it may be possible, given sufficient data and samples, to articulate a broader hierarchy of personality and several levels of abstraction, with the level of abstraction that is most conceptually or predictively useful depending on the purpose for which it is needed. Even so, it is clear that the FFM will retain a privileged position within any hierarchy. In the service of this aim, a technique for establishing personality (and other) hierarchies that is based on factor analysis, although it is not strictly factor analytic, bears mention. In what Goldberg (2006) has affectionately yet irreverently termed the "Bass-Ackwards" method, factor solutions of increasing complexity are estimated (e.g., one-factor, two-factor, three-factor), the factor scores are saved, and then are correlated to estimate the "unfolding" of a trait hierarchy. This simple but powerful technique has been put to good use examining the hierarchical structure of various measures, and has shown what Goldberg (1981) argued for conceptually, that most of the enumerated trait models (i.e., the Big-Three, Big-Four, Big-Five) can be handled by considering them as instantiations of varying levels of abstraction. For instance, Markon Krueger, and Watson (2005), examining the joint structure of adaptive and maladaptive personality measures, noted that at the apex sat alpha and beta, at a level down alpha split into neuroticism and disinhibition, next disinhibition split into agreeableness and conscientiousness (or more accurately their inverses), and finally, at the fifth level, beta split into extraversion and openness.

Convergence between Normal and Abnormal Personality Structure

Around the same time that personality science was beginning to gain traction with a consensual structural model for personality attributes in the FFM, the American Psychiatric Association (1980) made a major revision to its diagnostic manual and system (i.e., the *Diagnostic and Statistical Manual of Mental Disorders*, or *DSM*), and codified personality disorders (PDs) into 11 discrete, categorical diagnoses (this has since been

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reduced to 10). Almost immediately, researchers and clinicians began complaining about its lack of clinical utility and mismatch to the phenomena it was putatively describing (Widiger & Kelso, 1983). Many stringent critiques of this system have been published over the years (see e.g., Krueger & Eaton, 2010; Widiger & Clark, 2000; Widiger & Trull, 2007), and therefore a detailed description of the system's many limitations does not bear enumeration here (see, as well, the chapter by Widiger, Gore, Crego, Rojas, & Oltmanns). Suffice it to say, however, that the major critiques are structural—there does not appear to be 10 cleanly separable disorders, nor has any credible and replicated research supported the categorical distinction of disordered and not disordered. This is evidenced by the fact that the personality disorder (PD) diagnoses covary within individuals at a much higher degree than would be expected by chance, and indeed the most commonly used diagnosis in practice has been one of “mixed” or “PD Not Otherwise Specified” (i.e., PD is present, but does not match any of the categories and instead reflects a blend of features; Verheul & Widiger, 2004). Without belaboring the point, a poorly articulated structural model impedes accurate clinical diagnosis, communication, and treatment, while also frustrating research efforts attempting to identify etiological and maintenance mechanisms, and develop efficient treatments.

Although the epistemological differences between psychiatry and personality science are traditionally large, it is difficult to argue that a system developed to map the structure and major units of personality pathology should bear no resemblance to the empirical structure derived for basic personality. As far back as the 1950s, Leary (1957) argued convincingly that the same system needed to be used in the description of both to achieve harmonized scientific and clinical endeavors. As the FFM gained prominence throughout the 1980s, a natural next question was whether, and if so how, the five domains of basic personality interfaced with the 10 categorical diagnoses of the *DSM* PDs (Widiger & Frances, 1985). Considerable work has examined their interface, enough to support two relatively recent meta-analyses (Samuel & Widiger, 2008a; Saulsman & Page, 2004). However, consistent with the theme of this chapter, the focus in this chapter will be on the use of factor analysis for answering this question.

Wiggins and Pincus (1989) were the first to use EFA to study how the two systems interdigitate.⁶ They analyzed student analogue responses to the NEO PI domains, the Revised Interpersonal Adjective Scales—Big Five (IASR-B5; Trapnell & Wiggins, 1990), the Minnesota Multiphasic Personality Inventory (MMPI) PD scales of Morey, Waugh, and Blashfield (1985), and the Personality Adjective Check List (PACL) PD scales (Strack, 1987). The pattern of loadings on the resulting five-factor structure was easily interpretable and conceptually clear. The personality dimensions of NEO Extraversion and IASR-B5 Dominance, and the PD dimensions of MMPI Histrionic, Narcissistic, and PACL Antisocial marked the first factor positively and MMPI and PACL Schizoid and

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Avoidant scales marked the factor negatively, reflecting what appeared to be a bipolar dimension ranging from intrusiveness/attention-seeking to detachment/withdrawal. The second factor was most strongly marked by NEO and IASR-B5 Neuroticism, and was additionally positively marked by MMPI Borderline, Dependent, and Avoidant, and PACL Passive-Aggressive and Avoidant, with smaller negative loadings from MMPI and PACL Narcissistic and PACL Antisocial scales, thereby reflecting a modestly bipolar dimension ranging from negative affectivity and distress to a presumed problematic lack of concern for such. Factor three represented a dimension that ranged from overaffiliativeness through antagonism, with positive loadings from NEO Agreeableness, IASR-B5 Affiliation, and PACL Dependent, and negative loadings from PACL Narcissistic and Antisocial and MMPI Paranoid. The fourth factor reflected a dimension ranging from compulsivity to impulsivity/indolence, with strong positive loadings from NEO PI and IASR-B5 Conscientiousness and PACL and MMPI Compulsive, and negative loadings from MMPI Antisocial and Passive-Aggressive. Finally, NEO PI and IASR-B5 Openness and MMPI Schizotypal marked the fifth factor.

In many ways this study, although not without limitations, reflected the seminal empirical demonstration that the FFM and pathological personality constructs could be organized within the same structural model. Of note is that almost all of the PD scales had strong loadings on one of the factors, and these were easily interpretable. Also noteworthy is the fact that some scales (e.g., Narcissistic, Antisocial, and Dependent) differed in their loading across instruments. For instance, MMPI Dependent was a strong marker of negative affectivity, whereas the PACL scale of the same name marked the overly nurturant versus antagonism domain. This type of variability in the content of scales with the same name causes problems when used as predictors or criteria in individual studies (e.g., Samuel & Widiger, 2008b), but can be resolved with factor analytic studies, assuming that sufficient markers of the diverse domains are being sampled. Finally, the emergence of the fifth factor that combined Openness and Schizotypy presaged what has ultimately become a contentious topic in this area of research, which will be addressed again later in this chapter.

Wiggins and Pincus' (1989) joint EFA of PD scales and FFM scales raises the question of what the stand-alone structure of PD would be, unbuttressed by FFM scales. Although many individual studies have examined this over the years (see, e.g., Wright & Zimmermann, 2015, for a review), O'Connor (2005) used EFA techniques with target rotations to ascertain the consensus structure of the 10 *DSM* PD constructs pooling across many studies (see also the chapter by O'Connor). He concluded that a four-factor structure was the best fit, with clear resemblance to four of the FFM domains: neuroticism (e.g., borderline, avoidant, dependent), antagonism (e.g., histrionic, narcissistic, antisocial), extraversion/introversion (e.g., schizoid, avoidant,

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histrionic), and conscientiousness (obsessive-compulsive). Thus, even without the anchors of FFM the conceptual overlap was clear. Missing, of course, was a domain reminiscent of the fifth factor, openness. Results such as these led some relatively early to suggest that a four-factor, but not five-factor model would be a reasonable compromise between the FFM and the empirical structure of PD (Widiger, 1998).

Despite this seemingly strong evidence for a model of PD that resembles the FFM, at least in large part, there has been rigid resistance by many to replacing the *DSM's* discrete categorical model. One of the traditionally cited reasons was that there was a lack of agreement on the structure of personality. However, it is difficult to consider this as anything more than a contrived criticism at this point, and each of the major alternative models is more alike than dissimilar—especially at the primary domain level of analysis (e.g., Markon et al., 2005; Widiger & Simonsen, 2005). Widiger and Simonsen (2005), in much the same way Goldberg (1981) did with normal personality, reviewed 18 different models of normal and maladaptive personality and concluded that although there are differences in the precise make-up of the lower-order scales, all models either contain or can be conceptually accommodated by four broad domains: extraversion versus introversion/detachment, agreeableness versus antagonism, emotional stability versus neuroticism/emotional dysregulation, and constraint/conscientiousness versus disinhibition (they also identified a fifth domain, unconventionality versus closedness to closedness to experience, but excluded it from the primary proposal because it was not included within some prominent models). The conceptual similarities articulated by Widiger and Simonsen (2005) have been born out in numerous empirical factor analytic studies that have examined these models alone (e.g., Calabrese, Rudick, Simms, & Clark, 2012; Kushner, Quilty, Tackett, & Bagby, 2011) or in combination with other measures (e.g., Clark, Livesley, Schroeder, & Irish, 1996; Markon et al., 2005).

Many researchers have developed questionnaires/inventories that were intended to conform (more or less) to the *DSM's* structure [e.g., Personality Diagnostic Questionnaire-4 (PDQ-4), Hyler, 1994, and Millon Clinical Multiaxial Inventory (MCMI-III), Millon, Davis, & Millon, 1997]. However, others have adopted a different approach, pivoting away from the *DSM* constructs and instead developing measures that reflect the putative constituent or transdiagnostic features of maladaptive/pathological personality functioning. Examples of this approach include Clark's Schedule for Non-Adaptive and Adaptive Personality (SNAP; Clark, 1993), which was developed around a theoretically triarchical temperament structure, and Livesley's Dimensional Assessment of Personality Pathology (DAPP; Livesley & Jackson, 2009; Livesley, Jang, & Vernon, 1998), which was developed to match the four-factor structure reviewed above (Livesley, Jackson, & Schroeder, 1989). Factor analysis of each of these measures supports their intended structure, or, in the case of the SNAP, an alternative four-factor structure is defensible

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(e.g., Calabrese et al., 2012; Pettersson et al., 2014). It is important to understand, however, that both the SNAP and the DAPP each includes only one thought-disordered scale out of a total of 15 and 18 scales, respectively. This makes it very unlikely that a separate domain will emerge that captures psychoticism/oddity/peculiarity in an EFA of these measures. Ongoing efforts to develop measures that more explicitly are matched to the FFM are underway or close to their conclusion. In one such effort, Widiger and his colleagues (Widiger, Lynam, Miller, & Oltmanns, 2012) have developed individual measures for each of the *DSM* PD constructs, but using FFM-based facet scales. However, this effort has thus far emphasized a conceptual mapping of items to lower-order constructs, and these have yet to be subjected to factor analytic work across the different measures (see also the chapter by Widiger and colleagues). In another effort, Simms and colleagues (2011) have been developing a computerized adaptive test of PD (CAT-PD) that aimed to provide comprehensive coverage of PD features, while also ensuring adequate coverage of a pathological FFM model (see also the chapter by Simms, Williams, and Simms). Although the measure is not yet finalized, early EFAs suggest that the CAT-PD scales conform to expected structure when analyzed in conjunction with normal range and pathological traits (Wright & Simms, 2014).

Leading up to the recent revision of the *DSM* (i.e., *DSM-5*) it appeared as though there might be a shift from the categorical model to a model based on dimensional features of PD. Indeed, this is what the *DSM-5* Personality and Personality Disorder Work Group ultimately recommended. The model they suggested was based, in part, on five broad domains of individual differences in personality pathology, based on 25 lower-order facets. No doubt the five broad domains might have been expected a priori, however, these were established based on a bottom-up process, guided by EFA.⁷ In brief, the Work Group members enumerated the features they deemed necessary for the comprehensive mapping of the PD phenotype, which resulted, after deliberations, in 37 primary features. These were then instantiated in self-report scales and administered to two large samples, one matched to population demographics and one reporting previous mental health treatment, respectively, and then subjected to a variety of factor-analytic techniques (Krueger, Derringer, Markon, Watson, & Skodol, 2012). As a result of these analyses, the initial 37 scales were reduced to 25 scales that loaded on five factors labeled negative affectivity, detachment, antagonism, disinhibition, and psychoticism. The 25 scales and five domains were furthered as part of the *DSM-5* PD model, and also resulted in a final instrument, the Personality Inventory for the *DSM-5* (PID-5; Krueger et al., 2012). Since then, support for the structure has been rapidly accruing via replication in independent samples (e.g., De Fruyt et al., 2013; Wright et al., 2012) and via independent raters (e.g., Markon, Quilty, Bagby, & Krueger, 2013; Morey, Krueger, & Skodol, 2013).

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Furthermore, the five domains of the *DSM-5* model would appear to offer clear conceptual matches to the FFM. Several studies now show that when the PID-5 domains are subjected to conjoint analyses with normative range scales the joint structure emerges as might be predicted. De Fruyt et al. (2013) and Thomas et al. (2013) both used EFA to show that the patterns of loadings aligned in factors that reflected a coherent joint structure. Furthermore, Gore and Widiger (2013) and Wright and Simms (2014) used ESEM to conduct exploratory analyses while also accounting for method variance associated with each of several measures. Thus, although the *DSM-5* model was not developed to match the FFM structure a priori, what has ultimately resulted is a model that provides a clear bridge for including the FFM in the diagnostic nosology. A further potential of this outcome is discussed below. However, although these results are encouraging, the proposed *DSM-5* model for PD was not adopted, and its future remains uncertain at this juncture. One possibility is that research of the type that is emerging now can be used to revise and improve the model for inclusion in a subsequent revision.

In spite of what appear to be clear convergences related to normative and maladaptive structures, several issues remain. Krueger and colleagues (2011) recently summarized these as involving *structure*, *bipolarity*, *hierarchy*, and *range*. Although there are some distinctions to be made among these four issues, they are all variations on structural considerations and are amenable to study by factor analytic techniques. The first two of these will be discussed.⁸

Structure, in the context that Krueger and colleagues (2011) meant it, refers to the mapping of specific content onto the primary domains (i.e., likely the FFM), and by extension the best interpretation of each domain. The reason this remains somewhat of a challenge is that a comprehensive mapping of clinically relevant personality domains necessarily invokes new content because basic trait models generally do not provide adequate coverage of specific areas of impairment (Trull, 2005). Furthermore, the relationship between pathological facets and normal traits can be complex. For example, when items of normal range trait measures are modified to reflect maladaptive functioning, the pattern of covariation among domains is altered (Haigler & Widiger, 2001). It appears that as extremity or maladaptivity is increased, content may have a tendency to be altered as well. This is particularly evident in the specific composition of scales related to disinhibition, constraint, and antagonism (Krueger et al., 2011). On the one hand, disinhibition and constraint are theoretically opposite maladaptive poles of the same dimension (i.e., conscientiousness; e.g., Samuel, 2011; Widiger, Livesley, & Clark, 2009; Widiger & Mullins-Sweatt, 2009). However, in different structural analyses of traits, disinhibition and constraint sometimes emerge as opposing poles (e.g., Markon et al., 2005; Watson, Clark, & Chmielewski, 2008) and sometimes as separate domains (e.g., De Clercq, De Fruyt, Van Leeuwen, & Mervielde, 2006; Morey, Krueger, & Skodol, 2013).

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In addition, when these domains do separate, disinhibition scales often join antagonism scales to form a dimension that more closely resembles the externalizing spectrum (e.g., Krueger, Markon, Patrick, Benning, & Kramer, 2007; Morey et al., 2013). Undoubtedly, measurement issues (i.e., the content of the specific scales; e.g., Samuel & Widiger, 2010) are involved in addition to substantive structural questions, but further research to clarify the joint structure of normal and abnormal traits is likely warranted.

As previously alluded, an ongoing structural issue involves the fifth personality domain. In normal range trait models there is broad support for the domain of openness to experience/intellect (Goldberg, 1993), whereas in maladaptive models, a dimension related to oddity, peculiarity, aberrant thinking, or psychoticism has been suggested to capture content related to schizotypy (Harkness & McNulty, 1994; Harkness, Finn, McNulty, & Shields, 2012; Tackett, Silberschmidt, Krueger, & Sponheim, 2008; Watson et al., 2008). Evidence is somewhat mixed on whether these can be conceptually and empirically integrated (e.g., Piedmont, Sherman, Sherman, Dy-Liacco, & Williams, 2009; Watson et al., 2008). Several EFA studies find clear support for the convergence of openness and schizotypy (e.g., De Fruyt et al., 2013; Gore & Widiger, 2013; Markon et al., 2005; Thomas et al., 2013; Wiggins & Pincus, 1989) whereas in others the picture is murkier (e.g., Watson et al., 2008; Wright & Simms, 2014). Returning to basic factor analytic principles may help clarify some of the discrepant results. For instance, Watson et al. (2008) reported on three different studies, each of which they interpreted as suggesting that schizotypy/oddity reflected a domain outside of the FFM and did not correspond to openness. However, although they were thorough in many respects (e.g., several samples and studies, different measures across studies, extraction and comparison of several solutions), in other respects their analytic approach raises questions about whether their conclusions can really be considered final. Most importantly, in each of their analyses it could be argued that they oversaturated their models with scales related to schizotypy/oddity, which may have served to virtually guarantee that a separate factor would emerge for schizotypy/oddity. Finally, in studies 2 and 3, scales related to schizotypy/oddity were the only pathological scales in the analyses, raising the question of method artifact. ESEM could fruitfully be applied here to clarify these results.

Turning to the issue of bipolarity, certain aspects of pathological personality functioning are theorized to be extreme poles of the same dimension (Samuel, 2011; Widiger, Livesley, & Clark, 2009; Widiger & Mullins-Sweatt, 2009). Although there is evidence to suggest that many domains operate in this way (e.g., extraversion/detachment; Markon et al., 2005; Watson et al., 2008), some domains, disinhibition/constraint in particular, are more variable across studies. This can be observed in certain external correlates, in which both poles manifest positive correlations (e.g., with obsessive-compulsive disorder,

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Kotov, Gamez, Schmidt, & Watson, 2010; Wu, Clark, & Watson, 2006). Other domains, such as antagonism/agreeableness, have specific content that is hypothesized to fall at one end of the dimension, but instead shift domains (e.g., dependency and attachment anxiety frequently shift to negative effectivity; Markon et al., 2005; Wiggins & Pincus, 1989). The question of unipolarity versus bipolarity remains an understudied issue in large part because most personality trait inventories measure, or are keyed in the direction of, a single pole of the primary trait domains. For instance, it is common for normal range inventories to provide scales that tap agreeableness but not antagonism. Yet normal range and pathological trait inventories tend to be complementary in this regard, and therefore when studied together more of the poles receive measurement coverage.

Relatedly, recent work by Pettersson, Turkheimer, and colleagues (2010, 2012, 2014) has revived the notion of “evaluation” (Edwards, 1957; Peabody, 1967) in personality questionnaires and their work suggests that this may be a compelling resolution to some of the thorny issues considered here. Briefly, evaluation is defined as the tendency to respond in the affirmative to positive attributes, irrespective of content, and to indiscriminantly deny negative attributes (or vice versa were the scale to be keyed toward negative evaluation). In the study most relevant to this discussion, Pettersson and colleagues (2014) had participants code items reflecting the *DSM* PD features and their opposites for evaluativeness, transformed these into factor loadings, then compared them with the loadings of the items on the first principle component extracted from the same items collected from participants. The congruence coefficient between the two was 1.0, demonstrating perfect agreement between the ratings of evaluation and the loadings on the first principle component. The authors next coded the SNAP items for degree of evaluation, transformed these ratings to factor loadings for a target rotation, and rotated an EFA of the SNAP items such that there was an evaluation factor and three unrelated content factors. The resultant content factors demonstrated increased bipolarity (i.e., pathological content at both poles of the dimension) relative to a solution that does not account for item evaluativeness. Although thus far only applied to a limited set of scales and measures, statistically isolating evaluation in order to focus on the structure of pure content is compelling and may resolve some longstanding concerns that are otherwise difficult to resolve factor analytically.

At the same time, isolating evaluation is not a simple solution and faces several challenges, as any method does. For one, as with all EFAs combined with rotation methods, the resultant factors must be interpreted, and although some investigators may view the loadings on a first orthogonal factor as evaluation, others may view it as reflecting personality pathology’s core impairments (e.g., Hopwood, Malone, et al., 2011; Sharp et al., 2015). The issue here is that the first orthogonal factor often contains

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impairments of seemingly opposing content (e.g., socially inhibited *and* needs admiration). Impairments in functioning across domains accord well with many theories of personality pathology, but the evaluative perspective raises reasonable questions on commonsense grounds. Recall that the interpretation of a dimension such as this cannot be adjudicated within the factor analytic framework, and therefore additional data must be gathered. Of particular importance may be temporally sequenced data. This is because endorsing impairments of opposite content may be justified if individuals do in fact demonstrate both, although presumably not both at the same time (e.g., Wright, 2014). A modest amount of data exists that suggests that personality pathology, at least of some types, predicts shifts in content of behavior over time (Wright, 2014; Wright, Scott, Stepp, Hallquist, & Pilkonis, 2015; Wright, Hallquist, Beeney, & Pilkonis, 2013), although more work in this area is needed. Additionally, as Pettersson et al. (2014) note, their analyses have been limited to self-report scales, and it is possible that evaluation would be attenuated to a large degree with interviewer or other-report data. Hopefully more work involving repeated sampling, different raters, and the prediction of external criteria will emerge over the coming years.

The Next Challenge: A Metastructural Model of Personality and Psychopathology

Investigating the overlap between the normative trait domains of the FFM and *DSM* personality disorder features, with a view toward achieving structural integration, is a natural goal. However, it may be too narrow. This is because the relationship between the FFM traits and the personality disorders is not privileged, and in fact the FFM traits show robust relationships with most mental disorders (Andersen & Bienvenu, 2011; Kotov et al., 2010). It may surprise readers to know that the strengths of association between personality traits and clinical syndromes frequently surpass those between traits and personality disorders. This may be due to the more clearly defined and less heterogeneous nature of clinical syndromes relative to PDs, the low reliability of PD assessments, or some combination of both. Regardless of the relative strength of associations, the *DSM's* clinical syndromes also appear to be moderately to strongly related to personality traits from the FFM. Recognition of this fact immediately raises the question of whether the structure of personality and psychopathology writ large could be incorporated within a coherent “meta-structural” model (see also the chapter by Bagby).

In recent years there has been a steadily growing literature on the quantitative modeling of the structure of mental disorders. Based on the observation that psychiatric comorbidity (i.e., diagnostic covariation) is extensive in the general population, far outpacing chance cooccurrence (Kessler et al., 1994, 2005), and polydiagnosis is the rule

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rather than the exception (Zimmerman & Mattia, 1999), there has been an increased interest in identifying the fundamental domains of psychopathology, in much the same way personality theorists sought to delineate the fundamental units of personality (Krueger & Markon, 2006). Mirroring the structural work in personality, efforts to quantitatively derive an empirical structure of psychopathology have relied on factor analysis and related techniques. Although this approach has been profitably applied to both child (Achenbach, 1966; Lahey et al., 2008) and adult (Kotov et al., 2011; Krueger, 1999; Krueger & Markon, 2006) disorders, the current review is confined to structural models of adult psychopathology.

Early investigations focused primarily on “the common mental disorders,” which include syndromes of high population prevalence that are readily ascertained in epidemiological samples, such as the unipolar mood disorders, anxiety disorders, antisocial behavior, and substance abuse. Factor analyses, usually CFA, applied to diagnoses and symptoms of the common mental disorders resulted in what is now a well-replicated two-factor structure of internalizing (e.g., unipolar mood disorders, anxiety disorders) and externalizing (e.g., substance use, antisocial behavior) spectra that are robust across age, sex, ethnicity, culture, informant type, and *DSM* axes (Eaton et al., 2012; Eaton, Krueger, & Oltmanns, 2011; Forbush & Watson, 2013; Kramer, Krueger, & Hicks, 2008; Krueger, Caspi, Moffitt, & Silva, 1998; Krueger, Chentsova-Dutton, Markon, Goldberg, & Ormel, 2003; Lahey et al., 2008; Slade & Watson, 2006). As was discussed in the context of the factor analytic studies of personality attributes, the particular admixture of variables analyzed constrains the resulting structure, and early studies were understandably conservative in their focus on common mental disorders. This approach was necessitated by the nature of many of the early samples, which were often epidemiological, and were coded for diagnostic categories as opposed to more fine-grained symptoms, limiting the amount of variability for some of the rarer disorders (e.g., psychosis, mania).

Studies have since sought out clinical samples or examined individual symptoms in epidemiological samples to investigate an expanded structure. There is now accumulating evidence that a *thought disorder/psychosis* (e.g., psychotic disorders, schizotypal personality disorder) spectrum is reasonably robust across samples and criterion sets (Kotov et al., 2010; Markon, 2010; Wolf et al., 1988; Wright, Krueger, et al., 2013). To provide more detail in the various ways in which factor analytic techniques are being employed in this domain, one recent study is highlighted. Wright, Krueger, and colleagues (2013) used EFA on symptom level data from 8,841 individuals included in the 2007 Australian National Survey of Mental Health and Well-Being, resulting in a six-factor model, with dimensions reflecting distress, fear, obsessive-compulsive features, alcohol abuse, drug abuse, and psychosis. Then, using CFA, models reflecting a three-factor structure (internalizing, externalizing, and psychosis) were compared to two

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different two-factor models that allowed the symptoms of psychosis to load on internalizing or externalizing domains, respectively. The three-factor model provided markedly better fit, supporting the three distinct but correlated domains of internalizing, externalizing, and psychosis.

However, it is clear that spectra of internalizing, externalizing, and psychosis cannot comprehensively account for the diverse array of pathologies of behavior and mental functioning observed in the population. As such, several ambitious studies have sought to expand upon this basic triarchic structure by incorporating additional diagnoses, most notably the PDs, and have begun to uncover additional spectra. To date only four published studies have explored the structure of psychopathology using a broad suite of clinical syndromes and personality disorders (Blanco et al., 2013; Kotov et al., 2011; Markon, 2010; Røysamb et al., 2011). Although each resultant model is necessarily unique given differences in the precise admixture of disorders (e.g., some do not include indicators of psychosis), sampling strategy (e.g., clinical versus epidemiological), and other features (e.g., disorder-level versus symptom-level analyses), two additional domains appear reasonably replicable across studies. First, Markon (2010) and Røysamb and colleagues (2011) each identified a new spectrum they respectively termed pathological or anhedonic introversion in EFA studies. In both cases, avoidant and dependent PDs were strong markers of the factor, although Røysamb et al. (2011) also found that schizoid and depressive PDs loaded strongly on the factor, which accounts for the slight difference in conceptualization. Blanco and colleagues (2013) also found evidence for a factor for which the strongest loadings came from avoidant and dependent PDs and social phobia.

Second, in three studies (Blanco et al., 2013; Kotov et al., 2011; Røysamb et al., 2011), which varied in their use of exploratory and confirmatory techniques, a domain related to antagonism, as labeled by Kotov and colleagues, has emerged. Again, slight differences have arisen in the makeup of this domain across studies, although narcissistic and histrionic PDs consistently exhibit the strongest loadings. Additional markers for this domain include obsessive-compulsive, borderline, paranoid, and (to a lesser extent) antisocial PDs. What these disorders share to varying degrees is an antagonistic interpersonal style that puts afflicted individuals at odds with others. Notably, these domains of introversion and antagonism, which emerge with the addition of PDs, each deals with maladaptive social/interpersonal functioning, consistent with the view that the PDs, at their core, reflect the interpersonal disorders (Benjamin, 1996; Hill, Pilkonis, Bear, 2010; Hopwood, Wright, Ansell, & Pincus, 2013; Meyer & Pilkonis, 2005; Pincus, 2005; Wright et al., 2012). Therefore, based on this initial suite of studies that have included PDs in structural models of psychopathology, the domains of introversion and

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antagonism appear to be good candidates to include alongside internalizing, externalizing, and thought disorder as broad, replicable domains of psychopathology.

Taken together, these domains bear a remarkable conceptual resemblance to the FFM or maladaptive variants thereof (e.g., the pathological personality trait domains included in *DSM-5* Section III system of PDs as reviewed earlier). The five domains outlined in the structural models of psychopathology are easy to conceptually map onto the FFM: internalizing—neuroticism; externalizing—disinhibition (or impulsivity/low conscientiousness); psychosis/thought disorder—openness to experience/unconventionality; antagonism/low agreeableness; pathological introversion/low extraversion. However, although intuitively compelling, direct empirical evidence for this structural coherence is only just emerging. In a recent study, Wright and Simms (2015) showed that the *DSM-5* PD traits, clinical syndrome symptoms, and traditional *DSM* PD criteria, when factored using ESEM to account for measurement effects, supported the hypothesized structure. Nevertheless, future studies are needed that replicate this work and combine analyses of personality traits (adaptive and maladaptive) with *DSM*-defined symptoms and disorders. Were this shared structure to be replicated, it would go a long way to providing an empirically supported basis for the conceptualization of psychopathology, and provide a much needed bridge between normality and psychiatric dysfunction.

Network Modeling: A Conceptual Challenge?

Recently the factor analytic basis of not only the FFM, but the structure of personality in general (including psychopathology), has been questioned (Cramer et al., 2010, 2012). The authors of these critiques have argued that factor analytic techniques are inappropriate for studying the structure of personality (and psychopathology) because they make a fundamentally incorrect assumption—namely, that there are unobserved (i.e., latent) variables that simultaneously “cause” observed features or behaviors. Rather, Cramer and her colleagues suggest that individual behaviors, features, attributes, symptoms, etc. are directly causal, and are related to each other in complex “networks.” Accordingly, they have proposed network models as alternatives to factor analytic techniques to understand the structure of personality. To illustrate using examples of theirs, they might argue that the items “like to go to parties” and “like to be around people” are not both markers of extraversion; rather, people “like to go to parties” *because* they “like to be around people.” Or, for example, the diagnostic criteria “fatigue” and “difficulty sleeping” for depression do not both arise because of an underlying depression, but rather because a person who has difficulty sleeping will then become fatigued. Extrapolating beyond these simple examples, the behaviors that constitute what

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are termed personality and psychopathology are not reflective of underlying entities, rather they *are* personality and psychopathology, and it is in their complex associations that personality arises as an emergent property.

On its surface, the suggestion that the field should move beyond descriptive models of the structure of personality to understanding the microcausal and mutually influencing inputs to a complex system is highly appealing. However, there are grave problems with the way the network modeling approach has been put forward that should foreclose any potential enthusiasm at this juncture. Indeed, for each of the articles cited above there has been sharp criticism leveled at the network approach (see commentaries associated with Cramer et al., 2010, 2012). There are currently three major problems with the network approach. First, and most relevant here, the authors make a straw man out of factor analysis and latent variable techniques. As described earlier in the methodological review, one way of thinking of factor analysis is as a causal framework, with the underlying factor directly causing the observed variables (see Figure 1). Also, a frequent, but unnecessary, assumption of factor models is one of conditional independence. Yet, also noted, factors do not necessitate such strict causal interpretations, and can be understood at a more practical and descriptive level (i.e., the shared variance among a group of items). Cramer and colleagues discuss factor models as if the only way to view them is in the strictest causal frameworks, and that these are inviolable and inflexible assumptions or perspectives. By doing so they make assumptions few personality theorists or applied factor analysts would make, creating a problem where there is none. Others have made this observation as well (Belzung et al., 2010).

Second, as currently implemented, network models offer little more than graphic representations of covariance/correlation matrices (see also Asendorf, 2012; Molenaar, 2010). In other words, the diagram that is the network model, although visually very captivating, is defined by and directly depicts the associations among individual items. Arguably these relationships are easier to appreciate when visually depicted, but can quickly become overwhelming, as is the case when the 240 items of the NEO PI-R are graphed in a network. A corollary of this fact is that network models offer no reduction in the complexity of the data, and as such do not reflect models in the sense of a more parsimonious and general description of a psychological phenomenon.

Third, the descriptions of causal associations that are hypothesized to make up personality and psychopathology constructs from the network perspective necessarily imply temporal relationships that play out over a multitude of (currently unknown) time scales. Yet the major demonstrations of the network perspective employ cross-sectional data that could not possibly test the type of causal associations that are hypothesized. Thus, there is a fundamental disconnect between what the perspective promises and what it currently offers.

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Although the current state of network models detracts little from the latent variable perspective (including factor analysis), and offers very little in replacement, it may be that with continued advances this perspective could contribute greatly to personality science. For it to be successful, it will require a greater clarity of conceptualization, better match between theory and data, and advances in methodology to accommodate true models of interindividual differences in intraindividual causal processes.

Conclusions

The early history of the FFM, in many respects, followed the history of factor analysis. As factor analysis advanced, so too did the field's understanding of the structure of personality. From the factor analytic perspective, the evidence for the five domains of extraversion, agreeableness, conscientiousness, neuroticism, and openness/intellect is quite strong. Although questions have been raised about the structural validity of the FFM, especially as instantiated in specific instruments, these can mostly be quieted by a careful consideration of whether the methods match the purposes of the investigation. Currently, it is scientifically more interesting and likely to lead to greater psychological insight, to consider in what ways the FFM may serve as an organizing framework for understanding diverse areas of human functioning that extend beyond basic personality, than to agonize over whether the FFM meets precise cutoffs for confirmatory model fit. This chapter emphasized the clear convergences between the structure of the FFM and the structure of personality pathology, and possibly even psychopathology more generally. A full and practically useful coordination of these systems though will require considerably more work, much of it factor analytic. The current review was necessarily selective, prioritizing breadth of content as opposed to depth, which has unfortunately left out the work of many brilliant and pioneering researchers. Several new techniques that also hold promise for future structural work in personality were not able to be covered (i.e., Bayesian CFA, multigroup EFA) without published examples in the literature as of yet. In spite of this, hopefully this review will stimulate others to take up these next waves of a long history of factor analytic investigations into the structure of personality.

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Notes:

⁽¹⁾ For more detailed reviews of the historical evidence for the FFM, the reader is directed to Digman (1996) or Goldberg (1993). At this point in the history of the FFM it would be impossible to cover all relevant studies and applications. As a result, many important contributions had to be neglected. Therefore this review is necessarily selective, and this is further compounded by my choice to focus on specific studies that provide illustrative examples as opposed to more cursory reviews of many studies. I offer my apologies to the authors of those many excellent studies that were not included.

⁽²⁾ Alternatively, a more pragmatic interpretation can be made that a factor merely represents the shared content from a set of indicator variables, such that when indicators covary strongly a factor can serve to parsimoniously summarize their associations. Thus the interpretation of a factor can range from the descriptive to the causal.

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⁽³⁾ Most modern statistical packages that offer CFA as a technique (e.g., LISREL, Mplus) have a number of default settings that prespecify many parameters in any given model (e.g., error covariances are fixed at 0.0). Whether the investigator relies on these conveniences or manually codes each parameter does not change the fact that a decision is being made on whether to fix or free each parameter.

⁽⁴⁾ To the knowledgeable reader several important names may be conspicuously absent from this historical narrative—names such as Eysenck and Tellegen. This is because they generally ascribed to a theoretical model of temperament/personality domains that was divided into three domains: Neuroticism/Negative Emotionality, Extraversion/Positive Emotionality, and Psychoticism/Constraint. Although undoubtedly too simplistic of a characterization of these author's important work, they developed measures that were intended to fit this trinity structure, and the measures mostly did (e.g., Tellegen & Waller, 2008). As will be discussed below, these formulations are not necessarily at odds with the FFM, and it is reasonably possible to coordinate both models hierarchically.

⁽⁵⁾ Note that when using sum scores of FFM domains or facets in applied research, this is, in effect, treating each item as if it has zero cross-loadings (and a 1.0 loading on the target scale). Thus the factor correlations observed in practice often mirror those observed in a CFA framework.

⁽⁶⁾ Technically they used principle components analysis, which is related to, but not the same as factor analysis. In the service of brevity, however, I will treat this work and others like it (e.g., O'Connor, 2005) as having conducted an EFA.

⁽⁷⁾ The rationale for many of the decisions made by the Work Group was political as opposed to scientific, and therefore was frequently driven by expediency to satisfy competing interests. A discussion of these issues goes beyond the current chapter, although the interested reader is directed to retrospectives by Krueger (2013), Skodol et al. (2013), and Widiger (2013).

⁽⁸⁾ I limit my review to structure and bipolarity here, having addressed hierarchy above, and because range, although important, generally requires the application of item response theory techniques, which are not currently applicable to fully dimensional scales. Nevertheless, a number of recent studies have started to examine range in personality scales, and I direct the reader to Walton and colleagues (2008), Samuel and colleagues (2010), and Stepp and colleagues (2012).

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