Online Appendix to accompany Sterba, Copeland, Egger, Costello, Erkanli & Angold (2010)

Longitudinal dimensionality of adolescent psychopathology: Testing the differentiation hypothesis

Some popular comorbidity models use higher-order factors (often called "core psychopathological constructs") to explain covariances among lower order factors—which themselves represent Diagnostic and Statistical Manual of Mental Disorders (DSM) syndromes. Other comorbidity models explain associations among lower order factors simply by allowing them to be correlated. Higher-order factor comorbidity models that have been proposed to date typically require estimation of fewer parameters than the purely lower-order factor models. The latter models require the estimation of many correlations among many syndromes, whereas the former models usually require the estimation of only a few higher-order factor loadings and a few higher-order factor correlations. Hence, when higher-order factor models are estimated the question is whether the decrement in fit associated with moving from the less parsimonious lower-order factor model to the more parsimonious higher-order factor model is statistically (and substantively) significant.

In this online appendix, we describe fitting a variety of higher-order factor models—each mentioned previously in the comorbidity literature—and comparing these with the final lower-order factor models for each age-group from Sterba, Copeland, Egger, Costello, Erkanli, and Angold (2010). In other words, results presented in this online appendix can be thought of as an extension of model comparisons #1-5 that were presented in Table 2 of Sterba et al. (2010) for each age group separately (age 9-10, age 11-13, and age 14-16).

Here, we considered the following higher-order models. Model F, the most parsimonious, had correlated internalizing and externalizing higher-order factors (Krueger, Caspi, Moffitt, & Silva, 1998), where lower-order major depression/generalized anxiety, separation anxiety, and social anxiety latent syndromes served as indicators for the former, while lower-order conduct disorder, oppositional defiant disorder, hyperactivity, impulsivity, and inattention latent syndromes served as indicators for the latter. Model G had the same correlated internalizing and externalizing higher-order factors as in Model F, but also allowed the major depression/generalized anxiety lower-order syndrome to load on both higher-order factors (Lahey et al., 2008). Model H had the same internalizing factor as in Model F, but the correlated externalizing factor had lower-order indicators of only oppositional defiant disorder and conduct disorder, while a third higher-order factor, attention deficit hyperactivity disorder, had lower-order indictors of hyperactivity, inattention, and impulsivity latent syndromes (Achenbach & Rescorla, 2001). Model I had the same externalizing higher-order factor as in Model F, but the correlated internalizing factor had two subfactors: "anxious/misery" (separate indicators are major depression and generalized anxiety) and "fear" (indicators are social anxiety and separation anxiety) (Vollenberg et al., 2001; Slade & Watson, 2006). For identification, variances for higher-order factors were constrained to 1, and additionally, if a higher order factor only had two indicators, one of these was constrained to 1.

Model (I) (not shown in table) required specifying generalized anxiety and major depression as two-dimensional, and so was only estimable at age 14-16. Model comparisons shown in the below table indicated that higher-order models (F), (G) and (H) had significantly worse chi-square and Bayesian Information Criteria (BIC) values than the best correlated lower-order syndrome models from Sterba et al. (2010). Model (I) had a BIC=-266845 (i.e., ΔBIC= -614) and a $\Delta\chi^2(9)=116.45$, worse than other higher-order models in which major depression and generalized anxiety were specified as unidimensional. Model (H), the least parsimonious, resulted in the smallest increase in BIC. Additionally, Model (H) was not age-invariant (major depression/generalized anxiety loaded significantly on externalizing at 9-10 and 11-13 only).

Implications of these findings. These findings tell us two things. First, the *less* parsimonious the higher-order factor model, the better the fit. In other words, the more the higher order structure resembled the lower order structure, the better the fit. This finding is consistent with there not being any simple, few core psychopathological construct arrangement that can adequately account for DSM syndrome covariation. Second, these findings regarding Model (I) suggest that, once unidimensionality of generalized anxiety and major depression is accounted for, such "anxious/misery" subfactors are not needed. Moreover, even when major depression and generalized anxiety are near-unidimensional (age 14-16), treating them as a unidimensional indicator in various internalizing-externalizing higher-order models (Model F, G, or H) resulted in better fit than treating them as bi-dimensional and estimating subfactors of "anxious/misery," for generalized anxiety and major depression, and "fear," for separation anxiety and social anxiety (Model I).

These results illustrate the problem with the typical practice of estimating higher-order comorbidity models using threshold DSM diagnoses as indicators of higher-order factors, without first verifying the unidimensionality of these syndromes and without controlling for symptom overlap (see Sterba et al. (2010) for further discussion). Misspecified dimensionality of lower-order factors (e.g. depression and generalized anxiety) or unaccounted symptom overlap can manifest in necessity for spurious higher order factors—a point that was anticipated by Wittchen, Hofler, and Merikangas (1999). That is, Wittchen et al. (1999, p. 930) cautioned that: "the exclusive reliance on threshold diagnoses carries substantial risks of artifactual explanations… symptom overlap between depressive and anxiety disorders might also result in the authors finding of a [higher order, explanatory] anxious-misery factor."

Continuation of Sterba et al. (2010) Table 2. Nested model comparisons for syndrome dimensionality testing.

Model Comparison	Less vs. more restrictive[2]	Age 9-10		Age 11-13		Age 14-16	
		$\Delta\ \chi^2$ (df) [1]	ΔBIC[3]	$\Delta\ \chi^2$ (df) [1]	ΔBIC[3]	$\Delta\ \chi^2$ (df) [1]	ΔBIC[3]
#6	Final vs. (F)	Δ 66.45 (10) ***	Δ -68	Δ 107.59 (10) ***	Δ -522	Δ 105.58 (10) ***	Δ -584
#7	Final vs. (G)	Δ 66.45 (10) ***	Δ -44	Δ 98.90 (9) ***	Δ -509	Δ 106.90 (9) ***	Δ -587
#8	Final vs. (H)	Δ 51.26 (12) ***	--	Δ 57.52 (10) ***	Δ -34	Δ 62.84 (10) ***	Δ -129
	Final model	**109.35 (53)*** **	**-26469**	**169.88 (79)**** **	**-147970**	**161.98 (78)***	**-267459**

Notes: *** $p<.001$; ** $p<.01$; * $p<.05$; -- could not be estimated. [1]Degrees of freedom for robust chi square tests of absolute fit and difference tests are *not* determined directly from the model specification, but estimated (Satterthwaite-type) as described in Muthén (1998-2004; equation 110). [2] The more restrictive model is supported if the chi square difference does not increase appreciably from the less- to more-restrictive model. [3] Same pattern obtained with sample-size-adjusted-BIC. ODD=Oppositional Defiant Disorder; CD=Conduct Disorder; H=Hyperactivity; IN=Inattention; I=Impulsivity; SAD=Separation Anxiety Disorder; SOC=Social Phobia; MDD=Major Depression Disorder; GAD=Generalized Anxiety Disorder.

Final model (from Sterba et al., 2010) = MDD/GAD + SAD + SOC + ODD + CD + H + I + IN

Model F = higher-order internalizing and externalizing factors in place of correlated latent DSM syndromes in final model

Model G= higher-order internalizing and externalizing factors as in Model G, but MDD/GAD loads on both

Model H = higher-order internalizing (indicators: MDD/GAD, SAD, SOC), disruptive (indicators: ODD, CD), attentional (indicators: H, I, IN)

Appendix References

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