Appendix

Model specifications for the invariance testing sequence.

The sequential strategy that was followed in the present study and the details of model specifications were devised from the work of Meredith and Teresi [30] on the invariance of first-order factor models, Cheung [80] on the invariance of second-order factor models, as well as Millsap and Yun-Tein [81] and Morin, Madore, Morizot, Boudrias and Tremblay [82] on the invariance of first-order factor models based on ordered categorical items. The Mplus inputs, based on the theta parameterization, are available upon request from the first author. For a formal mathematical presentation of these specification, the interested reader is referred to Millsap and Yun-Tein [81].

Invariance of the first order factor structure.

A note on thresholds. With ordered-categorical items, both the thresholds and the intercepts of an item cannot be identified at the same time and provide redundant information. Thresholds are the points on the latent response variate underlying the observed categorical item at which the observed scores change from one category to another. Intercept represent the intercept of the relation between the latent factor and the latent response variate underlying the observed categorical item. Mplus defaults involve working with thresholds rather than intercepts [76, 85] given that thresholds allow a greater level of flexibility.

Configural invariance. This step involves verifying whether the same factor model (i.e. with the same pattern of fixed and free parameters) is supported across groups, before adding any constraints. This model is first estimated separately in each group and then in the context of a multi-group model. For this model to be identified, (i) items' uniquenesses are fixed to one in the first referent group and free in the remaining comparison group; (ii) factor means are fixed to zero in the referent group and free in the comparison group; (iii) the loading of the referent variables (i.e. the first item from each factor) was fixed to one; (iv) the first two thresholds for the referent variables and the first threshold from the other variables were fixed to equality across groups.

Weak invariance. For the factors to have the same meaning across groups, their loadings need to be equivalent. Thus, weak invariance is tested by the addition of equality constraints on the factor loadings across groups. The loading of the referent variable was freed (but specified as equal across groups), but the factor variance was fixed to one in the referent group.

Strong invariance. Strong invariance indicates whether individuals with the same score on a latent factor answer the items in a similar way. In other words, strong invariance verifies if mean differences at the item level are fully explained by mean differences at the factor level. This assumption is tested by adding equality constraints on all thresholds across groups. Strong invariance is a prerequisite to valid latent mean-levels comparisons across groups.

Strict invariance. The more stringent assumption of strict invariance involves testing whether the items levels of measurement errors are equivalent across groups by adding equality constraints on items' uniquenesses across groups (i.e. fixing them to one in all groups). Strict invariance is a prerequisite to valid manifest mean-levels (i.e. based on summed/averaged scores) comparisons across groups.

Invariance of the factor variance/covariance matrices. The previous steps are sufficient to assume that the measurement properties of an instrument are the same across groups. However, it is also informative to test whether the full variance/covariance matrix is also invariance across groups. This is done by adding equality constraints on the factor covariances and by fixing all factor variances to one in all groups.

Latent mean invariance. Finally, factor means were constrained to equality across groups (i.e. fixed to zero in all groups). At this step, rejection of the invariance hypothesis indicate significant latent mean-levels differences across groups and the latent means estimated from the preceding model can be used to estimate the size of these differences. As the latent means are fixed to zero in the referent group in the preceding model, the latent means estimated in the comparison group represent mean-level differences between groups and the significance test associated with these latent means indicate whether they significantly differ from the other group.

Invariance of the second order factor structure.

Configural invariance. This step involves verifying whether the same higher order factor model is supported across groups. This model is estimated from the first order strictly invariant model (i.e. the first order part of the model is assumed to be strictly invariant or at least based on the results of the first four steps of the first-order invariance tests). For the second order part of this model to be identified, (i) second-order factor loadings were freely estimated in all group but the variance of the second-order factor was fixed to one in all groups; (ii) second-order intercepts (i.e. the means of the first-order factor once the second-order factor is taken into account) were fixed to zero in the referent group but freely estimated in the comparison group; (iii) the second-order factor mean was fixed to zero in all groups; (iv) the second-order disturbances (that is the variance of the first-order factor that remains unexplained by the second-order factor) were fixed to one in the referent group but freely estimated in the comparison group.

Weak invariance. Weak invariance of the second-order factor structure was tested by adding equality constraints on the second-order factor loadings across groups. At this step, the second-order factor variance could be freed in the comparison group.

Strong invariance. Strong invariance of the second-order factor structure was tested by adding equality constraints on the second-order intercepts across groups. At this step, the second-order factor mean could be freed in the comparison group.

Strict invariance. Strict invariance of the second-order factor structure was tested by constraining the second-order disturbances to equality (i.e. fixing them all to one) across groups.

Invariance of the second-order factor variance. Invariance of the second-order factor variance was tested by constraining it to one in all groups.

Latent Mean Invariance. Invariance of the second-order factor mean was tested by constraining it to zero in all groups.