Annex. Summary of the possibilities and limitations of SPSS, FACTOR, PRELIS and MPlus.

Below we present the possibilities and limitations of each of the most widely used programs in the context of applied research, complementing the most suitable roadmaps according to the new standards. Some programs present more advanced options, but due to space limitations, and given the generalist profile of this study, we will not describe them here.

SPSS

1) Factorial model. Type of data and association matrix

Possibilities: The standard version of SPSS only uses the linear factor analysis approach. The non-linear approach is possible by using additional SPSS programs such as TETRA-COM and POLYMAT-C (Lorenzo-Seva & Ferrando, 2012, 2015). Thus, when we use the standard version, SPSS analyzes the Pearson correlation matrix or the variance-covariance matrix, whether or not this is the suitable option according to the new standards. This program evaluates on demand the suitability of the matrix for its factorization by means of the KMO measure and Bartlett's Sphericity Test.

Limitations: SPSS does not directly analyze polychoric or tetrachoric correlation matrices. Although, as we just pointed out, there are programs that can estimate the polychoric and tetrachoric correlation matrices (Lorenzo-Seva & Ferrando, 2012, 2015), they are not integrated within the factor analysis. SPSS does not offer the researcher a preliminary and automatic analysis of the distribution of the items either.

2) Factor estimation methods

Possibilities: SPSS makes it possible to use some of the recommended factor estimation methods: Unweighted Least Squares, (ULS), Generalized Weighted Least squares, (GWLS), and Maximum Likelihood, (ML), and the most traditional principal axes.

Limitations: The default option is principal components (PC). However, we know that PC is not a factor analysis method, and, therefore, it is currently the least recommended estimation procedure for most psychological applications.

3) Factor selection methods

Possibilities: Different methods based on the amount of explained variance, such as the Kaiser method –default option-, the Scree test, and the proportion of variance explained by each factor. In addition, the researcher can use the option of fixing the number of factors according to his/her hypothesis. Finally, if the ML factor estimation method is used, the chi-square goodness-of-fit index is obtained.

Limitations: It does not offer the most recommendable criteria, such as the goodness-of-fit of the fitted factor model (which would allow us to also compare the fit of different rival models), or "extra" objective criteria such as Parallel Analysis (PA, first described in Horn, 1965) or the MAP (Minimum Average Partial) test (Velicer, 1976). However, it should be pointed out that there are macros for SPSS that can be implemented to carry out these analyses (O'Connor, 2000) (on the author's web page, macros can be downloaded for different programs https://people.ok.ubc.ca/brioconn/nfactors/nfactors.html). SPSS does not offer any method based on residual minimization either.

4) Factor rotation and item assignment methods

Possibilities: SPSS offers an adequate variety of orthogonal and oblique rotation methods: OBLIMIN DIRECT, PROMAX, VARIMAX, EQUAMAX and QUARTIMAX. All of them are guided by the Kaiser principle of factorial simplicity: each item is expected to have a high loading in only one factor. The researcher does not determine what that factor is.

Limitations: In this type of rotation guided by the principle of simplicity, the factorial purity of the measurement instruments is a key issue (Ferrando & Lorenzo-Seva, 2013, 2014).

In summary, SPSS can be used efficiently if we take into account the limitations it presents and take advantage of the possibilities it offers, although the conditions where it is adequate are rather limited (unless the available macros are used to estimate the tetrachoric or polychoric correlation matrices when the non-linear model is the most appropriate).

FACTOR

1) Factorial model. Type of data and association matrix

Possibilities: FACTOR makes it possible to choose between linear and non-linear EFA because it can analyze the Pearson correlation matrix, the variances-covariance matrix and, depending on whether the data are polytomous or dichotomous, the polychoric correlation matrix or the tetrachoric correlation matrix. This program automatically offers various tests of the matrix's adequacy for factorization, among which the KMO measure and Bartlett's sphericity test stand out. In addition, it offers the researcher a preliminary and automatic analysis of the distributions of the items to be analyzed and Mardia's multivariate normality test (1970), so that the selection of linear or non-linear factor analysis is an informed choice.

Moreover, FACTOR 10.3.01 handles missing values through a multiple imputation procedure (Lorenzo-Seva & Van Ginkel, 2016). This is a novel procedure in the context of EFA and it is not available in any other commercial software.

Limitations: FACTOR does not directly read the data from SPSS or Excel. Instead, the data file has to be in ASCII (.dat) format, without labels of variables, number of cases, or any information apart from the item scores. The program website does offer an excel file to preprocess the data and save them in ASCII format. This file was recently updated on the FACTOR web page to better adapt it to the updated format of Excel 2010/13.

2) Factor estimation methods

Possibilities: FACTOR makes it possible to use the common estimation methods ULS and ML. In addition, it incorporates another less well-known method: the minimum range factor analysis. This method allows the researcher to interpret the proportion of common variance explained by each retained factor (see, Lorenzo-Seva & Ferrando, 2006, 2013).

In its latest version (10.3.01), the program is offered in three modalities: 64-bits, 32-bits, and XP. The most efficient version is that of 64-bits because results can be obtained much more rapidly, and larger sets of data can be managed. In fact, this version can finalize analyses that the other versions (32-bits and XP) cannot because they produce a memory error.

Limitations: It does not have robust or weighted least squares (WLS) estimation methods, which are recommendable when the non-linear model is appropriate because they lead to more correct assessments of model fit (as long as the samples are large enough). The next version, 10.4.01, will incorporate these weighted estimation methods.

In another vein, analysis with the 32-bits and XP versions of FACTOR can take longer than with other programs (mainly when performing PA, which involves obtaining and analyzing a large number of random samples through bootstrapping).In addition, in the case of using XP, while performing the analysis, Windows can present an error message, and it may seem that the analysis has stopped and the program is not responding, but it is only a question of waiting. At other times, problems appear, and the program does freeze up. In these cases, it would be helpful to have a warning message from the program indicating that it is necessary to close the program and exit because the analysis cannot continue.

3) Factor selection method

Possibilities it offers: FACTOR requires the researcher to indicate the number of factors to retain. However, it aids in making this decision because it offers objective criteria for this purpose: PA classic implementation, PA optimal implementation (which analyzes the same type of correlation matrix as the one that will be analyzed -Pearson or polychoric-), the MAP test, and the HULL method (which makes it possible to choose between different numbers of factors by combining the principle of parsimony and the goodness-of-fit of the resulting model). Finally, it also offers information about the eigenvalues, so that the user can represent them graphically and apply the Cattell scree-test if desired. Furthermore, when the ML or ULS estimation methods are used (in the latter case, only with polychoric correlations), the program offers different goodness of fit indexes, including the chi-square test, GFI, AGFI, NNFI, CFI, RMSEA, and the non-centrality parameter estimate. Finally, it offers descriptive information about the distribution of residuals.

4) Factor rotation and item assignment methods

Possibilities: Like SPSS, FACTOR offers a variety of traditional orthogonal and oblique rotation methods, including OBLIMIN DIRECT, PROMAX and VARIMAX. FACTOR also includes the OBLIMIN and WEIGHTED VARIMAX procedure and other less well-known methods such as PROMAJ (Trendafilov, 1994). In addition, it offers other new and original methods such as SIMPLIMAX (Kiers, 1994) and PROMIN (Lorenzo-Seva, 1999). SIMPLIMAX is efficient but difficult to use because it requires certain specifications from the researcher (see Ferrando & Lorenzo-Seva, 2014). PROMIN is a special SIMPLIMAX case that does not require previous specifications. As Ferrando and Lorenzo-Seva (2014) explain, PROMIN makes the difficult decisions in the model proposal, so that it is quite close to the exploratory pole, where it is only necessary to specify the number of factors. It is as simple as the classic methods.

FACTOR also allows a more confirmatory approach within the EFA. Among the possible options, the "partially-specified procrustean rotation" makes it possible to propose a target matrix that specifies the value of the elements that are expected to be zero in the rotated pattern matrix (Browne, 1972a, 1972b). This target matrix guides the rotation of the factor loading matrix without imposing the traditional and less realistic principle of factorial simplicity (Kaiser, 1974).

Limitations: FACTOR offers more than 25 different rotations, some novel or less well-known. Which one should we choose? FACTOR does not have the typical user's manual. The applied researcher would appreciate some recommendations about when to use one rotation method or another.

FACTOR is a program specifically developed to meet the needs of novice, average, and advanced researchers in matters related to EFA. In this brief summary, we have only presented an overview of the most basic aspects, leaving the interested reader with options for performing second-order factor analysis, or for trying the intermediate factorial solutions between exploratory and confirmatory factor analysis. It should also be pointed out that the 9.2 version of FACTOR (Lorenzo-Seva & Ferrando, 2013) makes it possible to evaluate other non-linear approaches through Item Response Theory (IRT).

In summary, FACTOR allows many suitable options or combinations, always based on the fact that it automatically offers 1) criteria to assess the adequacy of the input correlation matrix for factor analysis and 2) criteria to assess the multivariate and univariate normality of the items' distributions. In addition, FACTOR is a program that is constantly being improved. The version in progress, 10.4.01, will include the following novelties: 1) factor estimation by means of the Diagonally Weighted Least Squares (DWLS) estimation method; 2) robust estimation for both ULS and DWLS; 3) revision of ML estimation methods to avoid convergence problems; 4) Bayesian estimation of the tetrachoric and polychoric correlation matrices; and 5) the possibility to obtain standard errors and confidence intervals for all the estimated parameters using bootstrapping procedures.

PRELIS (PRE-processor of LISREL)

With Prelis, the pre-processor of LISREL, it is possible to perform an Ordinal Factor Analysis, which is a non-linear analysis that uses full information estimation methods. Instead of analyzing polychoric correlations (where univariate and bivariate frequencies are used to estimate parameters), full information approaches use the whole response pattern to obtain information about parameter estimates (Bock, Gibbons, & Muraki, 1988). However, in this article, we only focus on the application of classic EFA, the topic of the review in Lloret et al. (2014). In this review, version 9.10 of LISREL was used, but the main differences from previous versions of LISREL will be pointed out.

1) Factorial model. Type of data and association matrix

Possibilities: When data are defined as continuous, PRELIS bases the analyses on Pearson correlations. When data are defined as ordinal, PRELIS bases the analyses on the polychoric or tetrachoric correlation matrices, depending on whether the data are polytomous or dichotomous, respectively. The corresponding variance-covariance matrices can also be analyzed. This is the option that appears by default. However, if the data are defined as ordinal and the MINRES (MINimum RESiduals) estimation method is used, which is equivalent to ULS (see the next section), then the polychoric (or tetrachoric) correlation matrix is analyzed, regardless of whether the covariance or correlation matrices are marked in the options (to use the variance-covariance matrix, see Jöreskog, 2002).

If the data are defined as continuous, the program offers information about the means and standard deviations of the items, as well as the skewness and kurtosis. In addition, it performs univariate normality contrasts automatically, and it offers the option of performing Mardia's multivariate normality test (Mardia, 1970). In the case of using ML, when there is severe multicollinearity for any of the variables, the program indicates this.

If the data are defined as ordinal, the program offers thresholds between response categories, as well as tests of the adequacy of the estimation of each bivariate correlation, in order to evaluate whether the latent variables underlying the ordinal items follow a normal distribution.

Thus, PRELIS offers the researcher a preliminary and automatic analysis of the distribution of the items.

Limitations: PRELIS does not offer information about the matrix's adequacy for factorization by means of the KMO measure or Bartlett's sphericity test.

2) Factor estimation methods

Possibilities: In addition to principal components (PC), which is not a true factorization method, PRELIS has two estimation methods: ML and MINRES. This latter method, proposed by Harman (1980), is equivalent to unweighted least squares (ULS), except for an orthogonal transformation of the factor loadings (Jöreskog, 2003). However, it should be mentioned that in version 9.10 of LISREL, the PC analysis does not appear as an estimation method within EFA, as in earlier versions, but rather it appears as a differentiated analysis.

Limitations: as in FACTOR, it does not have robust ML estimation methods or WLS.

3) Factor selection method

Possibilities it offers: In earlier versions of LISREL, the specific factor selection method depends on the estimation method used. When ML was used, the program fitted models with different numbers of factors (0, 1, 2, etc.) and offered goodness of fit indexes for the different models, specifically, the chi-square test and the RMSEA (Root Mean Square Error of Approximation) index for each model, and the significance of the chi-square difference between consecutive models. The stopping criterion in earlier versions of LISREL (8.30 and 8.80) takes into account various possible contingencies. If the null hypothesis that the model with zero factors fits the data cannot be rejected, the program stops. It would not make sense to continue with the analyses because the variables analyzed would be linearly independent. If the zero-factor model does not fit the data, the program increases the number of factors by one. If the probability associated with the chi-square statistic for a model with a *k* number of factors is greater than .10, the program considers that this model adequately represents the data, and it shows the solution for this model. If the probability associated with a model is less than .10, but the chi-square difference between this model and another model with an additional factor is greater than .10, the program stops because it considers that the difference between these models is not large enough to extract another factor, printing the solution for the most parsimonious model (i.e. with fewer factors). Finally, if the RMSEA value for a certain model with *k* factors is less than .05, the program prints the model solution with this number of factors. This latter criterion, according to Jöreskog, Sörbom, Du Toit and Du Doit (1999), is intended to guarantee that the number of factors will not be overestimated in large samples (Browne & Cudeck, 1993). If none of the aforementioned conditions are met, the program increases *k* (number of factors) by 1, and it continues the process until some of these conditions are met.

However, for LISREL 9.10, the criterion followed to maintain a certain number of *k* factors, regardless of the estimation method used, is the Kaiser criterion. Thus, the number of factors maintained will be equal to the number of eigenvalues greater than 1. Nevertheless, when using maximum likelihood (ML) with continuous data, the program continues to print the same decision table printed in previous versions, with the goodness-of-fit indices of the different models (and their comparison), from 0 factors to the number suggested by the Kaiser criterion. This information can be evaluated by the user to determine whether a lower number of factors could be sufficient to satisfactorily represent the data. In theory, it is also possible to set the number of theoretically expected factors. However, if the number of factors requested is different from the number extracted following the Kaiser criterion, the program does not print a solution.

Limitations: PRELIS does not offer additional criteria, such as PA or MAP, a variety of goodness of fit indexes, or the scree-test (although this can be obtained from the eigenvalues).

4) Factor rotation methods and item assignment

Possibilities: With both estimation methods (ML and MINRES), the following solutions are offered: 1) Non-rotated, 2) with orthogonal rotation, specifically VARIMAX (Kaiser, 1958), 3) with oblique rotation, specifically PROMAX (Hendrickson & White, 1964), and 4) the reference variable solution, which also offers the correlations between factors. This latter solution is obtained using the TSLS (Two-Stage Least Squares; see Jöreskog et al., 1999) estimation method, and the reference items chosen are the items in the PROMAX solution with the largest factor loading in the corresponding factor. The advantage of using this latter method is that it provides standard errors and *t* values for the factor loadings, except for the reference items. Consequently, it is possible to determine whether the parameter estimates are statistically significant. If one wants to estimate the reference variable solution using ML, it is possible to employ specific commands (see syntax examples in the manual). In this latter case, it is advisable to use the variance-covariance matrix as input, in order to obtain correct standard errors (see, Jöreskog et al., 1999).

In summary, PRELIS allows the use of different input matrix depending on the nature of the data and the most adequate model, but it is completely limited in terms of the factor selection method, and it has few estimation (only ML and MINRES) and rotation (VARIMAX as orthogonal and PROMAX as oblique) methods.

MPlus

1) Factorial model. Type of data and association matrix

Possibilities: MPlus offers different possibilities, allowing the researcher to analyze the appropriate matrix according to the nature of the data. When nothing is indicated in the input file, the program assumes that the data are continuous; when they are ordinal or categorical, this must be indicated with the corresponding instruction. For continuous items, it will estimate the Pearson correlation matrix; for ordinal polytomous items, it will estimate the polychoric correlation matrix; and for dichotomous data, it will estimate the tetrachoric correlation matrix. If the researcher thinks his/her data can be modeled more robustly and simply by using the linear model, then he/she will have to define them as continuous, as occurs with PRELIS.

In the case of categorical items, the program offers preliminary information about the distribution of the subjects in the different item response categories. Specifically, it offers the percentage and number of subjects who answered each of the possible alternatives.

Limitations: MPlus does not offer adequacy tests (such as KMO, for example) to evaluate the adequacy of the correlation matrix for its factorization. Nor does it offer preliminary and automatic tests to evaluate the fit of the data to normality.

2) Factor estimation methods

Possibilities it offers: MPlus offers a wide variety of factor estimation methods, and it allows the researcher to choose some of the recommended ones.

When the items have been defined as continuous, MPlus offers 4 possible estimation methods: ML, robust ML (MLM, MLMV), and ULS. With regard to the robust ML estimation methods, they offer robust estimations of the standard errors and the chi-square test. The MLM option provides a mean-adjusted chi-square model test statistic, so that the Satorra-Bentler chi-square is offered (Satorra & Bentler, 2001). The MLMV option produces a mean and variance adjusted chi-square test of model fit.

When there is at least one categorical item, MPlus also offers 4 possible estimation methods: weighted least squares (WLS), robust WLS (WLSM, WLSMV), and ULS. The default option is WLSMV; and the least recommendable option is ULS, which is less stable and, when combined with the tetrachoric correlation matrix, does not offer goodness of fit indexes (which also occurs with FACTOR). As in the case of the robust ML estimators, the robust WLS estimators offer robust estimations of standard errors and the chi-square statistic, and the name of each estimation method refers to whether the solution provides a mean-adjusted chi-square (WLSM) or a mean and variance adjusted chi-square (WLSMV).

Therefore, we can see that Mplus offers robust estimation methods for the violation of the multivariate normality assumption, such as WLS, Robust WLS (WLSM, WLSMV), or Robust ML (MLM, MLMV). Choosing one or another will depend on what type of matrix is more appropriate as input, considering the types of items.

3) Factor selection method

Possibilities: MPlus offers methods based on residual minimization. Specifically, it offers RMSEA and SRMR (Standardized Root Mean Square Residual).

This program requires the researcher to set the number of expected factors, and the output offers the result of the different models tested: from a one-factor solution, to a solution with the specified number of factors, up to a maximum of 9. Therefore, it makes it possible to compare the fit of alternative models based on their goodness-of-fit indexes. This comparison can be carried out based on incremental fit indexes (ΔRMSEA, ΔCFI and ΔNNFI), following the criteria recommended in the literature (e.g. Chen, 2007; Cheung & Rensvold, 2002; Widaman, 1985).

Limitations: It does not offer some of the "extra" criteria recommended, such as PA or MAP. It only employs the model comparison strategy.

4) Factor rotation methods and item assignment

Possibilities it offers: MPlus offers a wide variety of orthogonal and oblique rotation methods: VARIMAX, PROMAX, QUARTIMIN, OBLIMIN, GEOMIN, CF-VARIMAX, CF-QUARTIMAX, CRAWFER, CF-EQUAMAX, CF-PARSIMAX, CF-FACPARSIM and TARGET. All of the rotation methods are available with both orthogonal and oblique rotation, except VARIMAX, which is orthogonal, and PROMAX and QUARTIMIN, which are oblique. The default rotation method is oblique GEOMIN.

As presented in recent studies (Ferrando & Lorenzo-Seva, 2014), the rotation method used somewhat determines the more exploratory or confirmatory nature of the analysis performed. Specifically, the Target rotation available in MPlus allows a more confirmatory approach under the label of EFA. This rotation makes it possible to propose a target matrix that specifies the value of some of its elements, specifically those expected to be zero in the rotated pattern matrix. Therefore, this target matrix guides the rotation of the factor loading matrix. A more detailed description of the criteria followed when this rotation method is applied is provided in the study by Ferrando and Lorenzo-Seva (2014) under the name “partially-specified procrustean rotation”, and it can also be consulted in the study by Browne (2001) under the name “rotation to a partially-specified target matrix”. In addition, the items’ assignment to the factors is left to the researcher, who will apply the recommended criteria to determine which items belong to each factor.

Limitations: In MPlus, as in FACTOR, the applied researcher can feel overwhelmed by the large number of rotation options the program offers, and he/she may need some recommendations about when to use one rotation method or another.

In summary, MPlus can be used efficiently because it offers a wide range of possibilities, although it also has some limitations, mainly related to the factor selection criteria.