Published in final edited form as:

Marriage Fam Rev. 2015 ; 51(5): 385–395. doi:10.1080/01494929.2015.1059785.

Combining Parallel and Exploratory Factor Analysis in Identifying Relationship Scales in Secondary Data

Nathan D. Wood, Djidjoho C. Akloubou Gnonhosou, and Justin Bowling

Department of Family Sciences, University of Kentucky

Abstract

Common methods used in the literature to identify factors within exploratory factor analysis has been shown to be potentially problematic. This brief report illustrates a state of the art approach in identifying factor structure by adding parallel analysis prior to exploratory factor analysis. Parallel analysis enables researchers to have a high degree of confidence of the number of factors to extract prior to exploratory factor analysis. The procedure is illustrated by using items from the National Survey of Families and Households (NSFH) that were used to identify relationship scales.

Keywords

Parallel analysis; Exploratory factor analysis; relationship adjustment; marital quality; national survey of households and families

Each element of the research process forms a structure upon which an empirical or qualitative home is built. A critical component of quantitative research in family sciences lies in questionnaires. Numerous research articles are published each year that establish the reliability and validity of new questionnaires, refine existing questionnaires, or debate constructs that are “actually” measured. This literature base is essential as statistical procedures, results, and implications are all dependent on reliable and valid questionnaires. This paper has three main objectives: 1) Provide a call to the research community to incorporate current recommendations in exploratory factor analytic methods, 2) Illustrates the use of these methods to identify theoretically consistent scales within publicly available datasets such as the National Survey of Families and Households (NSFH; Sweet, Bumpass & Call, 1988), and 3) Place the resulting questionnaire within the relationship assessment literature.

Given the importance of questionnaire data, it is surprising that the field has not implemented recent research in exploratory factor analysis techniques (EFA) and has relied instead on methodology that is 50–60 years old. Of particular note, over-reliance on the Kaiser rule (i.e., retaining factors with Eigenvalues greater than one), and forcing subscale differences via varimax rotation still dominate the literature and are often default settings in statistical packages. More rigorous methods of determining the number of factors to extract

and rotational procedures that fit family science data are readily available (Costello & Osborn, 2005; Hayton, Allen, & Scarpello, 2004).

Multiple authors have shown that the Kaiser criterion (Kaiser, 1960) can misidentify the number of factors (Gaskin & Happell, 2014; Horn, 1965; Ruscio & Roche, 2012). While recognition of the weakness of the Kaiser criterion is well known, alternative methods have not been fully integrated into statistical software packages (O’Conner, 2000). Three main alternative methods to the Kaiser criterion are the scree plot (Cattell, 1966), Velicer’s minimum average partial (MAP; Velicer, 1976), and parallel analysis (Horn, 1965). Each of these methods has their attending strengths and weaknesses.

The scree plot approach is becoming more common, and is recommended by some (e.g., Costello & Osborn, 2005) due to its visual nature and simplicity in creating the plot. The scree plot test is best when a clear change of the slope is present. Challenges arise in cases where there may be multiple slopes changes or a more gradual change of slope. The scree plot method can be subjective however as it is based on the researcher’s perception of where the “elbow” of the plot levels out (O’Conner, 2000).

Velicer’s MAP test and parallel analyses both rely on statistical theory and represent stronger solutions to identify the appropriate number of factors to extract. The MAP approach is performed in conjunction with a principle component analysis and identifies factors that account for a systematic variance rather than the overall variance. To perform Velicer’s MAP test, a series of procedures are performed on the correlation matrices that allow for the identification of factors (O’Conner, 2000). Beyond researchers’ awareness of the MAP approach, the main challenge prior to 2000 was the lack of support, or script for a MAP approach in commonly used software.

Parallel analysis (PA; Horn, 1965) is the only approach that formally tests the probability that a factor is due to chance. Parallel analysis can minimize over-identification of factors based on sampling error and is superior to reliance solely on eigenvalue scores generated by factor analytic processes alone. Another key difference of PA is that the procedure identifies the number of factors prior to performing an exploratory factor analysis. Originally, PA would create 1,000–5,000 Monte Carlo simulations on randomly generated data that matched the sample size and the number of potential scale items in the original dataset. These simulations generated a 95th percentile cutoff line overlaid on a screeplot given the item and sample size constraints (see Figure 1 for an example). Factors above the 95th percentile line generated by the simulations were considered to be “beyond chance.” After performing a parallel analysis, researchers can confidently specify the number of factors to extract in the subsequent factor analysis.

Recent work (Ruscio & Roche, 2012) has extended Horn’s (1965) original work by allowing simulations to be performed on the observed data rather than generating random data. It is thought that running simulations off of observed data will lead to greater accuracy in determining the number of factors to extract. It is important to note that it is still up to the researcher to determine if the subsequent EFA grouping of items is theoretically consistent.

EFA Rotation and Extraction Recommendations

The use of maximum likelihood extraction and oblique rotation is counter to the “typical” approach in exploratory factor analysis. However, in attempting to establish best practices for EFA in the psychology literature, Costello and Osborn (2005) argued that maximum likelihood extraction is superior to traditional extraction techniques, but previous computing power made its use prohibitive. Oblique rotation allows freedom for factors to be correlated *or* independent from each other. Orthogonal rotation forces factors to be minimally correlated with each other running counter to the theoretical underpinnings of many scales such as marital adjustment (Costello & Osborn, 2005).

Item Selection in Secondary Datasets

Over the years, researchers have used a myriad of assessment techniques and relational concepts in the attempt to describe relationships and then use those descriptions as predictors or response variables in research. These attempts have led researchers to measure relationships via marital status variables, self-report questionnaires, and observational coding systems (see Bradbury, Fincham, & Beach, 2000; Fincham & Beach, 2010, for excellent reviews of this work over the past two decades). It is critical for researchers utilizing secondary datasets to select items that are consistent with the desired relational construct.

Unit of measurement assumptions often lies at the heart of the difference between relational adjustment scales and other scales such as marital quality. Spanier (1976) made the case that the DAS is a dyadic measure; in that individuals answering questions are to reflect on the interactions between them and their partner, including their relationship. Spanier (1976) and Spanier and Cole (1976) argued that satisfaction is an important part of relationship adjustment and included it as a component of relationship adjustment. However, Norton (1983) and many since (e.g., Mattson et al., 2013), argued that marital quality and satisfaction are subjective perceptions individuals have toward their relationships.

Instructions to participants, item wording, and response sets should be analyzed to determine the unit of analysis in focus. For example, instructions for participants in the NSFH for questions that may factor into a “satisfaction” scale ask them to reflect on their own experiences or perceptions. These instructions, item construction, and response set would be more consistent with marital quality/satisfaction scales rather than adjustment scales.

Beyond questionnaire instructions, dimensionality of the desired scale should be considered when selecting items from a secondary dataset. Relational adjustment questionnaires are multi-dimensional scales while other relational assessments tend to be unidimensional measures. Specifically, relational adjustment encompasses “a process, the outcome of which as determined by the degree of” satisfaction, consensus (i.e., agreement), cohesion (time together), “interspousal tensions and personal anxieties”, and “troublesome marital differences” (Spanier & Cole, 1976, p. 127–128). The sum of all the subscales are typically totaled to represent overall relational adjustment.

On the other hand, Norton (1983) argued that marital quality should be unidimensional when being used as a research tool. Norton's (1983) methodological criticisms of the DAS rightfully point to issues of overlap between common independent variables analyzing marital processes and then using the DAS, which assess for similar constructs, as the response variable. This criticism of multiple component marital assessments has been endorsed by later research (e.g., Finch & Linfield, 1997; Funk & Rogge, 2007; Weiss, 2005; Fincham & Rogge, 2010). It should be noted that when discussing the DAS, Spanier (1976) explicitly stated that subscales of the DAS could be used independently which could ameliorate this critique.

Therefore, researchers should be familiar with the different relational assessments and the attending constructs when reviewing available items in a national data set. Are the items available more consistent with a unidimensional approach similar to marital quality instruments or are the items more akin to multidimensional measures such as marital adjustment? Once items have been identified, and the sample size of the final dataset is known, it is possible to proceed with a PA and EFA approach.

Method

The sample for the current study came from the second wave of the National Survey of Families and Households (NSFH; Sweet & Bumpass, 1996). Wave 2 of the NSFH contained 1846 married heterosexual couples where respondents and their partners completed at least part of the relationship questions. Demographic variables reported were collected from the NSFH identified respondent contained in Wave 1 data. The present sample contained 919 male and 927 female respondents. Approximately 88.8% of respondents identified themselves as White, while 7.4% identified as African American, 3.1% Mexican/Puerto Rican/Cuban/other Hispanic. Of the 1846 respondents, 16.4% stated that had completed a certificate program such as a GED or, 31.1% bachelor's degree, 10.3% master's degree, while 3% completed a doctorate.

Data

The NSFH data is a nationally representative sample of households and families in the United States of America (see Sweet, Bumpass, & Call, 1988 for details of the original data collection process). Data was collected over three separate waves. The initial wave was collected in 1987 and contained data from 9,637 households. A main respondent, male or female, was identified in each household during the initial data collection process. A spouse was also identified in each household and data was collected from these individuals. Wave 1 data contained limited relational assessment items. However, demographic data regarding the couples were culled from the Wave 1 dataset. Waves 2 and 3 contained numerous relational assessment items across both waves, however, statistics and procedures for the current study were performed with wave 2 respondents. These data were originally collected by mailed questionnaires to respondents as well as spouses across both times (see Sweet & Bumpass, 1996; and Sweet & Bumpass, 2002 for Wave 2 and Wave 3 data collection procedures respectively).

Prior to PA and EFA, questions from the NSFH were compared to items from the Marital Assessment Test (MAT: Locke & Wallace, 1959), Dyadic Adjustment Scale (DAS: Spanier, 1976), Kansas Marital Satisfaction Survey (KMSS: Schumm et al., 1986), Quality Marriage Index (QMI, Norton, 1983), and the Revised Dyadic Adjustment Scale (RDAS: Busby, Crane, Larson & Christensen, 1995). Those items with the strongest similarity to established marital questionnaire items and theoretical constructs were selected for the initial round of data exploration.

Analysis

For the purposes of the study, statistical models were tested on the main NSFH participants only in order to remove issues of data non-independence by using married couples (919 male, 927 female). The analysis process consisted of an iterative process whereby a parallel analysis (Horn, 1965) was performed to identify the number of factors to extract, based on the number of questions in the analysis, followed by a maximum likelihood extraction factor analysis with oblique rotation (see Gerolimatos et al. 2012, for an example in the psychological field of parallel analysis leading to a subsequent factor analysis).

Parallel analysis for the current study was run in SPSS (v. 20) utilizing the rawpar.sps script developed by O'Connor (2000). Due to space considerations, researchers are referred to an updated SPSS script allowing for permutations of raw data at <https://people.ok.ubc.ca/briocconn/nfactors/rawpar.sps>. Five-thousand datasets were generated based on permutations of the raw data, using a common factor analysis approach (Hayton, Allen, & Scarpello, 2004). This procedure generates eigenvalues from the raw data along with the mean eigenvalues and eigenvalues representing the 95th percentile based on the Monte Carlo simulation. The initial PA and indicated five eigenvalues, or factors, from the raw data are above the 95th percentile estimates created by the Monte Carlo simulation. However, the slope of the generated screeplot for the five factor solution dramatically shift at the forth factor. Cattell (1966) recommends that a dramatic change in slope of the screeplot would indicate the cutoff for the number of factors to extract from the factor analysis. However, PA results would seem to indicate that the fourth and fifth factor, while only slightly above the 95th percentile, bears further investigation.

To further assess the possibility of a five factor solution, a factor analysis with maximum likelihood extraction with an oblique rotation was then performed specifying a five factor solution. When the five factor solutions was analyzed, only “happy with time spent with spouse” loaded on the first factor while “how happy with sexual relationship” loaded on second and the fifth factor. As a single item is insufficient to meaningfully measure a relational construct (Norton, 1983) and items loading on more than one factor are also suspect.

These two items were removed prior to the next parallel analysis which indicated a three factor solution (see Table 1). The screeplot derived from the results in Table 1 indicated a three factor solution with the screeplot clearly leveling out beyond the forth factor and below the 95th percentile criterion (see Figure 1). A second factor analysis with maximum likelihood extraction with an oblique rotation was then run on these 12 items specifying a

three factor solution a priori. Table 2 shows the allocation of the different items into the three factor solution. The three factors cumulatively account for 61.69% of the variance.

The final test of the applicability of a three factor solution came through an analysis of the reliability coefficients of the proposed scales. Reliability was tested for male respondents and female respondents separately. Satisfaction and disagreement factors had moderate to strong reliability for both genders ranging from .76 for male disagreement to .89 for female satisfaction. The cohesion scale for male and female respondents was on the low end of acceptable alpha levels ($\alpha = .64$ for males, $\alpha = .65$ for females). Reliability was strong for the overall NSHF multi-dimensional scale and is comparable with established relationship adjustment scales ($\alpha = .84$ for males, $\alpha = .83$ for females).

Discussion

This study has shown the utility of using a parallel analysis to identify the number of factors to extract in subsequent factor analysis. Ruscio and Roche (2012) suggested that PA shouldn't be blindly used, especially when the eigenvalues of factors are close to the 95th percentile cutoff. This study was a good example of their concern as the initial 14 item solution had factor four and five close to the 95th percentile and beyond the break point of the scree plot. When the EFA was performed, two items were not considered appropriate to include in the analysis. Once the items were removed, a three factor structure clearly existed.

Results from this study also provide a rich multi-faceted tool to researchers using the NSFH dataset. This study showed a strong factor structure for satisfaction, disagreements, cohesion, and one large domain, "marital adjustment" in the NSFH dataset. The satisfaction scale (factor 1) found in the NSFH contains items and response sets consistent with other satisfaction and quality scales and has a strong reliability. The items tend to reflect participant's overall experience of their relationship and partner. If researchers are interested in a satisfaction/quality measure in the NSFH, they should remove the cohesion scale and marital disagreement scale that was identified in this study.

The marital disagreement scale consisted of items typically associated with questions related to the "consensus" construct (Spanier, 1976; Spanier & Cole, 1976; Busby et al., 1995). The typical response sets in the QMI, RDAS, DAS, MAT, and even the KMSS range from positive (e.g., always agree or very happy) to negative (e.g., always disagree/very unhappy). The response set for the marital disagreement scale better aligns with the Johnson et al. (1986) construct of "marital disagreement" in that the response set for NSFH items measured the frequency of disagreements about topics.

By using this grouping of items, consensus could be implied by a relatively low frequency of disagreements. However, negative perception uniquely contributed to variance in marital outcomes and perhaps the inference of cohesion may not be as important as the measurement of disagreement (Fincham & Linfield, 1997; Fincham & Rogge, 2010). Fincham and Rogge (2010) reinforced the importance of utilizing positive and negative scales when using pencil/paper questionnaires. In the current context, it may be beneficial to

utilize Factor 2 as a “relational disagreements” factor and to include it in models separately from cohesion and satisfaction scales (Johnson et al., 1986).

The third factor, “Time Together” found in the NSFH scale hints at Spanier’s (1976) cohesion or Johnson et al.’s (1986) marital interaction constructs. The current grouping of items in the NSFH data contain questions such as frequency of doing things together as a couple, the amount of “free” time together, as well as time spent as a couple with friends.

The three scales conceptually can be categorized as “Satisfaction,” “Marital Disagreement,” and “Time Together” or “Marital Interactions.” Combining all the scales together also shows strong internal reliability and could be used as a proxy for relational adjustment. Total scores on relational adjustment scales (e.g., DAS, MAT, RDAS) are especially useful as screening instruments in identifying couples who are distressed or non-distressed (Crane, Middleton, & Bean, 2000).

Researchers using existing datasets will do well to clearly conceptualize their research question and then choose the scales that best represents the constructs they wish to study. Researchers are encouraged to utilize more rigorous methods of identifying the factor structure in EFA. Specifically, utilizing parallel analysis in conjunction with exploratory factor analysis is a potent combination, it is hoped that future EFA work will integrate these recommendations.

Acknowledgments

“The first wave of the National Survey of Families and Households was funded by a grant (HD21009) from the Center for Population Research of the National Institute of Child Health and Human Development; and the second and third waves were funded jointly by this grant and a grant (AG10266) from the National Institute on Aging. The survey was designed and carried out at the Center for Demography and Ecology at the University of Wisconsin-Madison under the direction of Larry Bumpass and James Sweet. The field work for the first two waves was done by the Institute for Survey Research at Temple University, and the third wave by the University of Wisconsin Survey Center.”

References

- Bradbury TN, Fincham FD, Beach SRH. Research on the nature and determinants of marital satisfaction: A decade in review. *Journal of Marriage and the Family*. 2000; 62(4):964–980.10.1111/j.1741-3737.2000.00964.x
- Busby DM, Crane DR, Larson JH, Christensen C. A revision of the Dyadic Adjustment Scale for use with distressed and nondistressed couples: Construct hierarchy and multidimensional scales. *Journal of Marital & Family Therapy*. 1995; 21(3):289–308.
- Cattell RB. The scree test for the number of factors. *Multivariate Behavioral Research*. 1966; 1:245–276.
- Costello AB, Osborne JW. Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Practical Assessment, Research & Evaluation*. 2005; 10(7):1–9.
- Crane DR, Middleton KC, Bean RA. Establishing criterion scores for the Kansas Marital Satisfaction Scale and the Revised Dyadic Adjustment Scale. *American Journal of Family Therapy*. 2000; 28(1): 53–60.
- Fincham FD, Beach SRH. Marriage in the new millennium: A decade in review. *Journal of Marriage and Family*. 2010; 72(3):630–649.10.1111/j.1741-3737.2010.00722.x
- Fincham FD, Linfield KJ. A new look at marital quality: Can spouses feel positive and negative about their marriage? *Journal of Family Psychology*. 1997; 11(4):489–502.10.1037/0893-3200.11.4.489-502

- Fincham FD, Rogge R. Understanding relationship quality: Theoretical challenges and new tools for assessment. *Journal of Family Theory & Review*. 2010; 2(4):227–242.
- Funk JL, Rogge RD. Testing the ruler with item response theory: Increasing precision of measurement for relationship satisfaction with the Couples Satisfaction Index. *Journal of Family Psychology*. 2007; 21(4):572–583. [PubMed: 18179329]
- Gaskin CJ, Happell B. On exploratory factor analysis: A review of recent evidence, an assessment of current practice, and recommendations for future use. *International Journal of Nursing Studies*. 2014; 51:511–521. [PubMed: 24183474]
- Gerolimatos LA, Gould CE, Edelstein BA. Exploratory factor analysis of the anxiety control questionnaire among older adults. *Behavior Modification*. 2012; 36:600–616. [PubMed: 22563044]
- Hayton JC, Allen DG, Scarpello V. Factor retention decisions in exploratory factor analysis: A tutorial on parallel analysis. *Organizational Research Methods*. 2004; 7(2):191–205.10.1177/1094428104263675
- Horn JL. A rationale and test for the number of factors in factor analysis. *Psychometrika*. 1965; 30(2): 179–185. [PubMed: 14306381]
- Johnson DR, White LK, Edwards JN, Booth A. Dimensions of marital quality. *Journal of Family Issues*. 1986; 7(1):31–49.
- Kaiser HF. The application of electronic computers to factor analysis. *Educational and Psychological Measurement*. 1960; 20:141–151.
- Locke HJ, Wallace KM. Short marital-adjustment and prediction tests: Their reliability and validity. *Marriage & Family Living*. 1959; 21:251–255.
- Mattson RE, Rogge RD, Johnson MD, Davidson EKB, Fincham FD. The positive and negative semantic dimensions of relationship satisfaction. *Personal Relationships*. 2013; 20:328–355.
- Norton R. Measuring marital quality: A critical look at the dependent variable. *Journal of Marriage & Family*. 1983; 45(1):141–151.
- O'Connor BP. SPSS and SAS programs for determining the number of components using parallel analysis and Velicer's MAP test. *Behavior Research Methods, Instruments, & Computers*. 2000; 32(3):396–402.
- Ruscio J, Roche B. Determining the number of factors to retain in an exploratory factor analysis using comparison data of known factorial structure. *Psychological Assessment*. 2012; 24(2):282–292. [PubMed: 21966933]
- Schumm WR, Paff-Bergen LA, Hatch RC, Obiorah FC. Concurrent and discriminant validity of the Kansas Marital Satisfaction Scale. *Journal of Marriage & the Family*. 1986; 48(2):381–387.
- Spanier GB. Measuring dyadic adjustment: New scales for assessing the quality of marriage and similar dyads. *Journal of Marriage & the Family*. 1976; 38(1):15–28.
- Spanier GB, Cole CL. Toward clarification and investigation of marital adjustment. *International Journal of Sociology of the Family*. 1976:121–146.
- Sweet, J.; Bumpass, L.; Call, V. The Design and Content of The National Survey of Families and Households. Center for Demography and Ecology, University of Wisconsin-Madison; 1988. (<http://www.ssc.wisc.edu/nsfh/home.htm>)
- Sweet, JA.; Bumpass, LL. The National Survey of Families and Households – Waves 1 and 2: Data Description and Documentation. Center for Demography and Ecology, University of Wisconsin-Madison; 1996. (<http://www.ssc.wisc.edu/nsfh/home.htm>)
- Sweet, JA.; Bumpass, LL. The National Survey of Families and Households – Waves 1, 2, and 3: Data Description and Documentation. Center for Demography and Ecology, University of Wisconsin-Madison; 2002. (<http://www.ssc.wisc.edu/nsfh/home.htm>)
- Velicer WF. Determining the number of components from the matrix of partial correlations. *Psychometrika*. 1976; 41:321–327.
- Weiss, RL. A critical view of marital satisfaction. In: Pinsof, WM.; Lebow, JL., editors. *Family Psychology: The Art of the Science*. 2005. p. 23–41.

Figure 1.

Screeplot of Eigenvalues derived from the NSFH Wave 2 data with Means and 95th percentile Eigenvalue Estimates from the Parallel Analysis. The figure shows the visual results of a parallel analysis where eigenvalues from the NSFH data compared to a Monte Carlo simulation of the data using permutations of the actual data. The plot clearly shows three factors above the 95th percentile line cutting the screeplot. Eigenvalues are on the y-axis.

Table 1

Results of Parallel Analysis

Factor	Eigenvalue from NSFH	Mean Eigenvalue from Monte Carlo Simulation	95 th Percentile Eigenvalue from Monte Carlo Simulation
1	3.853445	.157787	.194227
2	1.158353	.119166	.147024
3	.630339	.089128	.112523
4	.027510	.062584	.083363
5	.009162	.038337	.057004
6	-.035857	.015432	.033386
7	-.046597	-.006933	.009945
8	-.078123	-.028758	-.012172
9	-.118869	-.051096	-.033494
10	-.155949	-.074377	-.056391
11	-.168996	-.099652	-.079419
12	-.223560	-.131376	-.106365

Note: Where eigenvalues of factors from the actual data (column 1) exceed the 95th percentile eigenvalues from the Monte Carlo simulation (column 3), those factors can be considered to be actual factors present in the dataset.

Table 2

Exploratory Factor Analysis Results

	Pattern Matrix		
	Factor		
	Satisfaction	Disagreement	Time Together
How happy with the amount of understanding	.929	-.042	-.006
How happy with love and affection	.914	-.044	.015
Describe relationship	.744	.015	-.026
How happy with demands of spouse	.631	.103	-.052
Disagree over time spent together	-.064	.676	-.129
Disagree over money	-.011	.648	-.075
Disagree over sex	.020	.641	.030
Disagree over household tasks	.135	.617	.075
Disagree over Spouse's parents	-.019	.502	.033
How often shared activity last month	.001	.004	-.838
How often spend mutual time with friends	.013	-.047	-.509
Amount of free time with spouse	.043	.095	-.496

Note: The three factors combined to account for 61.69% of the variance with satisfaction, disagreement, and time together each accounting for 36.42%, 14.40%, and 10.87% respectively. Extraction method was maximum likelihood.