Creating Communicative Contexts: A factor analysis of the inservice questionnaire raises and interesting question.

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Abstract

A questionnaire was designed as a pre- and post-measure of possible change in the reports of participants in a professional development program for communication partners of students with severe intellectual disability. The program targeted the knowledge and skills that professionals need to have and their concerns in relation to assessment, programming and instruction in communication processes with these students.

Exploratory factor analyses conducted on the questionnaire revealed an interesting phenomenon. The solution computed on the pre-intervention cohort revealed no interpretable factors. The solution computed on the post-intervention group yielded an interpretable solution congruent with the constructs of the researchers.
The lack of a clear solution on the pre-test analysis indicates that the respondents did not differentiate clearly among the constructs of assessment, programming and instruction with respect to communication. Issues relating to the design and interpretable strength of such instruments are raised and explored. In particular, the efficacy of exploratory factor analysis vis a vis a confirmatory approach in such situations is examined.

Factor analysis is a statistical technique commonly used to identify a relatively small number of factors that can be used to represent relationships among sets of many interrelated variables (Norusis, 1993). There are two forms of factor analysis, exploratory and confirmatory approaches.

The exploratory approach generally follows a four step process. A correlation matrix for all of the variables or questions iscomputed. The second step, factor extraction, involves computation of the number of factors necessary to represent the data. The third step,rotation, focuses on transforming the factors to make them more interpretable. The fourth step involves the computation of scores for the various factors that can be used in a variety of other analyses (Norusis,

1993).

Generally, the reliability of the scales based on the factors is computed and, after any modifications have been made, the construct validity of the scales is tested. Having satisfied the conditionsof reliability and construct validity, the scales can be confidentlyused in further analyses.

The confirmatory approach also operates on the correlation matrixbut in this case a factor structure is hypothesised, or already known,and the task is to find out how well the respondents' data fits the model. The package, Lisrel 7, by Jîreskog and Sîrbom (1989) provides informative feedback on the goodness of fit of the data to the hypothesised factor model. Diagnostic information is also supplied through the provision of modification indices, a matrix of X2 statistics that provide the researcher with information about howthe model will improve if certain constraints are relaxed.

In essence therefore, the exploratory approach is a process of searching for a model to fit the observed relationships among the variables while the confirmatory approach involves assessing howgood the data fit the extant model. This distinction would be fine if it were not for step three in the exploratory approach where the researcher is faced with the task of interpreting the rotatedfactor matrix. The researcher is faced with a task of trying to interpret what the factors actually mean while simultaneously attempting to remain theory free. That is to say, the body of knowledge andtheory base that the researcher brings to the interpretation process can introduce additional uncertainties into the identification of the factors.

The confirmatory approach does not suffer from this problem in sofar as the theory is made overt right from the start. The research question then becomes one of evaluating how well the model fits the data.

The purpose of this paper is to compare and contrast theseapproaches with particular reference to a questionnaire that was designed tobe used with communication partners of students suffering from severe intellectual disability.

METHOD

A questionnaire was designed to probe the knowledge and skills that professionals need to have of, and their concerns in relation to, assessment, programming and instruction in communication processeswith students suffering from severe intellectual disability. In all, 19 questions were written to probe respondents knowledge of the three processes and 20 questions top probe their concerns aboutimplementing these. This paper is concerned with the 19 questions designed to investigate the level of respondents' knowledge about the three processes of assessment, programming and instruction.

A total of 329 questionnaires were completed and received prior tothe respondents engaging in the professional development program. These constitute the pre-test group. At the completion of the intervention nine weeks later, the same questionnaire was administered. In all,200 responses were received on the post-test. It is possible to draw some

conclusions about the nature of the group who completed the courseand about those who did not. This is the subject of ongoing researchand of an article to be published. These conclusions need not concernus here to any great extent.

An exploratory factor analysis was computed on the 529 responses.The factor structure that emerged was, to the surprise of theresearchers, confused. Consequently, further analyses were computed separatelyon the pre-test and post-test responses. The results of theseseparate analyses provided the authors with material for reflection on whatwas happening both in the statistical sense and in a real sense with the respondents.

The confusing outcomes were explored further using a confirmatory approach. It became clear as events unfolded that this approachwas able to provide the researchers with additional useful information,so useful, in fact, that the researchers began to question the theory laden nature of interpretation in the exploratory approach.

RESULTS

In this section output from SPSS V5.0 and Lisrel 7.0 are used to illustrate the nature and quality of the information used by the researchers in order to construct reliable and valid scales usefulfor further analyses.

Questions 1-8 were supposed to have been related to assessment, questions 9-14 to programming and questions 15-19 to instruction.

A Principal Components Factor Analysis with Varimax rotation usingSPSS V5.0 was computed for scores on the 19 items using the entire pre-and post-test groups' responses, i.e., 529 in all. In a surprisingresult, two factors emerged accounting for 52.7% and 12% of total variance. The rotated factor matrix is presented below in Table 1. Loadingsless than a value of 0.3 have been deleted from the output and the items sorted according to the value of the loadings.

TABLE 1

Rotated factor matrix (Varimax) for pre- and post-test groupresponses

		FACTOR 1	FACTOR 2
P	Q12	.91367	
P	Q13	.90584	
P	Q14	.88149	
P	Q10	.84517	
P	Q11	.84260	
P	Q9	.81278	.30434
I	Q15	.68505	.34411
A	Q8	.63316	.38897
A	Q7	.52340	
A	Q6		.76616
A	Q4		.76575
A	Q2		.75465
I	Q18	.34819	.72779
A	Q3		.71101
A	Q5		.70548
I	Q17	.39834	.69063
I	Q19	.34726	.67557
A	Q1	.42468	.61535
I	Q16	.50513	.56082

It will be observed that two items in factor 1 relate to assessment(Q7 & Q8) and one relates to instruction (Q15) while the remainder supposedly represent items that are related to programming. Factor2

appears to be a mixture of items that relate to assessment (Q1-Q6)and instruction (Q16-Q19).

This picture was entirely unsatisfactory as far as the inservice providers were concerned. Consequently further analyses werecomputed for the pre- and post-test groups separately.

The analysis for the pre-test group yielded three factorsaccounting for 49.6%, 12.1% and 5.6% of total variance. Table 2 shows therotated factor matrix for the pre-test group.

TABLE 2

Rotated factor matrix (Varimax) for pre-test group responses

		FACTOR 1	FACTOR 2	FACTOR 3
P	Q12	.88387		
P	Q13	.87492		
P	Q14	.83767		
P	Q9	.82388		
P	Q11	.81789		.31809
P	Q10	.81425		.32026
A	Q8	.65226	.45270	
I	Q15	.62989		.43179
A	Q7	.48859	.42210	
A	Q6		.76238	
A	Q2		.72918	
A	Q4		.71167	.30102
A	Q3		.64271	
A	Q5		.62752	.31184
A	Q1	.53119	.56669	
I	Q19		.32593	.73743
I	Q18		.40661	.71483
I	Q17	.30487	.35852	.69780
I	Q16	.46888		.57354

The picture here is more congruent with the theories of theinstrument developers. Three factors with Eigen values greater than 1 are extracted. Items 7, 8 and 15, however, continue to appear with programming items. Factor 2 is clearly related to assessment(Q1-Q6) and Factor 3 to instruction (Q16-Q19). Factor 1 seems to be the programming factor but contains some items that are supposedlyrelated to assessment. It will be noticed from Table 2 that therecontinues to be a reasonably large number of moderate sized loadingsattributable to other factors. Even with oblique rotation this picture could notbe

clarified any further.

In a rather similar result to the pre-test analysis, the analysisof the post-test responses yielded 3 factors accounting for 52.6%,12.7% and 6% of total variance.

TABLE 3

Rotated factor matrix (Varimax) for post-test group responses

		FACTOR 1	FACTOR 2	FACTOR 3
P	Q12	.90751		
P	Q13	.90264		
P	Q14	.89688		
P	Q10	.82061		
P	Q11	.81639		
P	Q9	.80502		
A	Q8	.64668	.41572	
A	Q7	.64138		
I	Q15	.59933		.58865
A	Q1		.77877	
A	Q3		.73893	
A	Q2		.73605	
A	Q6		.70242	
A	Q4		.65393	.39244
A	Q5		.58195	.42066
I	Q16			.80588
I	Q17		.36713	.75796
I	Q18		.44416	.67592
I	Q19		.44579	.60972

The orthogonal rotation in this case provides a slightly cleaner pattern of factor loadings. The oblique rotation in this case, however, produced a much cleaner picture. This is shown in Table 4 below. It will also be noticed the items Q7 and Q8 remain with the first factor interpreted to be the programming factor and that Q15 while now being grouped with similar items related to instructionis still loading on the programming factor.

TABLE 4

Rotated factor matrix (Oblimin) for post-test group responses

Pattern Matrix:

	FACTOR 1	FACTOR 2	FACTOR 3
P Q14	.96465		
P Q12	.96396		
P Q13	.95832		
P Q11	.84440		
P Q10	.84349		
P Q9	.81550		
A Q8	.63236		
A Q7	.62777		
A Q1		.83123	
A Q3		.75212	
A Q2		.71952	
A Q6		.69609	
A Q4		.60183	
A Q5		.49742	
I Q16			-.84935
I Q17			-.76363
I Q18			-.65815
I Q19			-.58144
I Q15	.52340		-.54195

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At this stage one might be tempted to think that reliability and validity analyses would be in order. After all, the pattern matrixis relatively clean, apart from items Q7 and Q8 and the loading of Q15on two factors. In actual fact I did do this, but the issue still bothered me from a methodological perspective. Here were theauthors using theory to write items and then using an exploratory technique that involved their theory to interpret the output. The procedure seemed circular.

Questions about the efficacy of exploratory techniques started toraise their heads, especially with regard to questionnaires like theauthors' which were, in essence, confirmatory. And why, if the pre-test and post-test groups' factor structures which did not appear to be radically different from each other separately, did the entire 529 responses produce something that was so muddy.

Consequently, the author turned to Lisrel in order to conduct a confirmatory analysis in order to see if anything more could belearned about the questionnaire and of the items that appeared to peculiar.

Three correlation matrices were computed using Prelis v1.20. Thefirst was for the entire group of 529 responses, the second for thepre-test group of 329 and the third for the post-test group of 200. Thepattern

matrix that was used was as dictated by the authors' theory, viz.,that items 1-8 related to assessment, items 9-14 to programming and items 15-19 to instruction.

By this stage of course, many of the questions raised by the exploratory analysis had given rise to hypotheses about what was happening and also about the outcomes of the Lisrel analysis.

Some of these hypotheses related to the nature of the pre-test and post-test groups. While these were not equivalent as indicated bythe numbers in each, the post-test group was a sub-set of the pre-testone. The cleaner nature of the factor structure produced by analysis ofthe post-test data in the exploratory phase suggested the hypothesisthat the intervention had indeed taught the concepts of assessment, programming and instruction as separate constructs. With thepre-test group the apparent inter-relation of these concepts suggested the hypothesis that the respondents had a more holistic view of the processes involved. In addition, the questions identified as being problematic probably were being interpreted by the respondents insuch a way as to suggest that there were elements of more than onefactor involved.

The correlation matrix produced by the 529 responses producedgoodness of fit statistics that indicated the model was wrong (X2=1919.47, df=149, p=0.000; GFI=0.723; AGFI=0.647; RMS Residual=0.094). Thatis to say, the probability that the model consisting of the threeseparate constructs of assessment, programming and instructions was correctis close to zero.

The correlation matrix produced by the 329 pre-test responsesproduced goodness of fit statistics that were relatively better but againthe probability that the model was correct was very small (X2=1042.98,

df=149, p=0.000; GFI=0.743; AGFI=0.672; RMS Residual=0.086).

Examination of the Modification Indices showed that the questions already identified as problematic would, if set free from thefactors to which they were constrained, result in marked improvements inthe goodness of fit statistics. For example, if item 7 were set freethe X2 would reduce by approximately 174. Nonetheless, setting freeall of the items with large modification indices would only serve toindicate that the hypothesis alluded to above was probably correct, viz.,that the respondents had a more holistic view of the three processes involved.

The correlation matrix produced by the 200 post-test responsesproduced goodness of fit statistics that were markedly better than theprevious two sets. The probability that the model was correct was now much better as indicated by the goodness of fit statistics (X2=138.15,

df=149, p=0.728; GFI=0.921; AGFI=0.899; RMS Residual=0.113). TheX2 statistic is now not significant (p=0.728) although the root mean square residual is rather large. Examination of the modification indices in Table 5 below show that the same three items wouldimprove the goodness of fit markedly if they were set free.

TABLE 5
Modification Indices for the Post-test group analysis

MODIFICATION INDICES FOR LAMBDA X

	assess	program	instruct
A1	.000	.449	4.352
A2	.000	2.968	2.148
A3	.000	.069	1.441
A4	.000	4.878	.038
A5	.000	.429	.410
A6	.000	4.125	.655
A7	.000	13.531	5.238
A8	.000	16.752	2.122
P9	2.622	.000	1.544
P10	.215	.000	.059
P11	3.319	.000	1.283
P12	1.135	.000	.732
P13	1.351	.000	.645
P14	3.056	.000	.977
P15	.382	12.045	.000
P16	.245	.443	.000
P17	.631	.408	.000
P18	.241	1.525	.000
P19	.038	2.773	.000

The modified model produced by setting items 7, 8 and 15 freeresulted in goodness of fit statistics that the author had never seen beforein a confirmatory factor analysis. They are as follows (X2=89.68,df=146, p=1.00, GFI=0.954; AGFI=0.940; RMS Residual=0.082).

Examination of the Lisrel Estimates for this solution indicatedthat the problematic items were probably being interpreted in ways quite different to those intended by the authors of the questionnaire.Items 7 and 8 loaded more heavily on programming than on assessment(0.626 v 0.161 for item 7 and 0.644 v 0.192 for item 8 respectively). The result was similar for item 15 which loaded more heavily on programming

than instruction (0.516 v 0.364).

A final analysis was undertaken where these three items were constrained to the programming factor rather than to assessment and instruction as in the first model. The goodness of fit statisticsfor this model were better than those for the earlier constrained modeland almost as good as for the slightly relaxed model (X2=98.16, df=149, p=1.00, GFI=0.950; AGFI=0.936; RMS Residual=0.090). Examination ofthe modification indices revealed that there would be no significant improvement in the goodness of fit statistics by freeing some ofthe items.

DISCUSSION

The issue of whether it is methodologically correct to employ an exploratory factor analysis technique rather than a confirmatory approach in circumstances such as the one described here is now, at least in the author's opinion, quite clear. The confirmatoryapproach yields more feedback to the researcher regarding the hypothesised factor structure of the questionnaire. In addition, the Lisrel package provides more informative feedback regarding the way in which respondents interpreted the items and yielded valuable information about the efficacy of the professional development coursedelivered.

The lack of fit of the model for the pre-test group together withthe feedback obtained from the modification indices seem to indicatethat the respondents had a holistic view of the three processes thatwere targeted in the professional development program. The program was `successful' in so far as the same model produced satisfactorygoodness of fit statistics. Items were identified, however, that allowed a better model to be developed that explained the respondents' data. In retrospect these items can be seen to involve the factors as indicated by the Lisrel analyses.

The larger methodological question of whether to employ anexploratory or confirmatory approach is still open to question as far as I am concerned. The issue of the appropriateness of the exploratory approach bothers me, however. The circularity involving theory dependence on the interpretation of the factors obtained from the rotation phase seems to me to be a difficult issue when evaluation studies such as this one are undertaken. Further, the feedbackabout the appropriateness of the factor structure is poorer for aneophyte such as myself.

It seems to me that in cases such as this one it is moreappropriate to undertake a confirmatory factor analysis where one's theory ormodel can be tested against the data rather than leaving it hidden untilthe interpretation and construct validity testing phases.

References

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