1-1-2004

Differentiating Information Skills and Computer Skills: A Factor Analytic Approach

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Introduction

Librarians have always assumed that the skills needed to use computers and the skills needed to find and evaluate information are two separate sets of skills. Today in the 21st century this view has been adopted by most university administrators if not by all information technology personnel. In the early years of the computer revolution, however, librarians found it necessary to convince those in academe who were outside library walls that this was true. By many it was thought that the provision of computer labs to students would be the venue for teaching information skills. Bibliographic instruction was considered redundant. Are they a single set of skills or are they different skills? To our knowledge this question has never been tested empirically. A survey given to incoming freshmen at Purdue University to determine computer skills and information literacy skills provided the data for such a test. The survey was administered in 1999 and 2000, giving two sets of data. Factor analysis was applied to the responses to 23 questions designed to measure these skills. This paper presents the results of that study which indicates that the factor influencing the learning of computer skills differs from the one for learning information skills.

Relationship of Computer Skills and Information Skills

In 1989, the American Library Association Presidential Committee on Information Literacy's Final Report defined information literate individuals as those who "recognize when information is needed and have the ability to locate, evaluate and use effectively the needed information…ultimately information literate people are those who have learned how to learn. They know how to learn because they know how information is organized, how to find information, and how to use information in such a way that others can learn from them."[1]

Many labels have been used to describe information and technology skills including information literacy, computer literacy, fluency with information technology[2], digital literacy[3], and information technology literacy[4] but all distinguish between the computer skills, the ability to use specific hardware and software programs, and the higher order thinking skills of information literacy. Although an individual needs computer skills to be information literate, it is generally agreed that information literacy has much broader implications than computer literacy.[5]

Computer literacy focuses on a separate and more concretely defined set of skills. A computer literate individual as defined by Mueller "possesses the necessary keyboard skills and hardware and software knowledge to use applications correctly; has a good understanding of computer hardware and software capabilities and limitations, and is skilled at exploiting computers to help accomplish information based tasks."[6]

In 1983, Horton described "an emerging new dimension to computer use".[7] While he saw computer literacy as an understanding of what computers (both hardware and software) can and cannot do, he compared society's increasing information needs to Abraham H. Maslow's hierarchy of basic needs. Individuals increase their information literacy as they move up the hierarchy of information needs from coping information to helping information, enlightening information, enriching information and finally edifying information. At each level more " sophisticated delivery systems come into play and the information and knowledge resources themselves become more specialized in content and difficult to efficiently and effectively identify and access."[8]

Shapiro has conceived of information literacy "as a new liberal art that extends from knowing how to use computers and access information to critical reflection on the nature of information itself, its technical infrastructure, and its social cultural and even philosophical context and impact."[9] In a brief outline of a curriculum encompassing computer literacy, the librarian's definition of information literacy, and a broader critical conception of a more humanistic sort, he lists seven dimensions of literacy: tool literacy, resource literacy, social structural literacy, research literacy, publishing literacy, emerging technology literacy and critical literacy**.** The current survey instrument touches on only three dimensions of Shapiro's seven: tool literacy, resource literacy, and research literacy.

With the advent of the Internet our information environment has become more complicated. Individuals are faced with abundant choices. Information is available from multiple sources but is increasingly unfiltered and must be assessed for authenticity, validity, and reliability. All are important components of the librarian's definition of information literacy. Frequent use of the web may improve computer skills and build confidence in finding some useful information but it does not necessarily improve critical thinking or guide analysis of the information found.

Measuring skills

How does one measure a skill? The only way to obtain a direct measure of a skill is by means of a test which measures that skill. Measures obtained by a survey instrument will always be an indirect measure, i.e., the variables in the survey will be proxy variables. Usually the respondent will either be asked, "how do you evaluate your abilities at doing this task?" or, "how often do you do this task?" The respondent then will be given several options to choose from. The response to either question results in a proxy variable, that is, it is a substitute for administering an in-depth skills test. The advantage of using proxy variables is that it is possible to obtain data on very large populations at a modest cost. In depth testing is very costly. In the Purdue survey we used a proxy variable. We asked the question: "how often do you do this task?"

The search for good proxy variables has been most active in adult literacy research. For years the proxy variable for adult literacy has been years of education. In 1992 the Educational Testing Service carried out the National Adult Literacy Survey (NALS) for the U.S. Department of Education. This involved in-depth testing of literacy skills for a large sample of U.S. citizens (at great expense). The NALS found that the simple question "how often do you read a daily newspaper?" correlates well with the detailed results of the in-depth literacy test.[10] This makes that question a good proxy variable for adult literacy. This type of correlation between a proxy variable and a true variable of measurement is referred to as a coefficient of validity. Similar results were obtained in

Canada. Neice and Adsett found that the responses to the question, "how frequently do you read a book?" was a good predictor of literacy. It explained 46% of the variance in a measure of adult literacy obtained through detailed testing.[11] Researchers in adult literacy have found that self-assessment works better if the questions are about specific tasks rather than about general ability. More specifically, composite scores from questions about specific skills give a generally good measure when compared to direct testing.[12] Since the authors did not administer an in-depth skills test, they were unable to obtain a coefficient of validity for the test. Based on the adult literacy research, however, the authors feel that the Purdue survey questions, which ask respondents to answer how frequently they performed certain specific tasks requiring differing skill levels, should give acceptable but not perfect measures of those skills. The measures should be improved when a composite of scores is used.

The Survey

Purdue University librarians chose to survey freshmen students to better identify and understand the skill levels of new students, and to assist the libraries in planning online and classroom instruction and handouts. Librarians were making assumptions about the level or levels of student computer, Internet, and information skills. At the time, current students characterized a one-credit information literacy class as too hard, or not relevant, which caused the librarians to wonder if their expectations of students were higher than student skill levels.

The Purdue survey instrument (see appendix A) consisted of thirty questions divided into areas of basic computer skills, advanced computer skills, Internet skills (including email), research skills, presentation skills, and learning styles. It asked that students use a mark scan score sheet to indicate the frequency of use on a five-point scale (daily, weekly, monthly, once, or never). In the course and other library instruction sessions librarians did not teach basic computer skills (survey questions 1-7), did not expect any programming skills (survey questions 8-9) and assumed only very basic knowledge of information research and presentation (survey questions 18-24).

The survey was administered during freshman orientation. This orientation provided a large sample of self-selected freshmen students to survey. Team leaders were encouraged to have students complete the survey during one of their “team time” sessions. In 1999, 2,700 surveys were distributed and 1,132 were returned (42% participation). In 2000 the program grew to include 3,100 freshmen but only 773 surveys were returned for a 25% return rate. Any self-selected survey presents the possibility for bias in the sample. The sense of the authors is, however, that any bias is minimal. There was a good proportional representation of students by sex and by disciple of study.

Data and Analysis

The data are based on responses to questions 1 and 2 and questions 4 through 24 of the survey instrument (see Appendix A for the survey questionnaire). Question 3 was not used because it limited the possibilities to Windows 95 or NT. The numerical scores for each question were:

Daily = 5

Weekly = 4

Monthly = 3

Once = 2

Never = 1

Two separate analyses were employed. For the first analysis, five composite variables were created: Basic Computer Skills, Advanced Computer Skills, Internet Skills, Research Skills, and Presentation Skills. The first three composites are measures of computer skills; the last two measure information skills. Each composite is an average of the answers to the questions listed under that rubric on the survey instrument.

For the second analysis the scores on each of the 23 questions were used as variables without respect to the rubric under which they were classified. Principle factor analysis with iterations was the factoring method used for all analyses. An orthogonal quartimax rotation was used.

Separating computer skills from information skills

If variables measure different phenomena, then factor analysis has the power to separate them into different groups. When variables measure the same thing, they will cluster around a common factor. If they cluster, the interpretation is that this factor is a causal variable contributing to whatever is common in that group of variables. If information skills and computer skills are two different sets of skills, then it is critical that the set of variables which measures computer skills cluster together and the set that measures information skills cluster together, but that the two clusters are separate from each other.

The separation of variables is determined by a number between -1 and 1 called a factor loading which is assigned to each variable. This separation can be represented in space by making one factor the x-axis and the other factor the y-axis. The factor loadings are then plotted on the x and y axes. Each factor loading is a measure of the causal influence of that factor on the variable. In the case of this research, the factors, i.e., the axes, were rotated to make all of the factor loadings zero or positive. This procedure has no effect on the separation of the variables into different groups. However, since each factor in theory represents educational experiences by which one attains skill, the causal effect must be positive. If there were negative factor loadings, this would mean that education decreased skills.

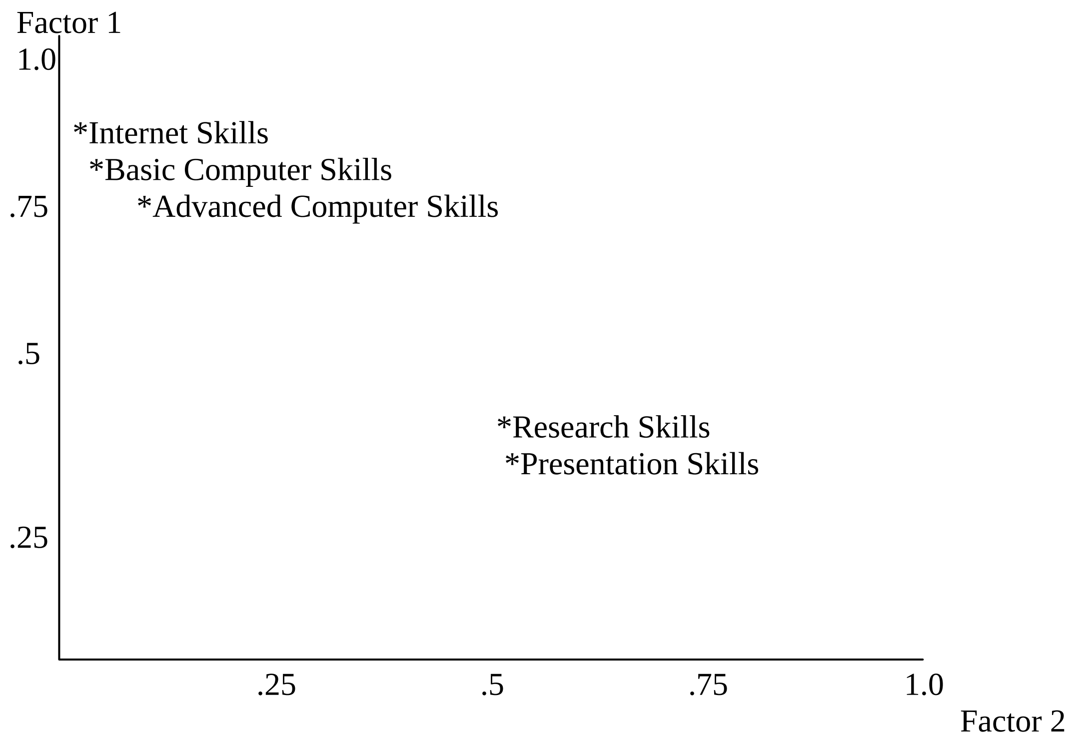
I. Analysis with five composite variables

The first analysis uses the data from 1999 and 2000 for the five composite variables. The two axes are the factors, and the factor loadings are the distances along the axis. From Chart 1 we have a visual image of the separation of variables measuring computer skills from those measuring information skills. See Appendix B for eigenvalues and goodness of fit.

CHART 1

Two Dimensional Display of

Factor Loadings for Composite Measures of Information and Computer Skills



The actual factor loadings for 1999 and 2000 are presented in Table 1. The loadings for 1999 are the coordinates for Chart 1.

TABLE 1

Factor Loadings for Five Composite Measures

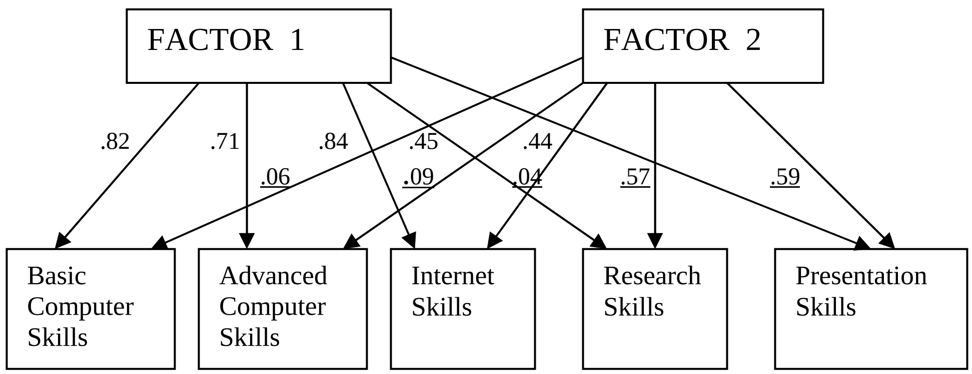
	Loadings for 1999		Loadings for 2000	
Variables	Factor 1	Factor 2	Factor 1	Factor 2
Basic Computer Skills	.82	.06	.81	.05
Advance Computer Skills	.71	.09	.73	- .01
Internet Skills	.84	.04	.82	.04
Research Skills	.45	.57	.52	.45
Presentation Skills	.44	.59	.43	.63

From Chart 1 and Table 1 it is apparent that the three computer skills have been grouped together and the two information skills have been grouped together. Due to the rotation, all of the factor loadings are positive. The one negative loading is very close to zero. This agrees with the theory that the factors represent learning experiences which cause the skill levels and hence should have positive values. Everyday experience also tells us that learning how to use computers should have an effect on information skills, but that learning information skills should have only minor effects on computer skills. The rotation of factors is also designed to reflect this observation. Factor 1, which represents the learning experiences leading to computer skills, is shown to have a strong effect on computer skills and a moderate effect on information skills. Factor 2, which represents the learning experiences leading to information skills, has a moderate effect on information skills but almost no effect on computer skills. No matter how one rotates the factors, however, factor 1 will always have a stronger influence on computer skills than on information skills, and factor 2 will always have a stronger influence on information skills than on computer skills. Table 1 shows that the factor loadings for 1999 and 2000 are almost identical.

Another helpful way to visualize the factoring results is to show the causal relationships between factors and variables. Illustration 1 below is a diagram using arrows to show a causal influence. A factor loading is associated with each arrow to indicate the strength of the causal influence. Loadings for factor 2 are underlined.

ILLUSTRATION 1

Graph Showing the Causal Effect of Factors on Composite Measures
of Information and Computer Skills



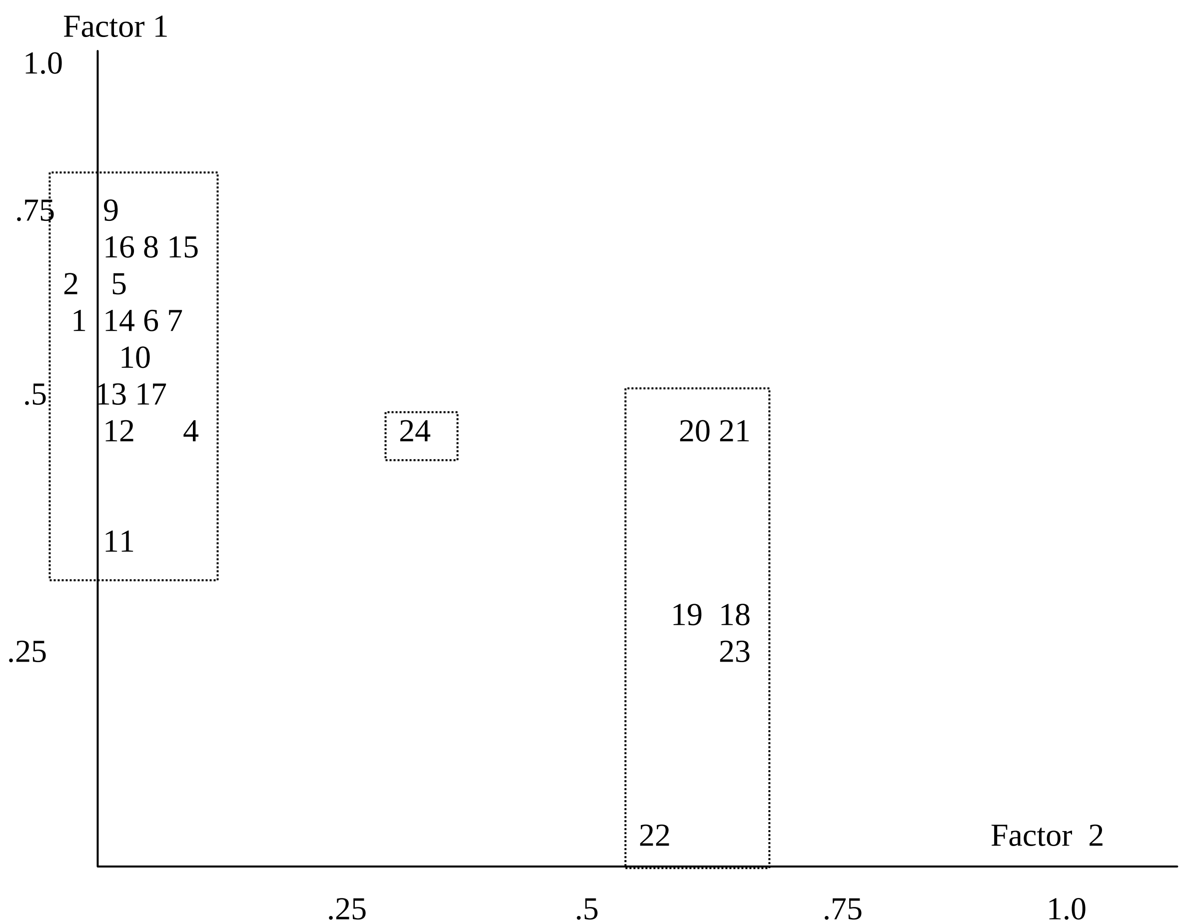
II. Analysis using 23 variables (Questions)

The second analysis uses the data from 1999 and 2000 for the 23 questions. Each question must stand on its own; they are not parts of a composite variable. Three factors were extracted in the analysis, but only two are presented here. Chart 2 shows the groupings along the axes for factor 1 and factor 2. The numbers on Chart 2 refer to the question numbers in the survey. See appendix A to match numbers to questions. See Appendix B for eigenvalues and goodness of fit.

CHART 2

Two Dimensional Display of

Factor Loadings for Individual Questions Measuring Information and Computer Skills



The factor loadings for 1999 and 2000 are presented in Table 2. The loadings for 1999 are the coordinates for Chart 2.

TABLE 2

Factor Loadings for 23 Questions

	Loadings for 1999		Loadings for 2000	
Variables	Factor 1	Factor 2	Factor 1	Factor 2
Question 1	.61	-.03	.53	- .01
2	.65	-.10	.55	- .08
4	.45	.18	.41	.20
5	.66	.04	.64	.09
6	.62	.14	.63	.15
7	.60	.15	.63	.16
8	.72	.05	.71	- .09
9	.78	-.04	.80	- .08
10	.57	.07	.48	.09
11	.37	.02	.10	.05
12	.45	.01	.16	.00
13	.52	.02	.27	.09
14	.60	.07	.61	.09
15	.72	.06	.75	- .08
16	.71	.01	.69	- .02
17	.71	.06	.50	.12
18	.29	.59	.23	.61
19	.30	.51	.31	.56
20	.45	.55	.44	.52
21	.43	.58	.47	.55
22	.02	.43	.10	.39
23	.26	.50	.23	.49
24	.45	.37	.45	.34

In the survey questions 1 through 17 measure computer skills. In Chart 2 they are grouped along the axis for factor 1. Questions 18 through 24 measure information skills. They are a bit more spread out. Questions 18 through 23 are generally grouped with factor 2. Factors were rotated in the same manner as in the previous analysis. Factor 1 shows a causal effect on both computer and information skills, but factor 2 shows only an effect on information skills. Question 24 is between the two groupings. Question 24 states, "I use Power Point or other presentation software." This could be interpreted as both a computer skill and an information skill. Its location between the two groups is therefore appropriate. Factor 1 has no effect at all on question 22. Question 22 states, "I rely on the help of a librarian." Since factor 1 is interpreted as learning experiences leading to computer skills, there is no reason why it should have a causal effect on question 22. Questions 20 and 21 are more influenced by factor 1 than are questions 18 and 19. Questions 20 and 21 refer to the use of online catalogs while questions 18 and 19 refer to no computer mediation. The factor loadings for 2000 are very close to those for 1999 except for the loadings for questions 11, 12, and 13 on factor 1. The reason for this difference is not clear. A few loadings on factor 2 are negative, but they are close enough to zero that they could be interpreted as zero loadings.

Conclusions

The results support the assumption that computer literacy and information literacy are not the same. Information skills and computer skills were clearly differentiated by factor analysis. This occurred not only for the composite variables, which had only a few constraints, but also for the 23 individual questions, which were highly constrained. Given the degree of constraint, there was a very good fit between the theory and the data. A useful sequel to this study would be research involving college seniors.

The study clearly shows that students need instruction in both skill areas. Libraries now have not only a logical rationale but also an empirically demonstrable foundation for the pursuit of information literacy programs. Librarians, in collaboration with other classroom instructors and information technology professionals, can and must develop information literate students by teaching research and evaluation skills that go beyond the mechanical skills necessary to use computers and databases.

Appendix A The Text of the Survey used to collect Data

To make your transition to college as easy as possible, the Purdue Libraries would like to know about your familiarity with information research and technology. We know that you come from a variety of backgrounds and represent differing user levels. The results of this anonymous survey will assist us in providing you with the most appropriate resources and instruction.

Please use the machine readable sheet for this survey. Select the most appropriate match for each question using the lettered scale provided.

Daily	Weekly	Monthly	Once	Never
A	B	C	D	E

Indicate Male or Female by marking letter in column 1 of LAST NAME.

Indicate School by marking one letter in column 1 of FIRST NAME.

Basic Computer Skills:

1. I create, copy, delete files and folders.

2. I change Windows settings such as properties, options, configurations, etc.

3. I use Windows 95 or NT.

I do the following using a computer:

4. compose documents using word processing software
5. compose documents using an editor (i.e. Notepad, pico/vi, etc.)
6. enter information into a database or spreadsheet
7. create databases or spreadsheets tables/queries/reports

Advanced Computer Skills:

8. I program computers using UNIX/CGI, Java, Perl, or other language.

9. I transfer files using FTP, Fetch, UNIX, etc.

10. I save documents to a zip drive.

Internet Skills:

11. I log into an account to send/receive e-mail.

12. I use a WWW browser such as Netscape or Internet Explorer.

13. I retrieve information from the internet using a search engine or directory.

14. I use Boolean operators (AND, OR, NOT) or proximity operators (adjacent, with) when I search.

15. I develop Web pages using HTML or other authoring tools.

16. I create multimedia graphics, sounds, etc.

17. I participate in news groups or chat rooms.

Research Skills:

18. I write research papers that require references to resources and a bibliography.

19. I cite my resources using the MLA or APA format.

20. I search for resources using an online catalog.

21. I have found journal articles using an online index.

22. I rely on the help of a librarian.

Presentation Skills:

23. I present in front of a group.

24. I use Power Point or other presentation software.

(Questions 25 - 30 are on learning styles. For brevity they are not listed here since they were not used in the analysis.)

Appendix B

There is no magic number that states how many factors to use in a factor analysis. For theoretical reasons we have looked for two factors to explain computer learning and information learning as separate learning experiences. There is, however, a rule of thumb that states that the number of factors should be as many as the eigenvalues of one or higher. Table 3 below gives the eigenvalues for these analyses.

TABLE 3

Eigenvalues for the First Three Factors

	Data for 1999	Data for 2000
For 5 composite variables	2.93 .87 .46	2.89 .86 .49
For 23 questions	7.91 2.15 1.87	7.27 2.19 2.01

Factor loading represents the amount of causal influence a factor has on an observed variable. In that sense the factor loadings are the substance of the theory. Therefore, factor loadings allow one to compute theoretical correlations between the observed variables. The survey data from these same variables allow one to do actual correlations between variables. If the theoretical correlation between two variables is very close to the correlation based on the survey data, then we say that there is a good fit between theory and data. If there is not a good fit, then we reject the theory; if there is a good fit then we say that the theory is a reasonable explanation of the data.

The analysis using the five composite variables will have 10 correlations. The analysis using the 23 questions as variables will have 253 correlations. Getting a good fit with 10 correlations is not difficult because there are not a lot of constraints on the system. On the other hand, an analysis requiring 253 matches between a theoretical correlation and a data based correlation will have many constraints and will be difficult to obtain. For both analyses there is a good fit between theoretical correlations and correlations based on the data. Table 4 below shows the average differences between the theoretical correlations and the data based correlations for both analyses. As one can see from this table, the average differences are quite small, indicating a good fit of theory to data.

TABLE 4

Mean Differences Between Data Correlations

and Factor Model Correlations*

	Data for 1999	Data for 2000
Two factors & 5 Variables	.009	.008
Three factors & 23 Variables	.044	.046

*(Root Mean Square Differences)

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