DOCUMENT RESUME

ED 480 139 TM 035 216

AUTHOR	Kim, Se-Kang; Davison, Mark L.
TITLE	Application of PAMS (Profile Analysis via Multidimensional Scaling) Model to Constructing Cognitive Ability Patterns.
PUB DATE	2000-04-00
NOTE	14p.; Paper presented at the Annual Meeting of the American Educational Research Association (New Orleans, LA, April 24-28, 2000).
PUB TYPE	Reports - Research (143) -- Speeches/Meeting Papers (150)
EDRS PRICE	EDRS Price MF01/PC01 Plus Postage.
DESCRIPTORS	*Adults; *Cognitive Ability; Factor Analysis; Factor Structure; Interest Inventories; *Multidimensional Scaling; Profiles; *Structural Equation Models
IDENTIFIERS	Woodcock Johnson Psycho Educational Battery

ABSTRACT

This study described an explicit multidimensional scaling (MDS) model for profile data, the Profile Analysis via Multidimensional Scaling (PAMS) model. It also illustrated the application of this model to the study of the structure of cognitive ability patterns using the Woodcock-Johnson Psychoeducational Battery-Revised (WJPB-R; 1989; 1991) and used the bootstrap technique to estimate the standard errors of the MDS coordinates. Data came from 176 adults in the norming sample of the WJPB-R. The example demonstrates that, within the context of the model in the first equation in the paper, scale values are test parameter estimates and can be interpreted in terms of prototypical profile patterns (and mirror image patterns) corresponding to dimensions. Observed profile patterns are represented as linear combinations of the prototypes. Person parameters are interpreted with respect to these same prototypical profile patterns. Profile level parameters quantify individual differences in overall profile height. Correspondence indices quantify the degree of match between observed profiles and dimension prototypes. As illustrated, correspondence indices can be used to study associations between match to prototypes and external variables. (Contains 4 tables, 6 figures, and 11 references.) (SLD)

Application of the PAMS (Profile Analysis via Multidimensional Scaling) Model to Constructing Cognitive Ability Patterns

Se-Kang Kim

University of Missouri-Columbia

and

Mark L. Davison

University of Minnesota

RUNNING HEAD: Cognitive Ability Patterns

This manuscript was prepared for 2000 AERA annual meeting. Correspondence concerning this paper should be addressed to Se-Kang Kim, Ph.D., Department of Educational and Counseling Psychology, 16 Hill Hall, University of Missouri, Columbia, MO 65211 (or via E-mail: kimse@missouri.edu)

Factor Analysis (FA) and multidimensional scaling (MDS) have been used to study the structure of human abilities. In his comparison of FA and MDS, MacCallum (1974) suggested one reason why FA has been so dominant. MacCallum noted that FA is based on an explicit model linking the observed test scores to model parameters. This model-based link between observed test scores and parameters makes FA a far richer method for the study of profile type data where rows represent people and columns represent tests or test items. In the absence of an explicit model, MDS parameter estimates are far less rich in meaning.

The purpose of this paper is to; (1) describe an explicit MDS model for profile data, and the model was called the PAMS (Profile Analysis via Multidimensional Scaling) model (Davison, 1996, 1994); (2) illustrate the application of the model to the study of the structure of cognitive ability patterns using Woodcock-Johnson Psychoeducational Battery---Revised (WJ-R; Woodcock and Johnson, 1989; Mcgrew, Werder, and Woodcock, 1991); and (3) utilize the bootstrap technique to estimate standard errors of MDS coordinates.

The PAMS model starts with the following equation: $M_{pt} = c_p + \sum_k^K \omega_{pk} \cdot x_{tk} + \varepsilon_{pt}$. (1). An element M_{pt} in the model is the observed score of person p on test t. In profile data, each row represents a person (p) and each column represents an observed variable or a test (t). The basic assumption of the PAMS model is that one can posit a small set of latent profiles such that the observed profiles can be accounted for as linear combinations of the latent ones. This leads to a linear model. The parameter c_p equals the mean score in row p, that is, $c_p = (1/T)\sum_t M_{pt}$, which indexes the overall height of person p's profile. The parameter c_p is called the level parameter.

Each term in the sum on the right side of Equation (1) refers to a latent profile pattern k. Since latent profiles correspond to MDS dimensions, one can think of k as designating either a latent profile pattern or the corresponding MDS dimension. Each term in the sum is the product of a person parameter ω_{pk} and a test parameter x_{tk}. The test parameter x_{tk} equals the score of test t in latent profile k or the coordinate of test t on MDS dimension k. The person parameter, ω_{pk}, is a weight for person p on latent profile k. That is, ω_{pk} indexes the degree of correspondence between the actual profile of person p and the latent profile k. The error term ε_{pt} represents residuals from the model.

The MDS representation in this model is based on a decomposition of an individual's profile into two aspects. The first aspect is a profile level. The profile level is defined as an unweighted average of the scores in the profile, which is $c_p = \frac{\sum_{t=1}^T M_{pt}}{T}$. In other words, the level parameter c_p represents person p's average score on T tests, and determines the height of person p's profile. The PAMS model uses this level parameter c_p to identify individual differences in observed profile heights.

The second aspect is the profile pattern defined as deviations about the profile level; i.e., a deviation *T*-length vector = { M_{pt} - c_p }. Individual differences in profile patterns are represented by $\sum_k \omega_{pk} \cdot x_{tk}$ in Equation (1). The person parameter ω_{pk} indexes how well a person's observed profile matches the latent profile or MDS dimension *k*, and the test parameter x_{tk} is the coordinate of the latent profile or MDS dimension *k*.

Method

The results of this analysis partially came from (Davison, Kuang, and Kim, 1999).

Participants. The data for the illustration below came from 176 adult participants between the ages of 25 and 39 in the norming sample of the Woodcock-Johnson Psychoeducational Battery---Revised (WJ-R; Woodcock and Johnson, 1989; Mcgrew, Werder, and Woodcock, 1991).

Instruments. The cognitive ability part of the WJ-R includes 14 subtests arranged into seven ability clusters of two subtests each. The ability clusters and the two subtests in each are as follows: Long-term Memory (Visual-Auditory Learning, Memory for Names), Short-term Memory (Memory for Sentences, Memory for Words), Speed of Processing (Visual Matching, Cross Out), Auditory Processing (Incomplete Words, Sound Blending), Visual Processing (Visual Closure, Picture Recognition), Comprehension-Knowledge (Picture Vocabulary, Oral Vocabulary), and Fluid Reasoning (Analysis-Synthesis, Concept Formation).

Profile interpretation of test parameter estimates. The 3-dimensional solution was obtained using a nonmetric scaling procedure, ALSCAL. The bootstrap technique was applied to estimate scale-value standard errors. The bootstrap method is a resampling technique and its application does not require any particular distribution (e.g., normal or lognormal) of scale values. The bootstrap method takes one element at a time from the original sample with replacement and generates new samples of the same size of the original sample as many times as the researcher wants.

For example, given a random sample of 176 records, one would select at random one case from the sample, document its value, replace it, and then randomly select another case, document its value, replace it, etc. This step would be repeated until the first sample size reaches one hundred and seventy six. Then one would repeat these steps, say, one hundred times to generate one hundred replicated samples of sample size 176. With each replicated sample, one can compute scale-values for stimuli. Since there are 100 bootstrap-replicated samples, one has 100 replicates of each scale-value. Thus, one can compute the standard deviation of the 100 replicates (of the scale-value) about the mean of them, which is a *bootstrap-standard error* (BSE) of the scale-value.

With the bootstrap standard error estimates, *z-tests* were used to determine statistical significance of the scale-value estimates, stating the null hypothesis that the estimates were equal to "0." Here "statistical significance" means that the estimates were significantly different from "0."

Table 1.WJ-R MDS Scale-values and Bootstrap Standard Error Estimates.

Tests	DIM = 1		DIM = 2		DIM = 3	
	Scale-values	Bootstrap SE	Scale-values	Bootstrap SE	Scale-values	Bootstrap SE
1. Mmry for Name: *LT*	1.0015	0.5585	-0.4280	0.7287	-0.8651	0.5814
2. Mmry for Sentence: *ST*	-0.4576	0.5663	0.8160	0.4519	-0.4407	0.4737
3. Visual Matching: *SP*	-1.8619	0.9799	-0.5280	1.1878	**1.7008**	0.6506
4. Incomplete Words: *AP*	-0.8380	0.7360	0.3281	1.0026	**-1.5748**	0.5749
5. Visual Closure: *VP*	1.2633	1.1496	**-1.9762**	0.8569	0.4582	0.8636
6. Picture Vocabulary: *CK*	1.2106	1.0241	1.4934	0.9032	1.0598	0.8055
7. Analysis-Synthesis: *FR*	-0.0404	0.4148	0.2236	0.5770	0.5326	0.6902
8. Visl-Adtry Learning: *LT*	**1.1505**	0.5394	-0.2486	0.5894	-0.1940	0.4821
9. Mmry for Words: *ST*	**-2.4501**	0.7834	0.1777	1.2879	-0.8501	0.7256
10. Cross Out: *SP*	-0.9974	0.6499	-0.3421	0.6633	0.7680	0.4631
11. Sound Blending: *AP*	-0.1977	0.3305	0.2832	0.5275	-0.3051	0.7009
12. Picture Recognition: *VP*	0.5627	1.0670	**-1.7804**	0.6281	-0.5028	0.8005
13. Oral Vocabulary: *CK*	0.6520	1.0479	**1.6472**	0.6545	0.3193	0.6917
14. Concept Formation: *FR*	**1.0025**	0.4765	0.3342	0.5708	-0.1060	0.5104

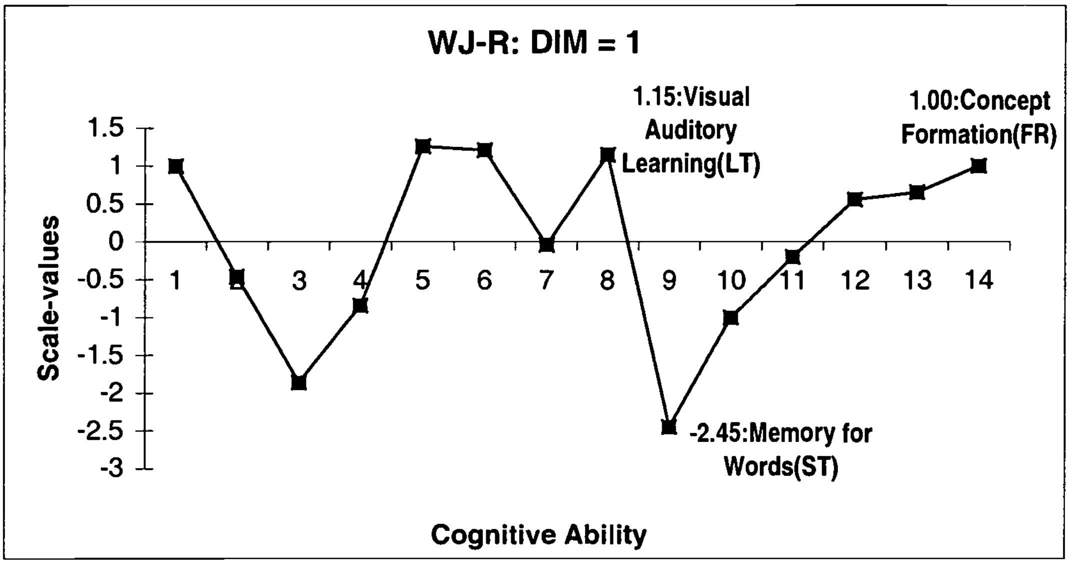
Note: only significant scale-value estimates were made bold and underlined scale-values are greater than absolute value of one, whose values are conventionally included for interpretation when their standard errors were not available; LT = Long-term Memory; ST = Short-term Memory; SP = Speed of Processing; AP = Auditory Processing; VP = Visual Processing; CK = Comprehension-Knowledge; FR = Fluid Reasoning.

The scale-values for the first dimension were plotted as a profile pattern, where the horizontal axis represented cognitive ability tests and the vertical axis represented the scale-values. The fourteen scale-values in Dimension 1 were tested using *z-statistics* with the bootstrap standard error estimates. Only statistically significant estimates were labeled with their values and used in the interpretation of the dimension. Without the standard error estimates, the significance tests cannot be performed. In this sense, the standard error estimates play a crucial role in determining which scale-values are included for interpretation.

Results and Discussion

In the profile pattern of Dimension 1, there were significant peaks for the Long-term Memory subtest, Visual Auditory Learning and the Fluid Reasoning subtest, Concept Formation. These tests seem to assess skills for which memory capacity to build reasoning is critical. A significant lower point in the profile occurred for one Short-term Memory subtest, Memory for Words. Persons with this profile performed better on Long-term Memory and Fluid-Reasoning subtests than on the Short-term Memory subtests. Given the high points for the Long-term Memory and Fluid Reasoning subtests, coupled with the low point for the Short-term Memory subtests, it is called a *Long-term Memory vs. Short-term Memory* profile.

Figure 1 Dimension 1: Long-term Memory vs. Short-term Memory Profile

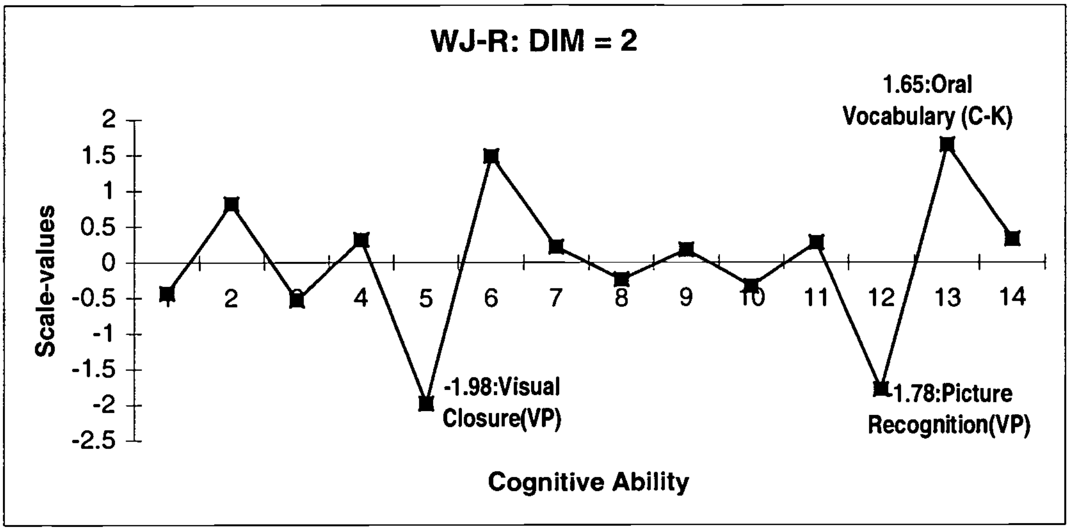


Note: LT = Long-term Memory, ST = Short-term Memory, FR = Fluid Reasoning, and SP = Speed of Processing

In multidimensional scaling, the dimensions can be reflected without loss of fit. That is, it is completely arbitrary which end of a dimension is positive and which is negative. Therefore, for each dimension profile, there is a mirror image profile obtained be reversing all of the signs. In the case of Dimension 1, reflecting the signs of all tests yields a profile with peaks for the Long-term Memory subtest (Visual-Auditory Learning) and for the Fluid Reasoning subtest (Concept Formation) and a valley for the Short-term Memory test (Memory for Words). Persons with this mirror image profile would have higher scores on the Short-term Memory subtest and than on the Long-term Memory subtest and the Fluid Reasoning subtest.

The second dimension was plotted as a profile pattern. Again, only (statistically) significant scale-values for the subtests were plotted along the vertical axis. Above each subtest, there appears its scale-value along Dimension 2. The dimension 2 profile had a significant peak above the Comprehension-Knowledge subtest, Oral Vocabulary. The two significant lower points in the profile occurred for the two Visual Processing subtests (Visual Closure and Picture Recognition). It was labeled a *Comprehension-Knowledge vs. Visual Processing* profile. Persons who resemble this profile would perform better on the Comprehension-Knowledge subtest than on the Visual Processing subtests (Visual Closure and Picture Recognition). People with the mirror image profile would perform better on the Visual Processing subtests than on the Comprehension-Knowledge subtest.

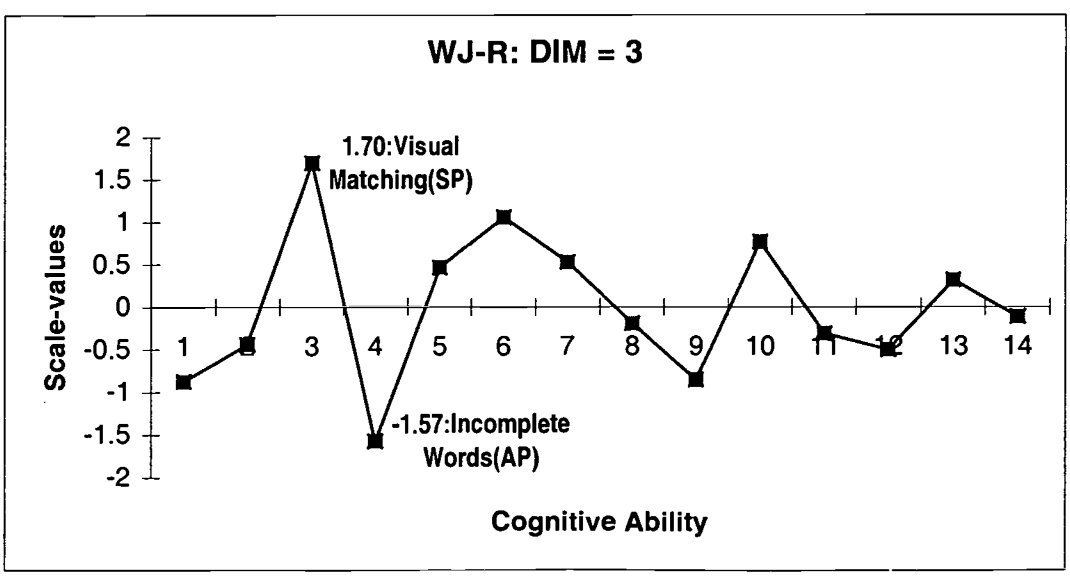
Figure 2 Dimension 2: Comprehension-Knowledge vs. Visual Processing Profile



Note: C-K = Comprehension-Knowledge and VP = Visual Processing

The Dimension 3 was plotted as a profile pattern. In this profile, only two scale-values were significant; one for the Auditory Processing test (Incomplete Words) and the other for the Speed of Processing test (Visual Matching). The scale-value for Incomplete Words was negative, whereas the one for Visual Matching was positive. This profile was labeled a *Speed of Processing vs. Auditory Processing* profile. A person with this profile would perform better on Visual Matching than on Incomplete Words. Conversely, someone with the mirror image profile would have displayed a stronger performance in the area of Auditory Processing than in Speed of Processing.

Figure 3 Dimension 3: Speed of Processing vs. Auditory Processing Profile



Note: SP = Speed of Processing and AP = Auditory Processing

A person with this profile would perform better in Visual Matching than in Incomplete Words. Conversely, someone with the mirror image profile would have displayed a stronger performance in the area of Auditory Processing than in the area of Speed of Processing.

Profile Interpretation of Person Parameters

Table.2. Person Parameter for 10 Participants

	Long-term Memory vs. Short-term Memory Dimension 1	Visual Processing vs. Comprehension -Knowledge Dimension 2	Speed of Processing vs. Auditory Processing Dimension 3	Level Parameter	R-Squrd
Participant #	Wp1	Wp2	Wp3	Cp	R^2
2	0.47	-0.10	-0.55	-0.63	0.71
9	0.07	0.07	0.09	-0.50	0.05
16	**0.51**	**0.58**	**-0.48**	**0.28**	**0.81**
23	-0.32	0.22	0.07	0.02	0.34
36	**0.64**	**-0.20**	**0.02**	**0.73**	**0.65**
40	0.03	-0.02	0.09	0.13	0.04
42	0.54	-0.01	-0.23	0.37	0.58
46	**-0.02**	**0.44**	**0.02**	**0.11**	**0.60**
67	0.30	-0.43	-0.04	-0.99	0.64
149	0.21	0.58	0.51	0.73	0.89

In Table 2, column 1 shows participant's number and column 2 displays their correspondence indices for the *Long-term Memory vs. Short-term Memory Profile* pattern in Figure 1. Those with positive correspondence indices, such as Participant 36, have observed profile patterns that display a trend similar the Reasoning vs. Working Memory profile pattern in Figure 1. Those with negative correspondence indices, such as Participant 23, have observed profile patterns that displayed the mirror image trend, higher on the Speed of Processing test (Visual Matching) and Short-term Memory test (Memory for Words) than on the Long-term Memory tests (Memory for Name and Visual Auditory Learning) and Fluid Reasoning test (Concept Formation). Columns 3 and 4 display the correspondence indices for Dimension 2 and 3 respectively Visual Processing vs. Comprehension-Knowledge and Speed of Processing vs. Auditory Processing.

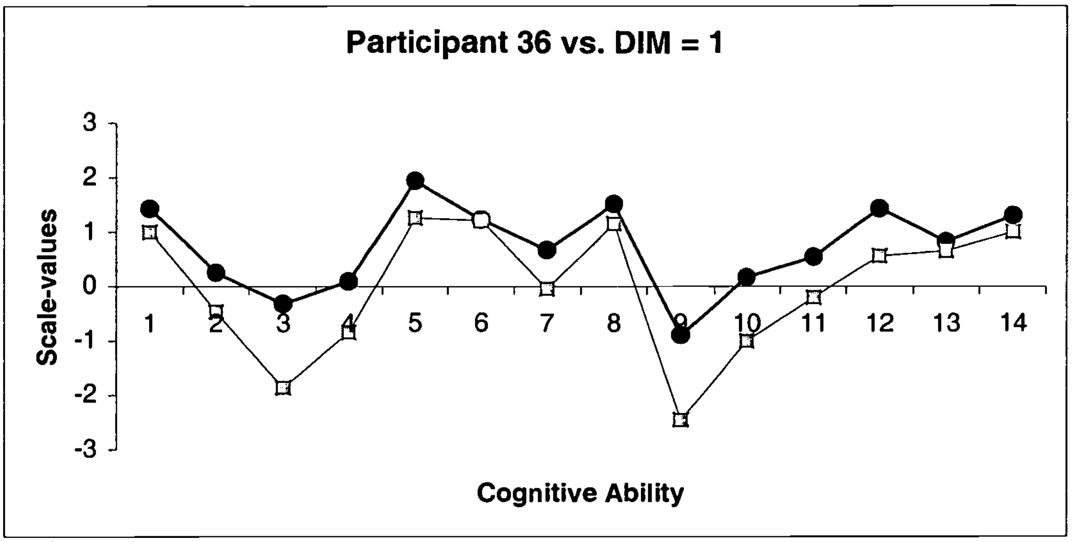
For some participants, there is only one dimension with a correspondence index that is large in absolute value; e.g., Participant 46. Their observed patterns resemble only one of the three dimensions. Others have weights that are substantial in absolute value on more than one dimension; e.g., Participant 16. Their observed profiles are a blend (linear combination) of the patterns reflected by two or more dimensions.

Column 5 contains the level parameter for each participant. Since the raw test scores in this analysis were standardized to have mean 0.0 and variance 1.0, level parameter estimates above 0.0, such as that for Participant 149, indicate a above average profile level.

Column 6 shows the proportion of variance in each participant's profile accounted for by the three dimensions. The profiles of some participants were recovered quite well, such as Participants 16 and 149, for whom over 80% of the profile variance was accounted for. For other participants, Participants 9 and 40, virtually none of the variance in their profiles was accounted for by the three dimensions.

In comprehending the meaning of the correspondence indices, examination of individual profiles can be instructive. Consider Participant 36, whose profile was accounted for well, $R^2 = 0.65$. The correspondence index for Dimension 1 is large, while the other two correspondence indices are trivial. This suggested that the observed profile of Participant 36 should resemble the Dimension 1 profile pattern in Figure 1. The squares in Figure 4 show the Dimension 1 profile and the circles show the observed profile of Participant 36. As expected, the two profile patterns were similar and the observed profile had peaks for the Long-term Memory tests, Memory for Names and Visual-Auditory Learning, and the Fluid Reasoning test, Concept Formation and the expected valleys for the Speed of Processing test (Visual Matching) and the Short-term Memory test (Memory for Words). The profile was elevated, as reflected by the Level Parameter estimates of 0.73 and this particular person scored above average overall, and showed greater strength in Visual-Auditory Learning and Fluid Reasoning than in Speed of Processing and Short-term Memory.

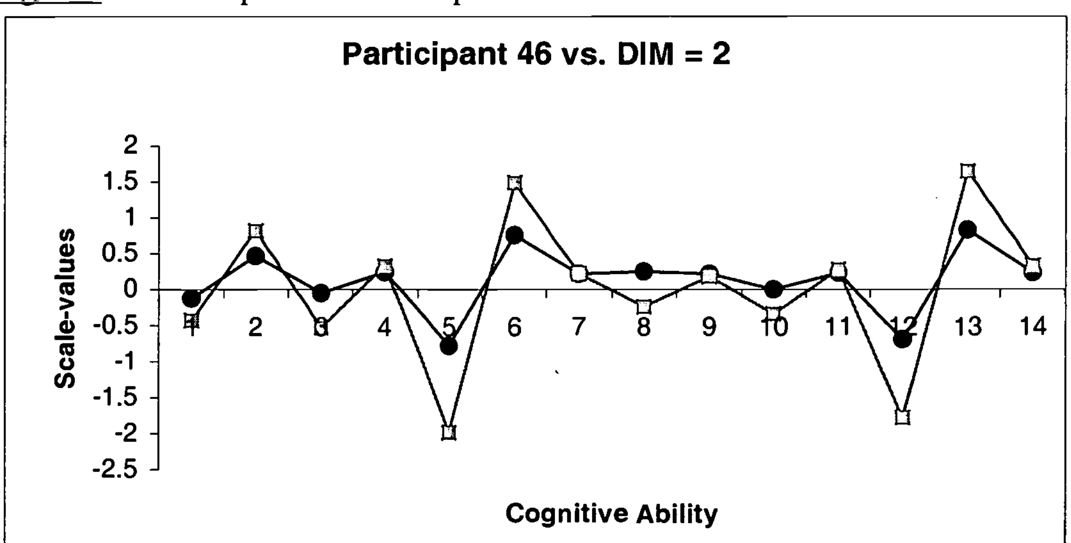
Figure 4 Observed profile of Participant 36 vs. Dimension 1 Profile



Note: squares and circles are for dimension and observed profiles, respectively

As a second example, consider Participant 46, whose profile is accounted for reasonably well, $R^2 = 0.60$. The correspondence index for Dimension 2 is large, while the other two correspondence indices are trivial. This suggested that the observed profile of Participant 46 should resemble the Dimension 2 profile pattern in Figure 2.2. The triangles in Figure 2.4 show the observed profile of Participant 46. It is only slightly elevated, as reflected by the Level Parameter estimates of 0.11 and it displays the expected peaks for the Comprehension-Knowledge tests (Picture Vocabulary and Sound Blending) and the expected valleys for the Visual Processing tests (Visual Closure and Picture Recognition). This particular person scored somewhat above average overall, and showed greater strength in Comprehension-Knowledge than in Visual Processing.

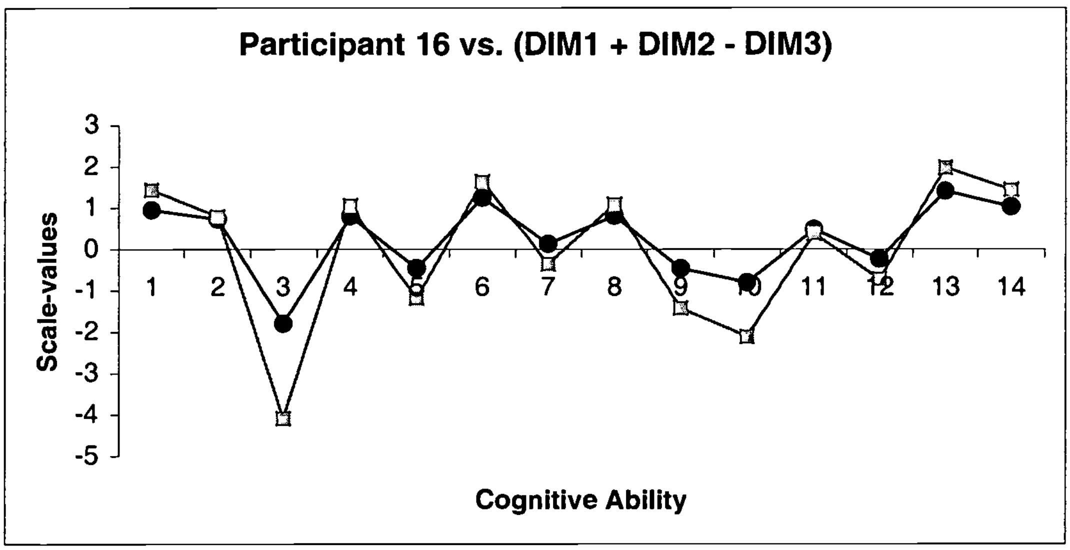
Figure 5 Observed profile of Participant 46 vs. Dimension 2 Profile



Note: squares and circles are for dimension and observed profiles, respectively

The last example illustrates that an observed profile can be represented as linear combinations of all three dimensions. Participant 16 is the case. As expected, the correspondence indexes were fairly large for all three dimensions and the observed profile was accounted for quite well, $R^2 = 0.81$. It was somewhat elevated, as reflected by the Level Parameter estimates of 0.28. This suggested that the observed profile of Participant 16 should resemble combinations of the Dimensions 1, 2, and 3 profiles. The circles in Figure 2.4 show the observed profile of Participant 16 and the triangles represent the total of three dimensions, Dimension 1 + Dimension 2 + Dimension 3. The profile patterns between the two were very similar as Figure 2.6 shows. The peaks were on Long-term Memory, Auditory Processing, Comprehension-Knowledge, Fluid Reasoning, and this particular person could do well on these subtests rather than on the Speed of Processing, Visual Processing, Short-term Memory tests.

Figure 6 Observed profile of Participant 16 vs. Linearly Combined (Dim 1 + Dim 2 + Dim 3) Profile



Note: squares and circles are for dimension and observed profiles, respectively

As can be seen in Table 3, the correspondence indices are largely uncorrelated with each other, whereas they were significantly correlated with the level parameter for each dimension. That is, those with higher profiles show a tendency toward a pattern with higher scores in Long-term Memory, Fluid Reasoning, and Comprehension-Knowledge than in Speed of Processing, Short-term Memory, and Visual Processing. Conversely, those with lower profiles show a tendency toward patterns with higher scores in Visual Processing, Short-term Memory, and Speed of Processing than in Comprehension-Knowledge, Fluid Reasoning, and Long-term Memory. It is important to note that individual differences in overall profile levels can be correlated with individual differences in profile patterns.

Table 3. Intercorrelations of Person Parameter Estimates

	DIM 1:Wp1	DIM 2: Wp2	DIM 3: Wp3
DIM 2: Wp2	0.07		
DIM 3: Wp3	0.03	0.03	
Level: Cp	0.16**	0.37**	0.16**

Table 4 shows the correlations of person parameters with scores on the ACHIEVEMENT SUBTESTS of the WJ-R: Letter Word Identification, Passage Comprehension, Calculation, Applied Problem Solving, Dictation, Writing Sample, Science, Social Studies, Humanities, Word Attack, Reading Vocabulary, Quantitative Concepts, Proofing, and Written Fluency. Correspondence indices for the last two dimensions had significant ($p < 0.01$) positive correlations with all of the achievement tests. In addition, the five achievement tests, Applied Problem Solving, Science, Social Studies, Humanities, and Quantitative Concepts, were significantly correlated with Dimension 1 correspondence indices. Especially the correspondence indices for Dimension 2 were highly correlated with the achievement tests. Particular ability in Comprehension-Knowledge as compared to Long-term Memory and Fluid Reasoning (Dimension 1) or Speed of Processing (Dimension 3) carried more advantage for measured achievement in school subjects.

Table 4. The correlations of person parameters with scores on the ACHIEVEMENT SUBTESTS of the WJ-R

ACHIEVEMENT SUBTESTS	W_{P1}	W_{P2}	W_{P3}	C_P
Letter Word Identification	.06	.46(**)	.20(**)	.72 (**)
Passage Comprehension	.13	.44(**)	.22(**)	.71(**)
Calculation	.09	.36(**)	.31(**)	.57 (**)
Applied Problem Solving	.20(**)	.48(**)	.26(**)	.67 (**)
Dictation	-.02	.38(**)	.31(**)	.68(**)
Writing Sample	.12	.41(**)	.22(**)	.68 (**)
Science	.26(**)	.50(**)	.19 (**)	.56 (**)
Social Studies	.24(**)	.55(**)	.23 (**)	.65(**)
Humanities	.29(**)	.45(**)	.23(**)	.67(**)
Word Attack	-.05	.36(**)	.19(*)	.69(**)
Reading Vocabulary	.15	.53(**)	.27 (**)	.70 (**)
Quantitative Concepts	.15(*)	.47(**)	.29 (**)	.65(**)
Proofing	.03	.36(**)	.27(**)	.72(**)
Written Fluency	.08	.31(**)	.37 (**)	.66(**)
N	176	176	176	176

Note: "*" & "**" mean significance at $\alpha = 0.05$ and $\alpha = 0.01$ respectively.

Correspondence indices for Dimension 2, Comprehension-Knowledge vs. Visual Processing were consistently correlated with all of the measures of achievement ($p < 0.01$). These correlations range from a high of 0.55 for Social Studies to a low of 0.31 for Written Fluency. Correspondence indices for Dimension 3, Speed of Processing vs. Auditory Processing were also consistently correlated with all of the achievement measures ($p < 0.01$). The correlations range from a high of 0.37 for Written Fluency to a low of 0.19 for Word Attack.

Ability profile level was also consistently correlated with achievement ($p < 0.01$). Correlations with the level parameter ranged from a low of 0.56 in Science to a high of 0.72 in Proofing. Overall, these correlations suggest that those who did well on the achievement tests tended to have ability profiles that were higher overall (profile level) and were somewhat higher in Comprehension-Knowledge than in other areas.

As this example illustrates, within the context of the model in Equation (1), scale-values are test parameter estimates and can be interpreted in terms of prototypical profile patterns (and mirror image patterns) corresponding to dimensions. Observed profile patterns are represented as linear combinations of the prototypes. Person parameters are interpreted with respect to these same prototypical profile patterns. Profile level parameters quantify individual differences in overall profile height. Correspondence indices quantify the degree of match between observed profiles and dimension prototypes. As illustrated above, correspondence indices can be used to study associations between match to prototypes and external variables, achievement tests in our example.

References

Davison, M. L., Kuang, H., & Kim, S-K. The Structure of Ability Profiles Patterns: A MDS Perspective on the Structure of Intellect. To appear in The Future of Learning and Individual Difference Research, P. Ackerman, P. Kyllonen, and R. Roberts (Eds), Washington, DC: American Psychological Association

Davison, M. L. (1996). Multidimensional scaling interest and aptitude profiles: Idiogrphic dimensions, Nomothetic factors. Presidential address to Division 5, American Psychological Association, Toronto (August 10)

Davison, M. L., Gasser, M., & Ding, S. (1996) . Identifying major profile patterns in a population: An exploratory study of WAIS and GATB pattern. Psychological Assessment, 8, 26-31.

Davison, M. L. (1994). Multidimensional scaling models of personality responding. In S. Strack & M. Lorr (Eds.), Differentiating Normal and Abnormal Personality. New York: Springer.

Davison, M. L. & Skay, C. L. (1991). Multidimensional scaling and factor models of tests and item responses. Psychological Bulletin, 110, 551-556.

Efron, B. &Tibshirani, R. J. (1993). An Introduction to the Bootstrap. Chapman and Hall, New York.

Kim, S-K., Davenport, E. C., & Davison, M. L. (1998). The Study of the Structure of High School Math Course-Taking via MDS. The Paper presented to the annual meeting of the American Educational Research Association, San Diego, LA

Kim, S-K., Davenport, E. C., & Davison, M. L. (1998). Differential Math Course-Taking Patterns by Gender and Ethnicity. The Paper presented to the annual meeting of the American Educational Research Association, San Diego, LA

Kim, S-K., Davenport, E. C., & Davison, M. L. (1997) All Math Courses Created Equal? The Paper presented to the annual meeting of the American Educational Research Association, Chicago, IL

MacCallum, R. C. (1974). Relations between factor analysis and multidimensional Scaling. Psychological Bulletin, 81, 505-516

Shao, J. & Tu, D. (1995). The Jackknife and Bootstrap. New York: Springer.

REPRODUCTION RELEASE

(Specific Document)

TM035216

I. DOCUMENT IDENTIFICATION:

Title: Application of the PAMS (Profile Analysis via Multidimensional Scaling) Model to Constructing Cognitive Ability Patterns

Author(s): Se-Kang Kim + Mark L Davison

Corporate Source: Univ. of Missouri-Columbia

Publication Date: 4/2000

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, *Resources in Education* (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY — Sample — TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) — 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY — Sample — TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) — 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY — Sample — TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) — 2B
Level 1 ✓	Level 2A ☐	Level 2B ☐
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) *and* paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, please →

Signature: Se-Kang Kim	Printed Name/Position/Title: Se-Kang Kim / Clinical Associate Professor	
Organization/Address: Same as before	Telephone:	FAX:
	E-Mail Address:	Date: [illegible]

(Over)