Correspondence Analysis and Rasch

Correspondence Analysis (CA) is a way of describing data by visualization. Tables of data are converted into graphical displays, called *maps,* and related statistics. This parallels Rasch approaches. But there are also marked philosophical differences: "The model must follow the data, and not the other way around" proclaimed Jean-Paul Benzécri, who, from the early 1960's, popularized use of CA in France. Yet Chikio Hayashi in Japan perceived CA to be an improved scaling technique to achieve the "quantification of qualitative data."

A CA map of a contingency table positions both row and column labels on the same two-dimensional plot. Thus patterns that describe "persons" and "items" simultaneously can be perceived. This feature of Rasch one-dimensional person-item maps is yet more striking when seen in two dimensions.

The accompanying Figure, presented as a good example of CA by Greenacre & Blasius (1994), shows that respondents in Japan chose "poor" and "don't know", while those in the USA and Britain are

polarized tending to choose either "very good" and "very poor". This plot is provocative, and certainly more appealing than its underlying cross-tabulation.

But this is also a paradox within CA. It attempts to present the data as maps, with their optically-implied equal-interval scaling, but without imposing the scaling models that are required to construct that linearity. A commonly-used technique in CA is least-squares estimation, a method that implies a degree of linearity in the original data.

Other CA researchers have "some difficulty in calling CA model-free" and perceive it to construct non-linear projections of the data. For them, CA has close similarities to latent class analysis, log-linear models, principal components decomposition and Goodman's RC-association models. Here, the overlap with Rasch techniques is again obvious. For example, Rasch models can be expressed in log-linear form. Also Erling Andersen notes that Georg Rasch himself derived the RC-association model from his own polytomous model (see *RMT* 15:1, 803).

In practice, CA has similar strengths and weaknesses to other forms of exploratory factor analysis. The cross-plots of dimensions within the data are suggestive, but not decisive. Since there is no strong theory about the
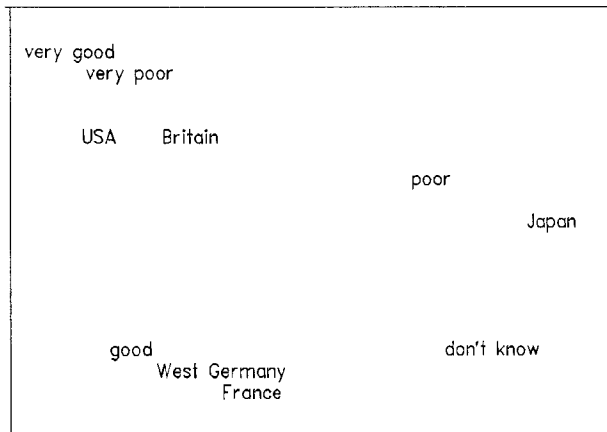
Greenacre & Blasius, Figure 1.3 (redrawn)

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nature of the numbers used to construct the plots, alternative plots can be presented as equally valid.

CA plots, however, are exciting and intriguing. This is widening their acceptance and influence among analysts and decision-makers. Sometimes under other acronyms, such as HOMALS. This suggests that Rasch practitioners would do well to feature graphical plots of measures, instead of tables of numbers, in presentations to both technical and non-technical audiences.

Quotes from M. Greenacre and J. Blasius, "Correspondence Analysis in the Social Sciences", Academic Press, London, 1994.

"Most problems cannot be solved. Most problems can only be survived. And one survives problems by making them irrelevant because of success. It's amazing how many minor ills the healthy body can stand without any trouble. One focuses on success, especially unexpected success, and runs with it."
Peter F. Drucker in P.F. Drucker, P.M. Senge, F. Hesselbein, "Leading in a Time of Change", Jossey-Bass, San Francisco, 2001.

"We spend a lot of our time fixing unimportant problems." Peter Senge, *op. cit.*

Journal of Applied Measurement
Volume 2, Number 3. Fall 2001

Congruence between a Theoretical Continuum of Masculinity and the Rasch Model: Examining the Conformity to Masculine Norms Inventory. *Larry H. Ludlow and James R. Mitchell.*

Detecting Unexpected Variables in the MMPI-2 Social Introversion Scale. *Chih-Hung Chang and Benjamin D. Wright.*

A Cross-cultural Procedure to Assess Reliability and Measurement Invariance. *Anil Mathur, Benny Barak, Yong Zhang, and Kuen S. Lee.*

Detecting Differential Rater Functioning over Time (DRIFT) Using the Rasch Multi-faceted Rating Scale Model. *Edward W. Wolfe, Bradley C. Moulder and Carol Myford.*

Understanding Rasch Measurement: Evidence for the Reliability of Measures and the Validity of Measure Interpretations. *Everett V. Smith, Jr.*

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Journal of Applied Measurement
Volume 2, Number 4. Winter 2001

Toward Establishing a Unified Metric for Performance and Learning Goal Orientations. *Caroline Dupeyrat and Everett V. Smith, Jr.*

Controlling for Rater Effects when Comparing Survey Items with Incomplete Likert Data. *E. Matthew Schulz and Anji Sun.*

Polytomous Modeling of Cognitive Errors in Computer Adaptive Testing. *Lih-Shing Wang and Chun-Shan Li.*

Comparing Holistic and Analytic Scoring for Performance Assessment with Many-facet Rasch Measurement. *Eunlim Chi*

Understanding Rasch Measurement: The Rasch Model, Additive Conjoint Measurement, and New Models of Probabilistic Measurement Theory. *George Karabatsos.*

Book Review - The Mathematics of Measurement: A Critical History by J. Roche. *William P. Fisher, Jr.*

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Rasch Measurement SIG Elections

Please vote for your choice of candidate for SIG Chair. The candidate for SIG Secretary is unopposed. Their 2 year terms begin at the AERA Meeting in April 2002. **Vote by email to** *vote@rasch.org*. Include in your email message only the name of the candidate for SIG Chair for whom you are voting. To be counted, send in your ballot on or before **March 1, 2002**.

For SIG Chair

Trevor Bond:
He is a senior staff member of the School of Education at James Cook University in Australia and is internationally known for his work on the application of Rasch analysis to developmental variables and educational outcomes. He undertook (with John King) the first state-wide survey of client satisfaction with public education for Education Queensland (1997/98) using Rasch measurement principles. Trevor's current book (co-authored with Christine Fox), *Applying the Rasch model: Fundamental measurement in the human sciences*, reflects his longstanding experience in educational settings as the background for applying fundamental measurement to outcomes in the human sciences. He is currently developing Rasch-based procedures for systematically collecting and analyzing student feedback about teaching and subjects at his university. He is a regular presenter on topics of educational and developmental measurement in the U.S., in particular. He regularly supports Rasch SIG presentations and has organized many Rasch based symposia for other AERA divisions and the Jean Piaget Society. Trevor actively supports newcomers to Rasch measurement. *www.soe.jcu.edu.au/staff/bond/*

Randall E. Schumacker
He is Professor of Educational Research at the University of North Texas and Adjunct Professor of Medical Education at the University of North Texas Health Science Center. You will find an interesting presentation on Rasch Models on his homepage. Randall has published various articles on Rasch measurement including Rasch quick norms; test equating; Rasch fit statistics; and many-Facets analysis. He completed a sabbatical at the University of Chicago in 1998, participated in several Rasch symposiums at AERA, and is currently finishing a chapter in an upcoming Rasch Measurement Book. He was the Founder, Editor (1994-1998), and current Emeritus Editor of *Structural Equation Modeling: A Multidisciplinary Journal*. He also founded the AERA Structural Equation Modeling Special Interest Group. *www.coe.unt.edu/schumacker*

For SIG Secretary

Edward W. Wolfe:
He is an Assistant Professor at Michigan State University teaching Measurement and Quantitative in the College of Education. His research focuses on cognitively-diagnostic assessment - an integration of cognitive science and latent trait models. Specifically, he examines the implications of departures from latent trait models (e.g., misfit and multidimensionality) and invariance of parameter estimates across subgroups (e.g., differential item functioning) for modeling cognitive states. Examples include the measurement of multidimensional change in individuals over time, identifying causes of differential cross-medium performance on traditional and computer-based tests, diagnosing rater effects in performance assessments, and explaining the cognitive demands of performance assessments. He is also interested in applications of Rasch polytomous, multivariate, and multidimensional item response models and the influence of computer-based testing on examinee performance. He has examined problems pertaining to barriers to the implementation of portfolios in secondary classrooms. *www.msu.edu/~wolfee*

Calendar of Events

Jan 7-23,	2002 Coursework, Perth, Australia David Andrich, *andrich@murdoch.edu*
Apr 1-5,	2002 AERA, New Orleans AERA, *www.aera.net*
Apr 4-5,	IOMW-XI Pre-Sessions, New Orleans Rasch topics, via *www.rasch.org*
Apr 6-7,	2002 IOMW-XI, New Orleans William P. Fisher, Jr., via *www.rasch.org*

POSITION ANNOUNCEMENT

Assistant/Associate Professor of Education (Educational Psychology: Measurement)

**Department of Educational and School Psychology and Special Education,
The Pennsylvania State University**

This is a 36-week tenure track appointment to be made at the assistant/associate professor level starting August of 2002; summer appointments in research and/or teaching may be possible. Full University benefits apply. Penn State has a strong commitment to the diversity of its workforce. We encourage applications from individuals of diverse backgrounds. Required qualifications Include:

Earned doctorate in Educational Psychology or a closely related field;
Relevant higher education teaching experience;
Evidence of scholarship relevant to Educational Measurement;
Demonstrated commitment to teaching and advising graduate students; Ability to teach item response theory (IRT) and structural equation modeling (SEM);
Commitment to collegiality and collaborative research efforts; and
Experience in working with individuals of diverse backgrounds (commensurate with appointment rank).

Desirable qualifications include:

Expertise in technical aspects of Measurement such as test equating methods, differential item functioning (DIF), and scale construction techniques; Expertise in hierarchical linear modeling (HLM).

Applications received by January 19, 2002 are assured full consideration; however, applications will be received until the position is filled. For more information, see
www.ed.psu.edu/employment/edpsymeas.asp

Dennis M. Roberts, Chair, *dmr@psu.edu*
EDPSY Search Committee
Box WB, 227 CEDAR Building
University Park, PA 16802-3109

POSITION ANNOUNCEMENT

Senior Psychometrician
NCS-Pearson
Eden Prairie, Minnesota

Education, skills and knowledge:
* Master's or doctoral degree in psychometrics or a related field from a nationally recognized institution of higher education.
* At least five years experience in psychometrics, including the construction, processing, analysis, and reporting of large-scale examinations.
* Experience directing a large-scale testing program.
* A strong background in computerized exam delivery, computer-adaptive testing, and item response theory (IRT).
* Thorough understanding of the principles of test construction, classical and IRT-based item analysis, and item calibration, linking, and equating.
* Ability to summarize complex technical information and communicate it to a variety of audiences.
* Good project management skills.

Duties and responsibilities:
* Works closely with the Psychometrician and the NCLEX Content Manager to ensure that the NCLEX items (1) meet specified statistical criteria, and (2) are available for pre-testing and review as expected.
* Conducts workshops for determining the cut-off score for the RN and PN exams.
* Conducts and supervises testing and operational research.
* Leads the Research Advisory Panel for future examination development.
* Works with software developers and QA analysts to ensure the integrity of the VUE testing system.
* Travels to VUE's Chicago office and elsewhere for project-related meetings as necessary.

To apply: go to *www.ncspearson.com* and click on "careers" tab and then "search now." Then search on keyword "psychometrician" and select this position. You should now be able to apply on-line.

ICMEE Report
November 11-13, 2001

Nov. 15, 2001: Just back from Penang, Malaysia as a paper presenter at the first International Conference on Measurement and Evaluation in Education organized by School of Educational Studies, *Universitii Sains Malaysia.*

Geoff Masters from ACER provided the opening plenary about setting Benchmarks and raised the role that objective measurement has in an educational evaluation system. From that moment on "Rasch" was an important byword for the whole conference. Given that Malaysia spend 23% of its GDP on education and outcome measurement systems are in the process on being implemented, the timing of this conference and the sharing of Rasch measurement ideas with the 200 participants might prove quite fortuitous.

Thanks to Wan Mohd Rani Abdullah who notified Rasch listers about this event. [To subscribe to the Rasch listserv, see *www.rasch.org/rmt*]

There were certainly some interesting papers presented and some important ideas canvassed. Two presentations which really caught my attention were a paper presented by Surintorn Suanthong and co-authored by Mary Lunz about "unanchoring" entitled "Factors Affecting Test Equating in Performance Examinations in Latent Trait Theory" and also a really scintillating performance by ex-MESA graduate Lee Ong Kim, from the National Institute of Education, Singapore, "Rasch One-step Equating for Measuring Reading Growth" - wow, what a presenter! [An example of his one-step work is in *RMT* 6:1.]

I encouraged both authors to submit to the *Journal of Applied Measurement* - this was real quality work.

The venue was marvelous, the setting idyllic, the food and shopping was great. Hospitality was wonderful. I felt so sorry for the hard-working organizers that a couple of key presenters didn't show - security concerns. (I felt much safer there than I do in New Orleans, Chicago or Mexico City.)

ICMEE 2003 will be in two years time - mark the date now: *www.geocities.com/drwanrani/index.html*

You are already sorry that you didn't go this time.
Trevor Bond, www.soe.jcu.edu.au/staff/bond/

Benjamin D. Wright
His Affliction

In the early hours of Tuesday, Oct. 30th, 2001, Ben Wright suffered a stroke in his home in Chicago. He was immediately admitted to the University of Chicago Hospitals for emergency treatment, including removal of a blood clot from his brain. On Tuesday, Nov. 27, Ben had recovered sufficiently to be transferred to the Weiss Memorial Hospital on north side of Chicago. As of December 6th, he was showing only minor signs of his affliction, and starting to find his hospitalization irksome!

His wife, Claire, and children, Amy, Andy, Chris and Sarah, are grateful for the many expressions of concern and support they have received.

Here's a brief Autobiography of Benjamin D. Wright, composed December 18, 1996:

"Benjamin D. Wright is Professor of Education and Psychology at the University of Chicago and Director of the Mesa Psychometric Laboratory. He was born March 30, 1926. He began his scientific work as a physicist at the Bell Telephone Laboratories in 1947, moving to the University of Chicago Physics Department in 1948. In 1950 he began a seven year study of the child care workers at the University's Orthogenic School. This led to a Chicago Institute for Psychoanalysis Certificate in Psychoanalytic Child Care (1954) and a University of Chicago Ph.D. in Human Development (1957). His studies of social science measurement, previously limited to factor and regression analysis, took a giant step forward when he met Danish mathematician Georg Rasch in 1960 and worked with him from 1960 until 1974. Since then Dr. Wright has published 150 papers on Rasch measurement; co-authored 12 books, including *Best Test Design* and *Rating Scale Analysis* and directed the development of the two most widely used Rasch measurement computer programs, *BIGSTEPS* and *Facets*. He has taught annual workshops and courses on Rasch measurement since 1969 and chaired 70 doctoral dissertations on that topic. Many of his students are contemporary leaders in psychometrics."

POSITION ANNOUNCEMENT

Australian Council for Educational Research
ACER
Melbourne, Australia

Associate Director and Head of Measurement Division

ACER seeks an Associate Director to manage and provide leadership to its Measurement Division. This position has become vacant following Prof. Ray Adams' decision to dedicate his attention to ACER's management of the OECD Programme for International Student Assessment (PISA).

As an Associate Director of ACER, the appointee will be a member of our senior management team involved in organization-wide strategic planning. As Head of the Measurement Division, the appointee will manage and provide leadership to the substantive work of a division of 40+ staff engaged in R&D projects across all areas of the curriculum and all sectors of education.

The successful applicant will be expected to build ACER's range of domestic and international projects and to identify opportunities to expand our assessment resources for professional practitioners. These roles will require a solid understanding of modern educational assessment/measurement, the ability to lead a multi-disciplinary team involved in a wide variety of projects, and exceptional written and verbal communication skills.

The position carries an attractive salary package with a 5-year renewable contract. Applications will be considered from 1 December 2001.

For more information, see *www.acer.edu.au* or email *personnel@acer.edu.au* or contact Sarah Matar on +61 3 9277 5639.

Rasch Measurement SIG Officers
Mary E. Lunz .... Chair
Tom O'Neill .... Secretary
George Karabatsos .... Program Chair

MCAT
Graduate Student Research Program
Summer 2002

(Raschies please note: we are particularly interested in research using the Rasch model.)

The Association of American Medical Colleges (AAMC) is pleased to announce the fifth annual Medical College Admission Test Graduate Student Research Program (MCAT GSRP). Two outstanding graduate students in the field of educational measurement or educational research, who have completed at least two years of related graduate study and have strong backgrounds in item response theory, will be selected to participate in the 2002 MCAT GSRP. The program is designed to give students an opportunity to develop professional skills through collaboration on a research project with a mentor and the MCAT research staff.

The 2002 GSRP will include two one-day visits to the MCAT offices located in Washington, D.C. The first visit will be an orientation to the research program, in May. The second visit will occur in September, following completion of the research project. This second visit will include a formal presentation to MCAT staff and other researchers. Applications to the summer 2002 MCAT GSRP must be received by February 22, 2002. Successful applicants will be informed by April 1, 2002.

Each researcher will receive a stipend of $5,000. AAMC will also cover the cost of travel, accommodation and related expenditure for the visits to Washington, D.C.

Visit *www.aamc.org/mcat* for information on how to apply, topics of interest to the MCAT research team, and research already completed under the MCAT GSRP.

Patricia M. Etienne, Ed.D.
MCAT Director of Research
Association of American Medical Colleges
2450 N St., NW
Washington, DC 20037
(202) 828-0693 *petienne@aamc.org*

A Measure of Quality

Excerpted from "The Ideas of the University", a compilation of the winning answers in a contest asking readers to write about important ideas associated with the University of Chicago. Of the 12 winners, only two related to Professors then still active at the University, Ben Wright and Mike Csikszentmihalyi of "Flow" fame. This winning entry was entitled "A Measure of Quality", and appeared in "The University of Chicago Magazine", 1992, 84:4, 25.

Without the University of Chicago, there would be no fundamental measurement in social science. Why has there been almost no progress in understanding and solving social problems in the last 100 years? Benjamin Drake Wright's diagnosis is that the fuzzy nature of data in the social sciences inhibits clarity of thought. To Wright, PhD '57, professor in education and psychology, the difficulty lies in the fact that social science data are often counts of qualitative events (e.g., absences from school, teenage pregnancies) that lack the quantitative structure needed for meaningful, simple arithmetic. "It is almost impossible to think about numbers that are not equal-interval," Wright declares. He then proposes the obvious, deceptively simple, first step: produce better measurement - fundamental measurement. In other words, construct interval measures with the characteristics of the carpenter's yardstick, but obtained from the counts of qualitative events familiar to social scientists.

In the spring of 1960, Wright was the sole participant to attend all of a series of lectures given at the University by an obscure Danish mathematician, Georg Rasch. These lectures introduced him to the apparently incredible notion that linear quantitative measures - fundamental measurement of the type on which the physical sciences are based - can be derived from examinees' right/wrong answers to questions on intelligence tests. Wright has taken this idea further. As an internationally known exponent of fundamental measurement, he has broadened its theoretical base, widening its practical applications (the Australian educational system, medical researchers in pain and disability, and physical scientists analyzing qualitative data on river pollution levels - all employ Wright's insights), and instructing practitioners in its use.

John Michael Linacre

"A prime requirement of scientific finds is that they shall be communicable to others."
      J.P. Guilford, Fundamental Statistics in Psychology and Education. New York: McGraw-Hill, 1956.

IOMW-XI
Call for Participation
April 6-7, Sat.-Sun., 2002
New Orleans (following AERA)

School of Nursing & Allied Health Professions, Louisiana State University Health Sciences Ctr, 1900 Gravier Street, New Orleans, LA 70112

The Eleventh International Objective Measurement Workshop will be an exciting opportunity for those interested in improved test and survey practices to actively participate in discussions and workshops, and to network with experts from around the world. Software pre-sessions are scheduled. Past IOMWs have attracted participants from as many as 15 countries and 20 US states.

Four types of participation are:
* Conventional paper presentations: research reports, instrument calibrations, methodology innovations, etc.

* Organized symposia: a set of papers addressing a common theme or research project; please provide a paragraph describing each contribution.

* Discussion workshops: small group discussions, soliloquies and harangues, method/computer demonstrations, etc.

* Poster session: There will be a poster session social hour after the Saturday afternoon workshops. Proposals for posters, software demonstrations, book signings, etc. are invited.

Social events at local restaurants on Friday and Saturday evenings. For those interested in Cajun cuisine, we will again visit Mulate's for jambalaya, gumbo, live music, and dancing.

Nearest AERA hotel: Radisson, 1500 Canal st.

IOMW-XI information and proposal submission, see *www.rasch.org*. Proposals due Feb. 1, 2002.

William P. Fisher, Jr., LSU School of Medicine *wfishe@lsuhsc.edu*, FAX: (504) 568-6905

A New Journal Coming in 2002!
MEASUREMENT: Interdisciplinary Research and Perspectives

Published by Lawrence Erlbaum Associates, Inc.
www.erlbaum.com/Journals/journals/MEA/mea.htm

Editor: Mark Wilson, University of California, Berkeley
Coeditors: Paul De Boeck, K.U. Leuven, Belgium; Pamela Moss, University of Michigan

Editorial Scope: This new journal is devoted to the interdisciplinary study of measurement in the human sciences. It will feature focus articles that make an important conceptual contribution to the field, along with commentaries that embody dialogue and debate across multiple perspectives. The journal's overarching theme is to promote the development, critique, and enrichment of the concepts and practices of measurement. Contributors will share a common link, the serious study of measurement from a broad range of disciplines and perspectives including psychometrics, ethnography, social theory, psychology, education, linguistics, sociology, and policy studies.

A distinctive feature of Measurement is open peer commentary on focus articles. Commentary authors will write "open reviews" of the focus article from a broad perspective to add richness and insight to debate. Through peer commentary and authors' responses, Measurement will provide an opportunity for discussion that is currently unavailable to the general readership.

Focus articles will include seminal papers on important issues in the field in the form of single papers, sets of linked papers, or summaries of recently published books on one of the following genres:
A report and/or discussion of empirical research with a broader scope and/or implication than found in other measurement-associated journals;
An unusually significant theoretical article that systematizes or gives new perspectives on a body of theory, research, and/or practice in measurement;
A novel interpretation, synthesis, or critique of existing measurement work;
A summary and commentary on a field of application of measurement that either is a significant contribution to measurement in that field, or which contains an important message for measurement work in general;
A rigorous, evidence-based critique of measurement theory and practices from outside the discipline; or
A rigorous, evidence-based critique from within measurement on theory and practices outside the discipline.

Audience: All those who have a serious interest in the study of measurement theory, application and criticism including psychometricians, sociometricians, mathematical psychologists, clinical psychologists, educational curriculum developers, policy researchers, educational and psychological test developers and assessment designers, professionals in medical and public health fields, and social scientists who study the history and effects of measurement practices.

Instructions to Contributors: Please see
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Authors should send four copies and one original manuscript to:

Karen Draney, Managing Editor
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Volume 1, 2002, Semi-Annual
(Available quarterly in 2003)

Individual: $50.00 US/Canada
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$200.00 All Other Countries
Electronic Only: $45.00 Individual
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ISSN: 1536-6367; E-ISSN: 1536-6359

"First find your basic principle, then settle how it is to be applied to your subject - that surely is the only way of putting truth into practice. History has its value whether as a guide or a warning, and we should be foolish indeed to underrate it: but unless its facts are related to a truth which illuminates them, they possess no more than an antiquarian interest."
W. J. Phythian-Adams in "The Way of At-one-ment", London: SCM, 1944.

Logit to Score Conversion

"How does one translate a logit value back to a raw score?"   L.C.

A motivation for constructing measures is to obtain units, e.g., logits, as independent as possible of the original raw score system. But logit-to-raw-score conversion is usually straightforward. If every person is observed on every item, then a conversion table is easy to construct. Compute the measure for every possible raw score using a method such as "Estimating measures..." in *RMT* 12:2. If different people are observed on different items, such as with adaptive testing, then you must specify which items are to be included in the raw score computation.

Oversimplification

"The invention of deliberately oversimplified theories is one of the major techniques of science, particularly of the 'exact' sciences, which make extensive use of mathematical analysis. If a biophysicist can usefully employ simplified models of the cell and the cosmologist simplified models of the universe then we can reasonably expect that simplified games may prove to be useful models for more complicated conflicts."

Attributed to John Williams, *The Compleat Strategyst*, New York, McGraw Hill, 1954.

And we can then also reasonably expect that simplified representations of complex interpersonal relationships, or of attitudes, beliefs, opinions, abilities, performances, etc., may also prove useful, as has in fact been repeatedly demonstrated in the history of Rasch measurement.   *William P. Fisher, Jr.*

Scales: Music and Measurement

Across the centuries, the development of tuning methods for musical instruments has been driven by the desire of musicians to expand the variety of harmonies and increase the types of easily playable music. There are intriguing parallels with the development of social science measurement. For instance, mathematical perfections were claimed for "Pythagorean" tunings, as they are now for some IRT models. On the other hand, special practical virtues were perceived in "just meantone" tunings, as they are now in raw-score-weighting schemes.

Most music we hear today is played with equal-temperament tuning. This became the *de facto* standard in 1854. In this tuning, the relationships between the notes sound the same in every musical key (either major or minor), wherever they are played on the piano. In each major (or minor) key the notes bear the same mathematical and acoustic relationship to each other as they do in every other key. This is a measurement ideal. One more note is the same amount extra everywhere on the piano. It is also a musical ideal. Playing music in another key does not require retuning. A transposed piece of music has the same musical feel, no matter what key it is played in. But there are costs. This type of tuning requires advanced technology and expertise. Also, the distinctive sounds of particular major and minor keys in earlier tunings, beloved of particular composers and performers, have been lost.

Prior to equal-temperament tuning, the pianist was required to make decisions. Is the note next above C to be C-sharp or D-flat? It could not be both simultaneously, as with equal temperament tuning. Once the decision was made, the piano was necessarily harmonically optimized for certain keys, and sub-optimal for others. J.S. Bach's *"48 Preludes and Fugues for the Well Tempered Clavier"* was written for this type of tuning. He demonstrates how the use of notes, tuned for one key, to play music written in a different key, produces a change of sound texture, and so a change of the emotional impact of the music on the hearer. This is type of change does not occur with modern equal-temperament tuning.

"Well temperament" tuning was prevalent from 1690 onwards. It's goal was to maximize the number of harmonies while simultaneously eliminating gross disharmonies from the scale of choice. This is equivalent to maximizing the reliability of a test for a particular sample.

Prior to "well temperament" tuning were the Pythagorean tuning methods. These followed an ideal of mathematical and musical perfection that worked nicely for centuries. But there were drawbacks. A change of musical key required retuning of the instruments. Tuning was done according to the performer's preference, so there was only a rough standardization of sound. Each musician claimed that his personal tuning method was a superior realization of the Pythagorean ideal of integer ratios between note frequencies. But Pythagorean tuning was simple, and musically effective. It's limitation was that only 11 of the 12 notes of an octave could be in tune simultaneously. Yet it was so easy and familiar, just as raw scores are today, that it was still widely used as late as 1800 A.D.

The development of tuning methods continues as musicians seek to enchant their audiences with ever more exotic harmonies and discords. Unfortunately, in a remarkable parallel to the current proliferation of psychometric models, "the history of tuning is saturated with clever and original theories that have no practical application." (Jorgensen, p.33)

> Jorgensen, O. (1977) Tuning the Historical Temperaments by Ear. Marquette: Northern Michigan University Press.

In "Establishing equivalence between scaled measures of quality of life," *J. Quality of Life Research,* 1996, 5, 20-26, R. Gonin, D. Cella, and S. Lloyd used item measures and standard errors from different samples to compute standardized differences. The resulting plot shows which inter-sample disagreements about item difficulties merit further investigation. This method was also proposed by Altman DG, Bland JM (1983), "Measurement in Medicine: The analysis of method comparison studies." *The Statistician* 32: 307-317.

Differential Item Functioning of 28 items