New Directions In Psychometrics

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Outline

1: The Past

The Psychometric Society has a 60-year history of developing and using quantitative methods to improve the scientific basis of psychological analysis.

2: The Present

We have come to a crossroads.

3: The Future

1. **The decline of the society and the field, with increasing difficulty of recruiting new members and finding jobs for students.**
2. **An infusion of new ideas for new directions in Psychometrics.**

4: New Directions

I believe that Psychometrics should expand its purview by working on

- **the development and use of Psychological tools useful to the practice of Statistics**

while at the same time it should strengthen the traditional focus on

- **the development and use of Statistical tools useful to the practice of Psychology.**

1: The Past

Psychometrika started publication in 1936. Topics in the 30's were:

1. **Factor Analysis**
2. **Test Theory**
3. **Data Analysis (Correlation, ANOVA, Principal Components, etc.).**
4. **Biophysics**
5. **Psychophysics**
6. **Matrix Algebra**
7. **Various applications to Psychology (learning, olfaction, etc.)**

1936-55:
During these two decades the topics gradually focused on Factor Analysis & Test Theory, and to a somewhat lesser extent, Data Analysis.

1956-75:
During the next two decades Multidimensional Scaling was added to the three "classical" topics, with emphasis on it for some time.

1976-96:
During the last two decades emphasis on the same 4 topics continued with some shift from MDS and FA to Test Theory, especially IRT.

The Past

My own past (especially for the youngsters here):

1. **In the 70's I helped develop Multidimensional Scaling and Alternating Least Square Optimal Scaling data analysis methods.**
2. **I attended almost every Psychometric Society meeting from 1967 to 1985.**
3. **I had 15 publications in Psychometrika between 1970-1985.**
4. **I was President of the society in 1981, and am very proud of it.**
5. **For 15-20 years this society was the focus of my work life. I loved coming to the meetings. I respected the society, its people and their work a lot.**

In the early '80's my focus shifted – I gradually came to feel that:

1. **I knew more about MDS and Optimal Scaling than was useful.**
2. **Further development of these methods would really just be tinkering with them, and while it would be mathematically satisfying, it wasn't useful to anyone outside of our society.**
3. **The methods and models had gotten much more complicated than users could understand, and than we could communicate to them.**
4. **Application to problems in Psychology, and Social Sciences, had gotten lost in the process of developing more complex methods and models.**

2: The Present

My personal present:

1. **I've shifted my focus to the graphical and computational sections of the ASA. I publish in ASA journals and attend ASA conventions.**
2. **I tell folks I'm a Statistician, not a Psychometrician.**
3. **I work on graphics to communicate complicated data analysis results.**
4. **I develop Cognitive Psychology theories to understand and model the data analyst, and software based on those theories.**

My view of the Psychometric Present:

1. **Much of what we do is too specialized.**
2. **Much of what we do is more mathematical and complicated than is useful. Its often hard to communicate what we do to those outside of our society.**
3. **We are too focused on minutiae - often mathematically tweaking existing work to provide a minute new feature that makes little useful difference.**
4. **We have lost sight of our original purpose: Developing mathematical and statistical tools that are <u>useful</u> and <u>relevant</u> to Psychology and other Social Sciences.**

3: The Future

I believe that we need to revive our traditional focus on Statistical and Mathematical tools that are <u>useful</u> for Psychologists and other Social Scientists.

1. **We need to be more <u>problem driven</u> rather than <u>tool driven</u>. Focus on the Psyche, not the Metrics. The consumer of our methods has been forgotten.**
2. **We need to expand our selection of statistical tools for helping Psychology.**
3. **We need <u>simpler</u> methods, not more complex ones.**
4. **We need to focus on communicating our message to those outside of our small society.**

But more fundamentally, we need to branch out to new areas as well as revive our traditional focus.

The Future

My main point:

I believe that Psychometrics should expand its purview by working on

1. **the development and use of Psychological tools that are useful in strengthening the scientific basis of the practice of Statistics;**

while at the same time strengthening the traditional focus on

2. **the development and use of Statistical tools useful in strengthening the scientific basis of the practice of Psychology.**

These "Psychological tools" include:

1. **Cognitive and perceptual models for statistical graphics and data analysis.**
2. **Empirical Psychological research methods to investigate the efficacy of the cognitive and perceptual models.**

In the remainder of this talk I will present examples of work that uses Psychological tools useful to strengthening the scientific basis of the practice of Psychology.

4: New Directions in Psychometrics

In fact, such research has been going on for the last decade.

1. **There are cognitive and perceptual models for designing statistical graphics and data analysis environments.**
2. **Some of these models have been used to guide empirical research on the design of statistical graphics.**

This research is called "Computational Statistics" and "Graphical Statistics".

1. **It is seen as part of Statistics. It is presented at ASA conventions. It is published in ASA journals.**
2. **Some of it is performed by "former Psychometricians" with training in the tools of Cognitive and/or Perceptual Psychology.**
3. **Some is performed by Statisticians with no training in Cognitive or Perceptual Psychology.**

I believe that Psychometricians should be involved in this research. They are uniquely qualified:

1. **They are familiar with the models and methods of Psychology; and**
2. **They are familiar with the problems of Statistics.**

4.1 Graphical Perception

Bill Cleveland and his associates (statisticians and computer scientists) are largely responsible for the resurgence of interest in the perception of statistical graphs.

1. **They have emphasized the need for empirical work and the need for a theory of graphical perception.**
2. **Their work has been based on psychophysics, including Weber's Law and Steven's Law.**
3. **They recommend that whenever possible, data values be represented by length, not area or volume.**

Graphical Perception

Ian Spence (former -?- Psychometrician) has performed fairly extensive empirical research on graph perception.

1. **He has studied how to present multiple groups on a scatterplot — by varying symbols, color, letters, line orientation, and symbol fill.**

   For example, he finds that judges are fastest with color, slowest with confusable letters (E,F,H), but there were no differences in accuracy (unless processing time was restricted).
2. **He has also studied how judges respond to the visual elements of pie charts, bar charts, and variations on these. (Pie charts are not as bad as I thought!)**
3. **He has compared several types of multivariate displays.**
4. **He has summarized many results and theory on graphical perception.**

Ian Spence will be talking about this work in an invited presentation to Division 5 of the APA convention in Toronto, in August.

4.2 Graphical Cognition

Linda Pickle and Doug Herrmann (statisticians) have proposed a cognitive model for map reading. They say that successful map reading involves:

1. **The map itself;**
2. **The experience and skill of the map reader;**
3. **The task to be done using the map.**

Each of these three components (map, reader, task) affects the cognitive processes underlying map reading. They propose 4 cognitive stages:

1. **Map Orientation — What geographic area does the map represent? What is the map designed to communicate?**
2. **Legend Comprehension — How are the values of the mapped statistic represented?**
3. **Map/Legend Integration — Match the legend scale to the map itself.**
4. **Extracting Information — Answer the questions to be asked of the map.**

Each cognitive stage depends on processes, including sensation, perception, comprehension, encoding information into memory, memory retrieval, and reasoning. Different stages involve different selections of these processes.

4.3 Graphical Models

Michael Friendly (former -?- Psychometrician) and John Sall (statistician and computer scientist) have discussed conceptual models for constructing graphs.

They argue that our cognitive and perceptual processes involve implicit conceptual models. For example:

1. **The "Spring Model" for scatterplots is a conceptual model that is designed to make sense out of scatterplots, regression lines, principal component planes, sample size, error variance, leverage, etc.**
2. **The "Gas Pressure Cylinder" model for categorical data is a conceptual model that is designed to make sense out bar charts, sample size, t-tests, etc.**

Michael Friendly will be discussing this new direction for Psychometrics in the next invited talk immediately following this one.

He will also be talking about this work in an invited presentation to Division 5 of the APA convention in Toronto, in August.

4.4 Cognitive Model for Data Analysis

Forrest Young (Psychometrician?), John Smith & David Lubinsky (computer scientists) have proposed a cognitive model for the data analysis process. They propose that there are three cognitive modes of behavior and thought.

We argue that the cognitive modes should correspond to different software environments (modes) that are uniquely designed for the cognitive mode.

The cognitive modes, and corresponding software modes, are

1. **Exploratory — when the analyst is exploring the data and generating hypotheses. Supported by a graphical user interface.**
2. **Confirmatory — when the analyst is confirming hypotheses. Supported by an alphanumeric user interface**
3. **Structural — when the analyst is constructing, maintaining or revising the data analysis. Supported by a graphical user interface.**

I have also argued that the user's cognitive mode also depends on the level of expertise of the analyst for the specific type of data analysis activity that is taking place.

Cognitive Model for Data Analysis

Finally, we have argued that the cognitive model for data analysis should incorporate the notion of a statistical strategy:

A statistical strategy is a formal representation of an expert statistician's conceptual structuring of

1. **the data analysis procedures needed to accomplish a specified data analysis task;**
2. **the data analyst's actions (choices, decisions, etc.) that are possible with the data analysis procedures;**
3. **the relationships between the procedures and actions needed to accomplish the task;**
4. **where the task is to understand a specified data analysis object (data set or data model).**

We argue that statistical strategies guide data analysts and their specific series of cognitive modes during the data analysis process, especially naive analysts.

We have argued that empirical work should be done to test hypotheses resulting from the cognitive model.

5: Conclusion

I've come to believe that Psychometrics has become

1. **too inbred - too many of us are paying attention only to ourselves. We have forgotten our "users" — Psychologists and other Social Scientists.**
2. **too driven by mathematics without regard to practical usefulness.**
3. **too focused on minutiae - often mathematically tweaking existing work to provide a minute new feature that makes little (if any) useful difference.**
4. **to focussed on methods and models that have gotten way more complicated than users can understand – and than we can communicate to anyone other than ourselves.**
5. **insufficiently driven by its original purpose of trying to provide mathematical tools useful to Psychologists.**

The common denominator of these points is:

we are too focussed on mathematics at the expense of usefulness.

Conclusion

I believe that Psychometrics is in need of rejuvenation, and that this can be done by expanding the purview of Psychometrics by working on

1. **the development and use of Psychological tools that are useful in strengthening the scientific basis of the practice of Statistics;**

while at the same time strengthening the traditional focus on

2. **the development and use of Statistical tools useful in strengthening the scientific basis of the practice of Psychology.**

The Psychological tools include the theories and methods of cognitive and perceptual Psychology.

I pointed out that these Psychological tools are already being used to improve the scientific basis of the practice of Statistics - especially for Graphics and Software design.

I encourage the field of Psychometrics, as represented by its practitioners, its journal and its annual meeting, to encompass and encourage the use of Psychological tools that are useful in strengthening the scientific basis of the practice of Statistics.

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