

# Optimal Designs for Linear Logistic Test Models

U. Graßhoff, H. Holling and R. Schwabe

**Abstract** An important class of models within item response theory are Linear Logistic Test Models (LLTM). These models provide a means for rule-based item generation in educational and psychological testing based upon cognitive theories. After a short introduction into the LLTM, optimal designs for the LLTM will be developed with respect to the item calibration step assuming that persons' abilities are known. Therefore, the LLTM is embedded in a particular generalized linear model. Finally, future developments are outlined.

## 1 Introduction

The following work is motivated by the construction of rule-based tests for measuring intelligence. Intelligence is a very important prerequisite for academic and vocational performance as it provides a basis for nearly all cognitive abilities and skills. Thus, measurement of intelligence has played an important role in psychological test theory for a long time.

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# Linear Models For Optimal Test Design Linear Models For Optimal Test Design

**Paola Monari, Matilde Bini, Domenico  
Piccolo, Luigi Salmaso**



## **Linear Models For Optimal Test Design Linear Models For Optimal Test Design:**

Linear Models for Optimal Test Design W. J. Linden, 2011-03-21      Linear Models for Optimal Test Design Wim J. van der Linden, 2005-08-09 Wim van der Linden was just given a lifetime achievement award by the National Council on Measurement in Education There is no one more prominent in the area of educational testing There are hundreds of computer based credentialing exams in areas such as accounting real estate nursing and securities as well as the well known admissions exams for college graduate school medical school and law school there is great need on the theory of testing This book presents the statistical theory and practice behind constructing good tests e g how is the first test item selected how are the next items selected and when do you have enough items      **Linear Models for Optimal Test Design** Wim J. van der Linden, 2006-01-01 Over my nearly forty years of teaching and conducting research in the field of psychometric methods I have seen a number of major technical advances that respond to pressing educational and psychological measurement problems The development of criterion referenced assessment was the first beginning in the late 1960s with the important work of Robert Glaser and Jim Popham in response to the need for assessments that considered candidate performance in relation to a well defined body of knowledge and skills rather than in relation to a norm group The development of criterion referenced testing methodology with a focus on decision theoretic concepts and methods content validity standard setting and the recognition of the merits of both criterion norm referenced and criterion referenced assessments has tremendously influenced current test theory and testing The second major advance was the introduction of item response theory IRT and associated models and their applications to replace classical test theory CTT and related practices Beginning slowly in the 1940s and 1950s with the pioneering work of Frederic Lord Allan Birnbaum and Georg Rasch by the 1970s the measurement journals were full of important research studies describing new IRT models technical advances in model parameter estimation and model fit and research on applications of IRT models to equating test development the detection of potentially biased test items and adaptive testing The overall goal has been to improve and expand measurement practices by overcoming several shortcomings of classical test theory dependence of test item statistics and reliability estimates on examinee samples dependence of examinee true score estimates on the particular choices of test items and the limitation in CTT of modeling examinee performance at the test level rather than at the item level      **Optimization of adaptive test design methods for the determination of steady-state data-driven models in terms of combustion engine calibration** Sandmeier, Nino, 2022-12-01 This thesis deals with the development of a model based adaptive test design strategy with a focus on steady state combustion engine calibration The first research topic investigates the question how to handle limits in the input domain during an adaptive test design procedure The second area of scope aims at identifying the test design method providing the best model quality improvement in terms of overall model prediction error To consider restricted areas in the input domain a convex hull based solution involving a convex cone algorithm is developed

the outcome of which serves as a boundary model for a test point search A solution is derived to enable the application of the boundary model to high dimensional problems without calculating the exact convex hull and cones Furthermore different data driven engine modeling methods are compared resulting in the Gaussian process model as the most suitable one for a model based calibration To determine an appropriate test design method for a Gaussian process model application two new strategies are developed and compared to state of the art methods A simulation based study shows the most benefit applying a modified mutual information test design followed by a newly developed relevance based test design with less computational effort The boundary model and the relevance based test design are integrated into a multicriterial test design strategy that is tailored to match the requirements of combustion engine test bench measurements A simulation based study with seven and nine input parameters and four outputs each offered an average model quality improvement of 36 % and an average measured input area volume increase of 65 % compared to a non adaptive space filling test design The multicriterial test design was applied to a test bench measurement with seven inputs for verification Compared to a space filling test design measurement the improvement could be confirmed with an average model quality increase of 17 % over eight outputs and a 34 % larger measured input area Diese Arbeit befasst sich mit der Entwicklung einer modellbasierten adaptiven Versuchsplanungsstrategie für die Anwendung in der Applikation des Stationärverhaltens von Verbrennungsmotoren Der erste Forschungsteil untersucht wie sich Grenzen im Eingangsraum in die Versuchsplanung eines adaptiven Prozesses einbinden lassen Ein weiterer Fokus liegt auf der Identifikation einer modellbasierten Versuchsplanung die eine bestmögliche Verbesserung der globalen Modellqualität hinsichtlich des Prädiktionsfehlers ermöglicht Es wird ein Grenzraummodell auf Basis der konvexen Hülle unter Zuhilfenahme eines Algorithmus zur Bestimmung eines konvexen Konus entwickelt das als Grundlage für eine Versuchsplanung in beschränkten Eingangsräumen verwendet wird Um die Anwendbarkeit bei hochdimensionalen Problemstellungen zu gewährleisten wird ein Verfahren vorgestellt das eine Berechnung auch ohne die Bestimmung der exakten konvexen Hülle und konvexen Kone ermöglicht Des Weiteren werden verschiedene Methoden zur datengetriebenen Modellbildung des Verbrennungsmotors verglichen wobei das Gauß Prozess Modell als die geeignetste Modellierungsmethode hervorgeht Um die bestmögliche Versuchsplanungsmethode bei der Anwendung des Gauß Prozess Modells zu ermitteln werden zwei neue Strategien entwickelt und mit verfügbaren Methoden aus der Literatur verglichen Eine simulationsbasierte Studie zeigt dass eine angepasste Mutual Information Methode die besten Ergebnisse liefert Ein neu entwickeltes relevanzbasiertes Verfahren erreicht die zweitbesten Ergebnisse bietet aber einen geringeren Berechnungsaufwand als das Mutual Information Verfahren Das Grenzmodell und das relevanzbasierte Verfahren werden in einem multikriteriellen Versuchsplanungsverfahren zusammengeführt das an die Anforderungen von Messungen an einem Verbrennungsmotorenprüfstand angepasst ist In einer simulationsbasierten Studie mit sieben bzw neun Eingangsparametern und jeweils vier Ausgängen konnte eine durchschnittliche Modellqualitätsverbesserung von 36 % und eine mittlere Vergrößerung

erung des vermessenen Eingangsraumvolumens von 65 % im Vergleich zu einer nichtadaptiven raumf l lenden Versuchsplanung gezeigt werden Das multikriterielle Versuchsplanungsverfahren wurde anhand von Pr fstandsmessungen mit sieben Eingangsparametern verifiziert Im Vergleich zu einer raumf l lenden Versuchsplanung konnte eine mittlere Modellqualit tsverbesserung ber alle acht Ausg nge von 17 % und ein um 34 % vergr erktes vermessenes Eingangsraumvolumen erreicht werden wodurch die Ergebnisse der Simulationen best tigt werden konnten

**Handbook of Item Response Theory** Wim J. van der Linden, 2016-10-14 Drawing on the work of internationally acclaimed experts in the field Handbook of Item Response Theory Volume One Models presents all major item response models This first volume in a three volume set covers many model developments that have occurred in item response theory IRT during the last 20 years It describes models for different response formats or response processes the need of deeper parameterization due to a multilevel or hierarchical structure of the response data and other extensions and insights In Volume One all chapters have a common format with each chapter focusing on one family of models or modeling approach An introductory section in every chapter includes some history of the model and a motivation of its relevance Subsequent sections present the model more formally treat the estimation of its parameters show how to evaluate its fit to empirical data illustrate the use of the model through an empirical example and discuss further applications and remaining research issues

*Handbook of Item Response Theory, Volume Two* Wim J. van der Linden, 2016-02-22 Drawing on the work of internationally acclaimed experts in the field Handbook of Item Response Theory Volume Two Statistical Tools presents classical and modern statistical tools used in item response theory IRT While IRT heavily depends on the use of statistical tools for handling its models and applications systematic introductions and reviews that emphasize their relevance to IRT are hardly found in the statistical literature This second volume in a three volume set fills this void Volume Two covers common probability distributions the issue of models with both intentional and nuisance parameters the use of information criteria methods for dealing with missing data and model identification issues It also addresses recent developments in parameter estimation and model fit and comparison such as Bayesian approaches specifically Markov chain Monte Carlo MCMC methods

**Technology and Testing** Fritz Drasgow, 2015-08-20 From early answer sheets filled in with number 2 pencils to tests administered by mainframe computers to assessments wholly constructed by computers it is clear that technology is changing the field of educational and psychological measurement The numerous and rapid advances have immediate impact on test creators assessment professionals and those who implement and analyze assessments This comprehensive new volume brings together leading experts on the issues posed by technological applications in testing with chapters on game based assessment testing with simulations video assessment computerized test development large scale test delivery model choice validity and error issues Including an overview of existing literature and ground breaking research each chapter considers the technological practical and ethical considerations of this rapidly changing area Ideal for researchers and professionals in

testing and assessment Technology and Testing provides a critical and in depth look at one of the most pressing topics in educational testing today The Open Access version of this book available at <http://www.taylorfrancis.com> has been made available under a Creative Commons Attribution Non Commercial No Derivatives 4.0 license **Integrating Timing Considerations to Improve Testing Practices** Melissa J. Margolis, Richard A. Feinberg, 2020-06-03 Integrating Timing Considerations to Improve Testing Practices synthesizes a wealth of theory and research on time issues in assessment into actionable advice for test development administration and scoring One of the major advantages of computer based testing is the capability to passively record test taking metadata including how examinees use time and how time affects testing outcomes This has opened many questions for testing administrators Is there a trade off between speed and accuracy in test taking What considerations should influence equitable decisions about extended time accommodations How can test administrators use timing data to balance the costs and resulting validity of tests administered at commercial testing centers In this comprehensive volume experts in the field discuss the impact of timing considerations constraints and policies on valid score interpretations administrative accommodations test construction and examinees experiences and behaviors and how to implement the findings into practice These 12 chapters provide invaluable resources for testing professionals to better understand the inextricable links between effective time allocation and the purposes of high stakes testing The Open Access version of this book available at <http://www.taylorfrancis.com> has been made available under a Creative Commons Attribution Non Commercial No Derivatives 4.0 license **Educational Research and Innovation Teaching as a Knowledge Profession Studying Pedagogical Knowledge across Education Systems** OECD, 2021-10-14 What knowledge do teachers need for 21st century teaching Today teachers have an important role in guiding and shaping students use of digital tools and optimising the educational benefits of their digital experiences **Advancing Methodologies to Support Both Summative and Formative Assessments** Ying Cheng, Hua-Hua Chang, 2014-03-01 Over the past thirty years student assessment has become an increasingly important component of public education A variety of methodologies in testing have been developed to obtain and interpret the wealth of assessment outcomes As assessment goals are getting increasingly multifaceted new testing methodologies are called for to provide more accessible and reliable information on more complex constructs or processes such as students critical thinking and problem solving skills Testing methodologies are needed to extract information from assessments on such complicated skills in order to advise teachers about certain areas of students that need intervention It is even a bigger challenge and a vital mission of today's large scale assessments to gain such information from testing data in an efficient manner For example PARCC and Smarter Balanced Assessments consortia are both striving to offer formative assessments through individualized tailored testing The book provides state of the art coverage on new methodologies to support traditional summative assessment and more importantly for emerging formative assessments **Advising on Research Methods** Hermanus Johannes Adèr, 2008 **Educational**

**Measurement** Craig S. Wells, Molly Faulkner-Bond, 2016-02-26 This book introduces and explores major topics in contemporary educational measurement criterion referenced testing item response theory IRT computer based testing cross lingual and cross cultural assessment and accountability testing Psychometric experts describe forward looking measurement practices and provide a contextualized understanding of how and why they were developed how they can be used and where they may go in the future In addition to presenting key concepts and formulas the volume covers established and emerging applications and discusses recurrent challenges that require additional research A helpful glossary of abbreviations is included The book is grounded in the work of Ronald K Hambleton

**Statistical Methods for the Evaluation of Educational Services and Quality of Products** Paola Monari, Matilde Bini, Domenico Piccolo, Luigi Salmaso, 2009-12-07 The book presents statistical methods and models that can usefully support the evaluation of educational services and quality of products The contributions collected in this book summarize the work of several researchers from the universities of Bologna Firenze Napoli and Padova The contributions are written with a consistent notation and a unified view and concern methodological advances developed mostly with reference to specific problems of evaluation using real data sets The evaluation of educational services as well as the analysis of judgements and preferences poses severe methodological challenges because of the presence of one or more of the following aspects the observational non experimental nature of the context which is associated with the well known problems of selection bias and presence of nuisance factors the hierarchical structure of the data that entails correlated observations and consideration of effects at different levels of the hierarchy and their interactions multilevel analysis the multivariate and qualitative nature of the dependent variable that requires the use of ad hoc statistical methodologies the presence of non observable factors e.g. the satisfaction calling for the use of latent variables models the simultaneous presence of components of pleasure and components of uncertainty in the explication of the judgments that asks for the specification and estimation of mixture models The first part of the book deals with latent variable models

Computerized Multistage Testing Duanli Yan, Alina A. von Davier, Charles Lewis, 2016-04-19 Unlike other forms of adaptive testing multistage testing MST is highly suitable for testing educational achievement because it can be adapted to educational surveys and student testing This volume provides the first unified source of information on the design psychometrics implementation and operational use of MST It shows how to apply theoretical statistical tools to testing in novel and useful ways It also explains how to explicitly tie the assumptions made by each model to observable or at least inferable data conditions

*Research for Practical Issues and Solutions in Computerized Multistage Testing* Duanli Yan, Alina A. von Davier, David J. Weiss, 2024-12-27 This volume presents a comprehensive collection of the latest research findings supporting the current and future implementations and applications of computerized multistage testing MST As a sequel to the widely acclaimed Computerized Multistage Testing Theory and Applications 2014 by Yan von Davier and Lewis this volume delves into the experiences considerations challenges and lessons learned over the past years It also offers

practical approaches and solutions to the issues encountered The topics covered include purposeful MST designs practical approaches for optimal design assembly strategies for accuracy and efficiency hybrid designs MST with natural language processing practical routing considerations and methodologies item calibration and proficiency estimation methods routing and classification accuracy added value of process data prediction and evaluation of MST performance cognitive diagnostic MST differential item functioning robustness of statistical methods simulations test security the new digital large scale Scholastic Aptitude Test software for practical assessment and simulations artificial intelligence impact and the future of adaptive MST This volume is intended for students faculty researchers practitioners and education officers in the fields of educational measurement and evaluation in the United States and internationally *Handbook of International Large-Scale Assessment* Leslie Rutkowski, Matthias von Davier, David Rutkowski, 2013-11-12 Technological and statistical advances along with a strong interest in gathering more information about the state of our educational systems have made it possible to assess more students in more countries more often and in more subject domains The Handbook of International Large Scale Assessment Background Technical Issues and Methods of Data Analysis brings together recognized scholars in the field of ILSA behavioral statistics and policy to develop a detailed guide that goes beyond database user manuals After highlighting the importance of ILSA data to policy and research the book reviews methodological aspects and features of the studies based on operational considerations analytics and reporting The book then describes methods of interest to advanced graduate students researchers and policy analysts who have a good grounding in quantitative methods but who are not necessarily quantitative methodologists In addition it provides a detailed exposition of the technical details behind these assessments including the test design the sampling framework and estimation methods with a focus on how these issues impact analysis choices *Leading-edge Educational Technology* Thomas B. Scott, James I. Livingston, 2008 This new book focuses on the that latest research gains in the field of educational technology which is a creative blending of idea and product technologies with subject matter content in order to engender and improve teaching and learning processes Educational technology is often associated with the terms instructional technology or learning technology Product technologies are tangible for example computer hardware or software Idea technologies are cognitive frameworks or schemes for example the Multiple Intelligence Theory proposed by Howard Gardner When products are thoughtfully blended with subject matter content such as mathematics or science concepts for a specific audience in a specific educational context such as a school one is using educational technology The words educational and technology in the term educational technology have the general meaning Educational technology is not restricted to the education of children nor to the use of high technology *Computer-Based Testing and the Internet* Dave Bartram, Ron Hambleton, 2005-09-27 No topic is more central to innovation and current practice in testing and assessment today than computers and the Internet This timely publication highlights four main themes that define current issues technical advances and applications of computer based



testing Advances in computer based testing new test designs item selection algorithms exposure control issues and methods and new tests that capitalize on the power of computer technology Operational issues systems design test security and legal and ethical matters New and improved uses for tests in employment and credentialing The future of computer based testing identifying potential issues developments major advances and problems to overcome Written by internationally recognized contributors each chapter focuses on issues of control quality security and technology These issues provide the basic structure for the International Test Commission's new Guidelines on Computer Based Testing and Testing on the Internet The contributions to this book have played a key role in the development of these guidelines Computer Based Testing and the Internet is a comprehensive guide for all professionals academics and practitioners working in the fields of education credentialing personnel testing and organizational assessment It will also be of value to students developing expertise in these areas

*Computers and Their Impact on State Assessments* Robert W. Lissitz, Hong Jiao, 2012-05-01 The Race To The Top program strongly advocates the use of computer technology in assessments It dramatically promotes computer based testing linear or adaptive in K 12 state assessment programs Moreover assessment requirements driven by this federal initiative exponentially increase the complexity in assessment design and test development This book provides readers with a review of the history and basics of computer based tests It also offers a macro perspective for designing such assessment systems in the K 12 setting as well as a micro perspective on new challenges such as innovative items scoring of such items cognitive diagnosis and vertical scaling for growth modeling and value added approaches to assessment The editors goal is to provide readers with necessary information to create a smarter computer based testing system by following the advice and experience of experts from education as well as other industries This book is based on a conference <http://marces.org/workshop.htm> held by the Maryland Assessment Research Center for Education Success It presents multiple perspectives including test vendors and state departments of education in designing and implementing a computer based test in the K 12 setting The design and implementation of such a system requires deliberate planning and thorough considerations The advice and experiences presented in this book serve as a guide to practitioners and as a good source of information for quality control The technical issues discussed in this book are relatively new and unique to K 12 large scale computer based testing programs especially due to the recent federal policy Several chapters provide possible solutions to psychometricians dealing with the technical challenges related to innovative items cognitive diagnosis and growth modeling in computer based linear or adaptive tests in the K 12 setting

*Handbook of Human and Social Conditions in Assessment* Gavin T. L. Brown, Lois R. Harris, 2016-06-23 The Handbook of Human and Social Conditions in Assessment is the first book to explore assessment issues and opportunities occurring due to the real world of human cultural historical and societal influences upon assessment practices policies and statistical modeling With chapters written by experts in the field this book engages with numerous forms of assessment from classroom level formative assessment practices to national accountability and

international comparative testing practices all of which are significantly influenced by social and cultural conditions A unique and timely contribution to the field of Educational Psychology the Handbook of Human and Social Conditions in Assessment is written for researchers educators and policy makers interested in how social and human complexity affect assessment at all levels of learning Organized into four sections this volume examines assessment in relation to teachers students classroom conditions and cultural factors Each section is comprised of a series of chapters followed by a discussant chapter that synthesizes key ideas and offers directions for future research Taken together the chapters in this volume demonstrate that teachers test creators and policy makers must account for the human and social conditions that shape assessment if they are to implement successful assessment practices which accomplish their intended outcomes

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