

Contents

1	Classical Test Theory	1
1.1	Classical True Score Model.....	1
1.2	Reliability	3
1.2.1	Cronbach's α	3
1.2.2	Other Reliability Coefficients	6
1.3	Generalizability Theory	7
1.3.1	Reliability and Generalizability	8
1.3.2	Multiple Sources of Error	10
	References	14
2	Factor Analysis	17
2.1	Correlation Coefficients	17
2.2	Exploratory Factor Analysis	23
2.2.1	EFA Model Formulation and Computation	23
2.2.2	Factor Rotation and Interpretation	26
2.2.3	Factor Scores	29
2.2.4	Determining the Number of Factors	30
2.3	Bayesian Exploratory Factor Analysis	35
2.4	Confirmatory Factor Analysis	39
2.4.1	CFA Model Formulation and Computation	40
2.4.2	Higher-Order CFA Models	45
2.4.3	CFA with Covariates: MIMIC	47
2.4.4	Multigroup CFA	48
2.4.5	Longitudinal CFA	52
2.4.6	Multilevel CFA	55
2.5	Bayesian Confirmatory Factor Analysis	57
	References	60
3	Path Analysis and Structural Equation Models	63
3.1	Multivariate Regression as Path Model	63
3.2	Moderator and Mediator Models	66
3.2.1	Moderator Models	67

3.2.2	Mediator Models.....	70
3.2.3	Combined Moderator-Mediator Models.....	73
3.3	Structural Equation Models	76
3.3.1	SEM Model Formulation and Computation	76
3.3.2	Multigroup SEM.....	79
3.3.3	Remarks on SEM Extensions	81
3.4	Latent Growth Models	82
3.4.1	Simple Latent Growth Modeling	82
3.4.2	Extended Latent Growth Modeling	86
	References.....	91
4	Item Response Theory	95
4.1	Introductory Remarks and Dimensionality Assessment.....	95
4.1.1	Classification of IRT Models.....	95
4.1.2	Assessing Dimensionality	95
4.2	Unidimensional Dichotomous IRT Models	98
4.2.1	The Rasch Model	98
4.2.2	Two-Parameter Logistic Model	105
4.2.3	Three-Parameter Logistic Model	109
4.3	Unidimensional Polytomous IRT Models	110
4.3.1	Rating Scale Model.....	111
4.3.2	Partial Credit Model and Generalizations	116
4.3.3	Graded Response Model	119
4.3.4	Nominal Response Model	121
4.4	Item and Test Information	123
4.5	IRT Sample Size Determination	126
4.6	Differential Item Functioning.....	131
4.6.1	Logistic Regression DIF Detection	131
4.6.2	Tree-Based DIF Detection	134
4.7	Multidimensional IRT Models	136
4.7.1	IRT and Factor Analysis.....	137
4.7.2	Exploratory Multidimensional IRT	138
4.7.3	Confirmatory Multidimensional IRT	143
4.8	Longitudinal IRT Models	145
4.8.1	Linear Logistic Models for Measuring Change	145
4.8.2	Two-Tier Approach to Longitudinal IRT	148
4.8.3	Latent Growth IRT Models.....	151
4.9	Bayesian IRT	152
4.9.1	Bayesian 2-PL Estimation.....	152
4.9.2	Dynamic 2-PL Model	155
	References.....	157
5	Preference Modeling	161
5.1	Models for Paired Comparisons	161
5.1.1	Bradley-Terry Model	162
5.1.2	Bradley-Terry Trees	163

Contents

	5.1.3 Bradley-Terry Lasso	164
5.2	Log-Linear Models for Preference	168
	5.2.1 Pattern Model for Ratings	169
	5.2.2 Pattern Model for Paired Comparisons	172
	5.2.3 Pattern Model for Rankings	173
5.3	Other Methods for Preference Data	175
	References.....	176
6	Principal Component Analysis and Extensions	179
6.1	Principal Component Analysis	179
	6.1.1 Singular Value and Eigenvalue Decomposition	179
	6.1.2 PCA Computation	183
	6.1.3 PCA Application and Practical Issues	187
6.2	Some PCA Variants	192
6.3	Three-Way Principal Component Analysis	194
	6.3.1 Parafac	195
	6.3.2 Tucker	198
6.4	Independent Component Analysis.....	201
	6.4.1 ICA Formulation.....	201
	6.4.2 Example: ICA on EEG Data	202
	References.....	208
7	Correspondence Analysis	211
7.1	Simple Correspondence Analysis	211
	7.1.1 Profiles, Masses, Inertia	211
	7.1.2 Simple CA Computation and Interpretation.....	218
	7.1.3 Example: Harvard Psychology Faculty	222
7.2	Multiple Correspondence Analysis	223
7.3	Configural Frequency Analysis.....	225
	7.3.1 Two-Dimensional Tables	226
	7.3.2 Higher-Dimensional Tables	228
	References.....	229
8	Gifi Methods	231
8.1	Setting the Stage.....	231
	8.1.1 Optimal Scaling: Measurement Levels as Functions	231
	8.1.2 Gifi Theory	233
8.2	Princals	235
	8.2.1 Mimicking PCA with Princals	236
	8.2.2 Princals on Ordinal Data	238
	8.2.3 Princals on Mixed Input Data	241
8.3	Homals	244
	8.3.1 Multiple Correspondence Analysis Using Homals	244
	8.3.2 Homals on Mixed Input Data	246
	8.3.3 Combined Homals-Princals Strategies	247
8.4	Lineals for CFA/SEM Preprocessing.....	252
	References.....	255

9 Multidimensional Scaling	257
9.1 Proximities	257
9.2 Exploratory MDS	258
9.2.1 SMACOF Theory	259
9.2.2 Exploratory MDS Example: PTSD Symptoms	260
9.2.3 Goodness of Fit in MDS	262
9.3 Confirmatory MDS	269
9.3.1 MDS with External Constraints	270
9.3.2 MDS with Internal Constraints: Spherical SMACOF	274
9.4 Unfolding	276
9.4.1 Data Structure for Unfolding	276
9.4.2 Rectangular SMACOF: Theory	277
9.4.3 Unfolding Example: Personal Values	278
9.5 MDS Extensions and Related Models	280
9.5.1 Procrustes	280
9.5.2 Individual Differences Scaling	283
References	285
10 Biplots	289
10.1 Variable Space and Subject Space Representation	289
10.2 Regression Biplots	291
10.3 Principal Component Analysis Biplots	296
10.4 Multidimensional Scaling Biplots	305
10.5 Correspondence Analysis Biplots	306
References	311
11 Networks	313
11.1 Network Basics: Relational Data Structures	313
11.2 Correlation Networks	314
11.3 Latent Network Models	319
11.3.1 Eigenmodels	320
11.3.2 Latent Class Network Models	321
11.4 Bayesian Networks	326
11.4.1 Directed Acyclic Graphs	326
11.4.2 Bayesian Networks Taxonomy	327
11.4.3 Bayesian Network Depression/OCD Data	328
References	333
12 Parametric Cluster Analysis and Mixture Regression	335
12.1 Model-Based Clustering Approaches: Mixture Models	335
12.1.1 Normal Mixture Models	336
12.1.2 Latent Class Analysis	340
12.1.3 Parametric Clustering with Mixed Scale Levels	344
12.1.4 Concomitant Variables	346
12.2 Mixture Regression Models	349
12.2.1 Mixture Regression Theory	349
12.2.2 Mixture Regression Applications	350

Contents

	Dirichlet-Based Clustering.....	354
12.3	12.3.1 Dirichlet Process Regression.....	355
	12.3.2 Clustering Texts: Topic Models	356
	References.....	363
13	Modeling Trajectories and Time Series	365
13.1	Introductory Remarks	365
13.2	Hidden Markov Models	365
	13.2.1 Markov Chains.....	366
	13.2.2 Simple Hidden Markov Modeling Strategies.....	369
	13.2.3 Hidden Markov Models with Covariates	374
13.3	Time Series Analysis.....	379
	13.3.1 Linear Models and Structural Change Detection.....	379
	13.3.2 ARIMA Models	383
	13.3.3 Time Series with Covariates: Intervention Analysis	392
13.4	Functional Data Analysis	394
	13.4.1 Smoothing Curves and Derivatives	395
	13.4.2 FDA Descriptives and Bootstrap.....	397
	13.4.3 Functional ANOVA and Regression Modeling.....	399
	13.4.4 Functional Principal Component Analysis	402
	References.....	405
14	Analysis of fMRI Data	409
14.1	fMRI Data Manipulation in R	409
	14.1.1 fMRI Data Structures.....	409
	14.1.2 fMRI Preprocessing	411
	14.1.3 Registration and Regions of Interest.....	414
14.2	Linear Modeling of fMRI Data	419
	14.2.1 The Correlational Approach	419
	14.2.2 Design Matrix.....	421
	14.2.3 Fitting the Linear Model	423
	14.2.4 Example: Neural Representation of Mental States.....	424
	14.2.5 Group Analysis	430
14.3	Multiple Comparisons in fMRI.....	431
	14.3.1 Controlling for the FDR	433
	14.3.2 Gaussian Random Fields	433
	14.3.3 Permutation Tests	434
14.4	Independent Component Analysis in fMRI	437
14.5	Representational Similarity Analysis.....	440
14.6	Functional Connectivity Analysis	442
	14.6.1 Seed-Based Correlational Analysis	443
	14.6.2 Wavelet Correlational Analysis	445
14.7	Conclusion and Outlook	446
	References.....	448
Index	451