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Committee II

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Materials

Preliminary title.

Methodological Implications and Analysis of Categorical Data in the Field of Social and Cognitive Development

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Table 1: Taxonomy of models for qualitative data*

I. Latent Attribute Models	
1. Latent structure models	- Lazarsfeld & Henry (1968)
Latent class model	- Goodman (1974)
Latent class with response error	- Dayton & MacReady (1980)
2. Scalability models	
Scalogram analysis	- Guttman (1950)
Probabilistic scale analysis	- Proctor (1970)
Multiple scale analysis	- Mokken (1971)
Bi- and Multiform scales	- Goodman (1975)
Probabilistic validation	- Dayton & MacReady (1976)
Order analysis	- Krus et al. (1976)
Scaling of order hypothesis	- Davison (1979, 1980)
Probabilistic unfolding	- Coombs & Smith (1973)
Quasi Independence model	- Goodman (1975)
...	
Latent trait models	
Rasch model	- Rasch (1966); Fischer (1974)
Normative ogive model	- Lord & Novick (1968)
Three parametric logistic model	- Birnbaum (1968)
Logistic change model	- Fischer (1976)
...	
4. Factor analysis models	
FA for dichotomous variables	- Muthen (1978); Christoffersson (1975)
Monotonicity analysis	- Bentler (1970)
II. Prediction Models	
1. Dichotomous regression model	
Logit model	- Grizzle, Starmer & Koch (1969)
2. Structural equation models	
Lisrel V	- Jöreskog & Sörbom (1981)
PLS	- Wold (1979)
3. Cross-classification with errors models	
Prediction analysis	- Hildebrand et al. (1977)
Fitting cross-classification	- Thomas (1977)
Matching model	- Hubert (1979)
4. Multidimensional contingency table with Partial Least Squares (PLS)	- Wold & Bertholet (1983)

Table 1 (continued):

III. Multinomial Response Models

1. Log-linear model	- Goodman (1972); Bishop et al. (1975); Haberman (1978/79)
2. Analysis of correspondence	- Benzécri (1973); Linder & Berchtold (1982)
3. Dual scaling for categorial data	- Nishisato (1980)

*Note: This taxonomy of models was initiated by Bentler (1980) and has been expanded by the present authors.

Table 6: Analysis of longitudinal samples by the Dayton & MacReady model. (Table entries are probabilities for model fit)

		Models		
Grade:	Sample:	Guttman-structure	Model A	Model B
1	2.1	< .005	.005	.000
2	2.2	< .005	< .005	.30**
3	2.3	< .005	.23**	.25**
4	2.4	< .005	< .005	.17**

**Fit

Table 7: Multiple contingency table. Cell entries are frequencies of observed pattern. This table serves as input data for the analysis with log-linear model (frequencies in brackets are set as structural zeros for quasi-independence model) and the Prediction analysis by Hildebrand et al. (1977). (Frequencies in brackets are substantive cells, the other ones are error cells)

Phases during/after pregnancy

Phases before pregnancy	(..00)	(..10)	(..01)	(..11)
(00..)	(1)	1	0	(2)
(01..)	0	0	0	0
(10..)	(5)	1	1	3
(11..)	(4)	(10)	2	(15)

Table 8: Models and results of hypothetical structures tested for independence by log-linear models (Option: Quasi-independence model)

Model	Patterns as structural zeros	Chi^2	df	p
1	0000; 1111 Concept-attainment-model)	15.99	9	.07
2	0000; 1000; 1100; 1110; 1111; (Guttman-structure)	6.02	6	.42**
3	as model 2 but including pattern 0011	4.20	5	.52**

** substantial fit

Table 9: Taxonomy and formal integration of several scaling models (also see table 1 for comparison)

Basic-Model: $p(u_h) = \sum_{t=1}^{s} \{ \prod_{i=1}^{n} (\alpha_{ijt}) \quad \theta_t \}$

Guttman-Model: $\alpha_{ijt} = 0 \text{ or } 1$

Proctor-Model: $\alpha_{ijt} = \beta^{x_{th}} (1 - \beta)^{n-x_{th}}$

Dayton & MacReady-Model: $\alpha_{ijt} = \beta_g^{x_{th}} (1-\beta_g)^{m_t - x_{th}} \beta_f^{y_{th}} (1-\beta_f)^{n-m_t-y_{th}}$

Goodman's Q.I.-Model: $(\alpha_{ijt}) = (\sum_{t=1}^{s} I_{ht}\theta_t + \theta_0 \prod_{i=1}^{n} \alpha_{ijt})$

Rasch-Model: $\alpha_{ijt} = \frac{\exp(\theta-\beta_i)}{1 + \exp(\theta-\beta_i)}$

Mokken-Model: $\alpha_{ijt} = f_{monton}(\theta,\beta)$

Log-Linear Model: $p(u_h) = \mu_{ij} = \gamma_{ij}^{12} \gamma_i^1 \gamma_j^2 \gamma^0$ (for 2 by 2 tabl.)

or: $\ln \mu_{ij} = \theta_{ij}^{12} + \theta_i^1 + \theta_j^2 + \theta^0$

u_h - the observed response pattern

v_t - the expected (theoretical, "a priori") resp. pattern

$\alpha_{ijt} = p(u_h/v_t)$ - the recruitment probability

$i = 1....n$ - the items

$j = 1....k$ - the response alternatives

$t = 1....s$ - the latent classes

β_g - the "guessing" parameter

β_f - the "forgetting" parameter

m_t - number of zero codes in v_t

x_{th} - number of "1" codes in u_h, when expecting "0" in v_t

y_{th} - number of "0" codes in u_h, when expecting "1" in v_t

θ - latent variable; subject parameter in RASCH-Model

β_i - latent itemparameter

I_{ht} - indication-parameter: 1, if $u_h = v_t$ and 0, if $u_h \neq v_t$

Figure 1 a/b: Examples of a "uniform-" and "biform-scale".

(a)

Item :			
1	2	3	4
(1	1	1	1)
(1	1	1	0)
(1	1	0	0)
(1	0	0	0)
(0	0	0	0)

(b)

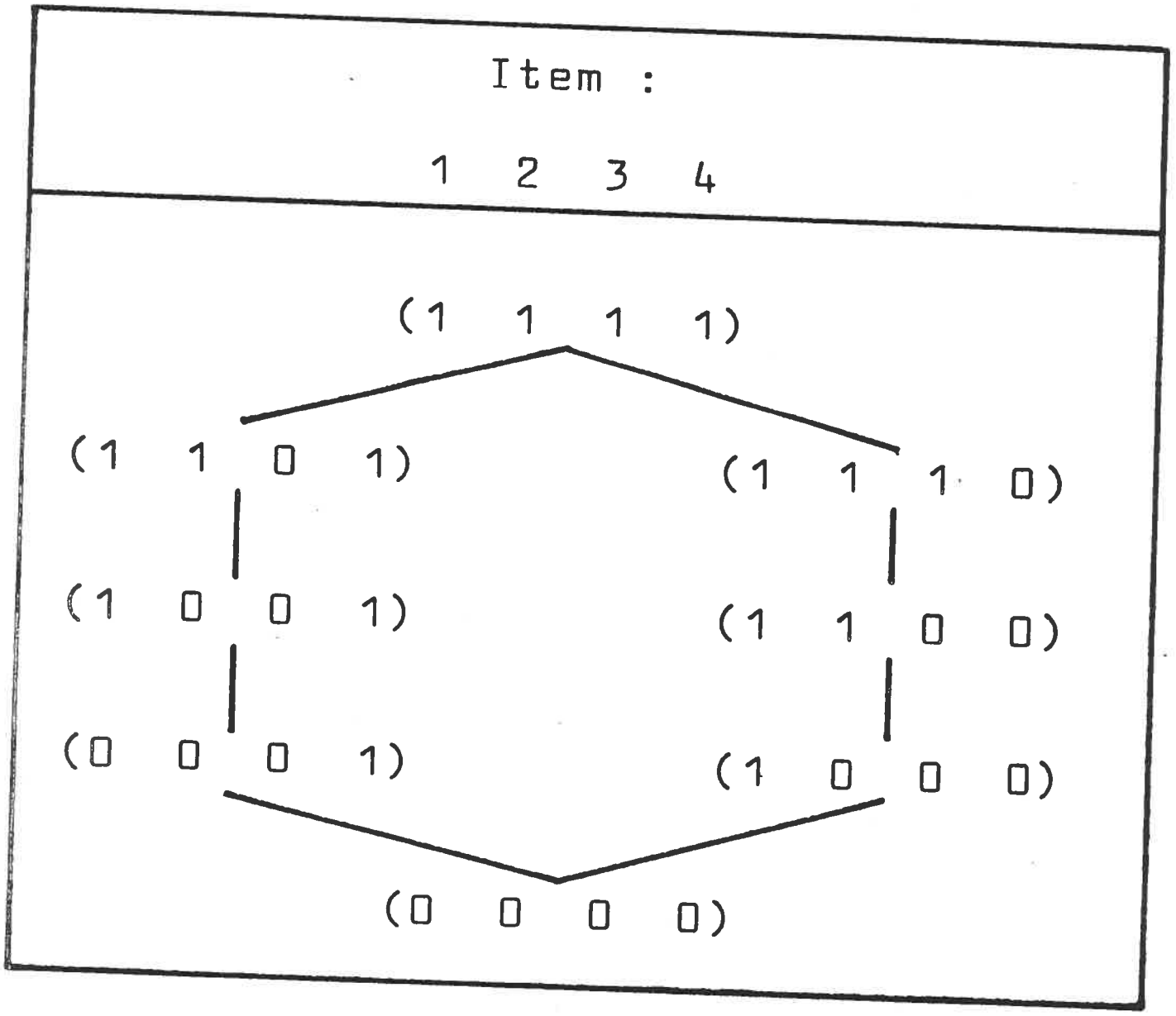


Figure 1 c/d: Examples of "multiform-scales"

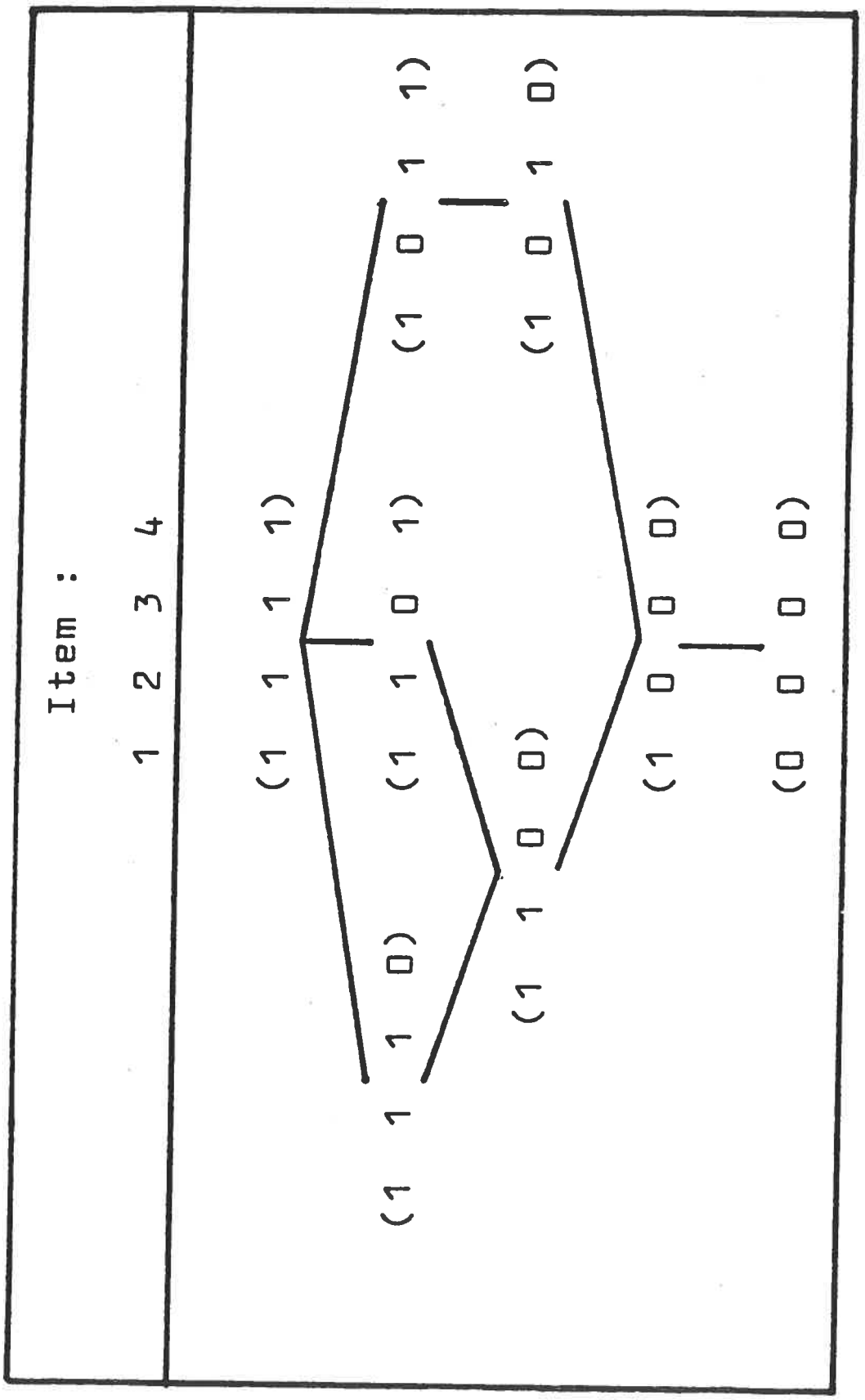


Figure 1 c/d: Examples of "multiform-scales".

(d)

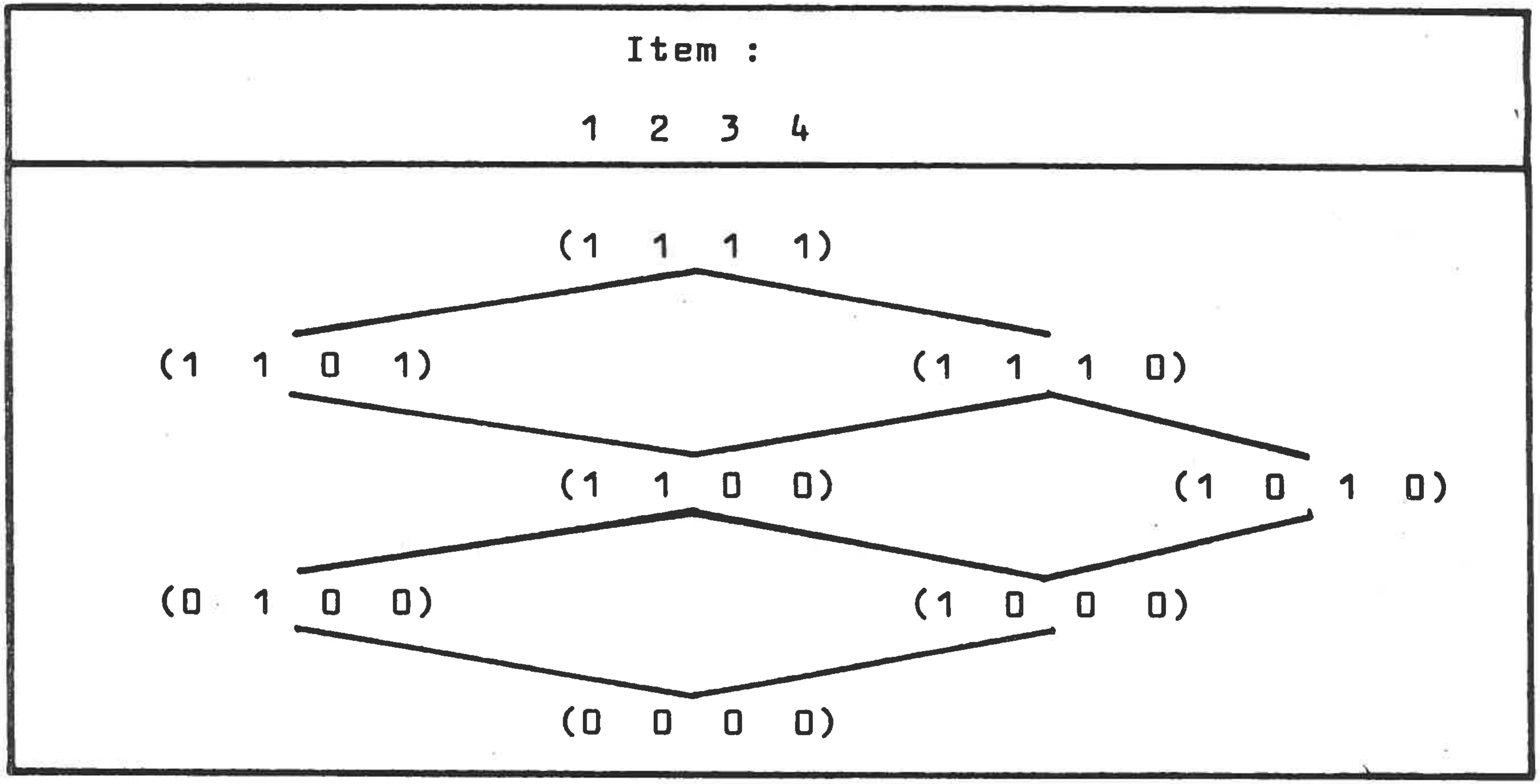


Figure 1e: Example of a symmetric diamond structure (see Shye, 1978, p. 274)

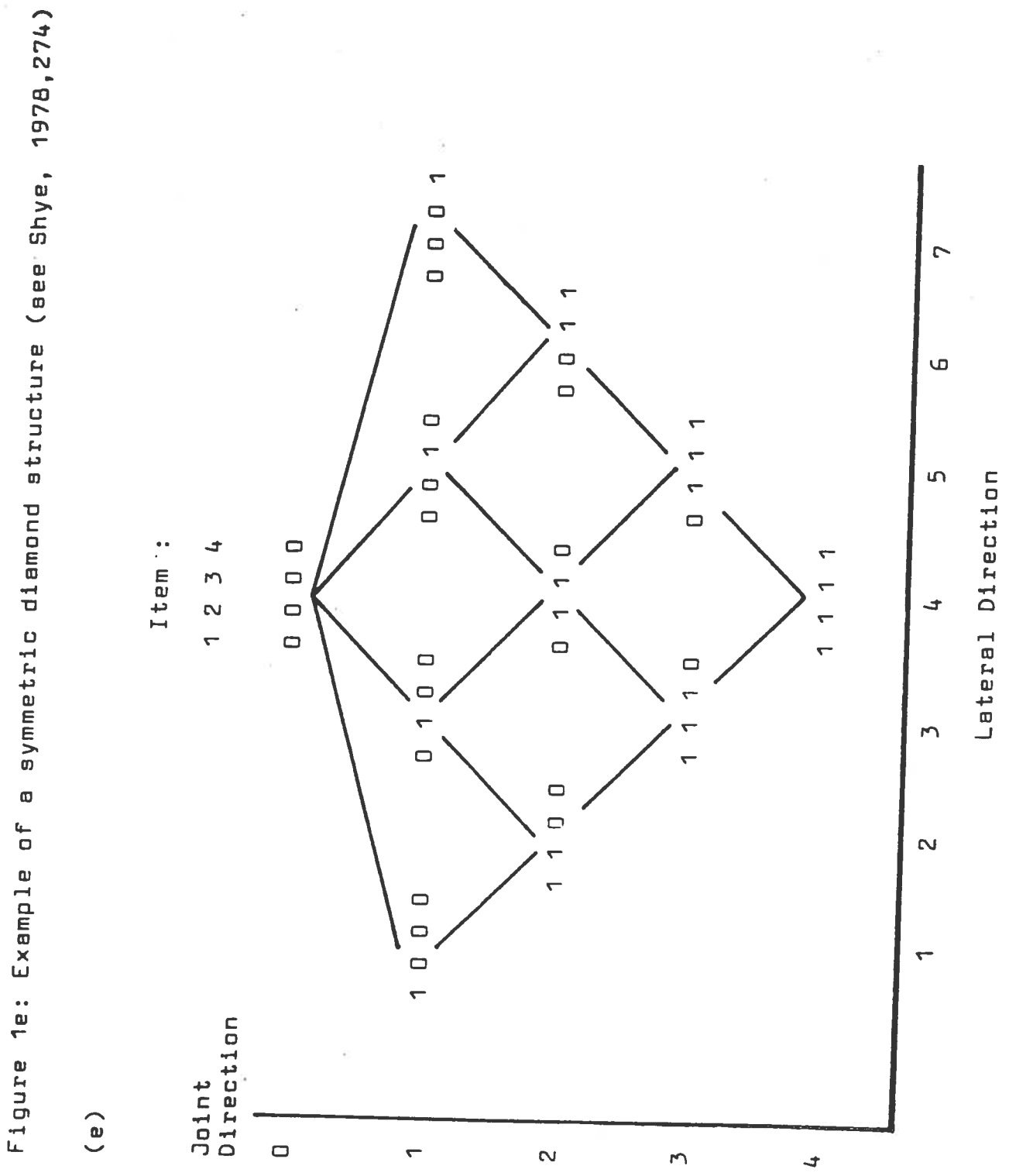
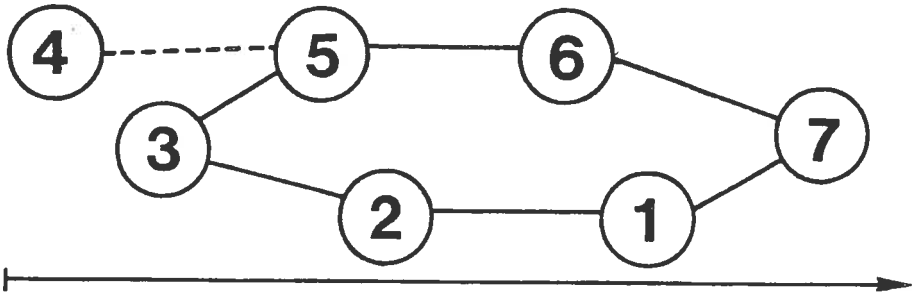


Figure 2: a) Model of a "cognitive-two-way-process"



Hypothetical task structure for the 7 tasks groups based on sample 2.1 - 2.4 and 3, derived from empirical results with Mokken-scaling, Dayton & MacReady analysis and Krus-Order-Analysis.

Model of a "cognitive-two-way-process"

Figure 2: b) Investigated samples for invariance tasks groups

Sample 2.1:	N = 45	children	primary school	age 5.8 - 7.1
Sample 2.2:	N = 45	"	"	" age 15 months later
Sample 2.3:	N = 45	"	"	" age 3rd grade
Sample 2.4:	N = 45	"	"	" age 4th grade
Sample 3 :	N = 34	children	"Montessori-school"	3rd grade
Sample 4 :	N = 203 (116+87)	children	age 4-7 (Table 3)	

Figure 2: c) Analyzed model structures for sample 4 (N = 203)

(2c)

Analyzed models for sample 4 (N = 203)	
	Item: 3 2 1 5 6
Concept- Attainement Model	0 0 0 0 0 1 1 1 1 1
Guttman-Structure	0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 1 1 1 0 0 1 1 1 1 0 1 1 1 1 1
Reduced-Two-Way-Biform-Model	0 0 0 0 0 1 0 0 0 0 1 1 0 0 0 1 1 1 0 0 1 0 0 1 0 1 0 0 1 1 1 1 1 1 1
Diamond-Structure Model	0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 1 1 0 0 0 0 0 1 0 0 0 1 1 0 0 1 1 1 0 0 0 0 0 1 0 0 0 1 1 0 0 1 1 1 0 1 1 1 1 0 0 0 0 0 1 0 0 0 1 1 0 0 1 1 1 0 1 1 1 1 1 1 1 1 1

Figure 2: d) Analyzed model structures for longitudinal sample (N = 45)

(2d)

Analyzed models for longitudinal samples 2.1 to 2.4 (N = 45)

No. of possible patterns: 64
No. of observed patterns: 12

Guttman-Structure

Item:	1	2	3	5	6	7
	0	0	0	0	0	0
	0	0	1	0	0	0
	0	0	1	1	0	0
	0	1	1	1	0	0
	0	1	1	1	1	0
	1	1	1	1	1	1

Biform-Structure

Item:	1	2	3	5	6	7
	0	0	0	0	0	0
	0	0	1	0	0	0
	0	1	1	0	0	0
	1	1	1	0	0	0
	1	1	1	0	0	1
	0	0	1	1	0	0
	0	0	1	1	1	1
	1	1	1	1	1	1

Biform-Structure with patterns ommitting task 3

Item:	1	2	3	5	6	7
	0	0	0	0	0	0
	0	0	1	0	0	0
	0	1	1	0	0	0
	1	1	1	0	0	0
	1	1	1	0	0	1
	0	0	1	1	0	0
	0	0	1	1	1	1
	1	1	1	1	1	1
	0	1	0	1	1	1
	1	1	0	1	1	1

Figure 3: Design for "aggregated group development"

Dependent variable: True patterns in terms of a hypothetical structure		Independent variable: times of measurement T_1	T_2	T_3
(1)	0000	33	5	0
(2)	1000	21	25	14
(3)	1100 or 1010	3	10	24
(4)	1110	0	10	9
(5)	1111	0	4	5
(6)	Residual patterns	2	5	6
	Total N:	59	59	59

DEL = -0.02 Variance-DEL = 0.00176

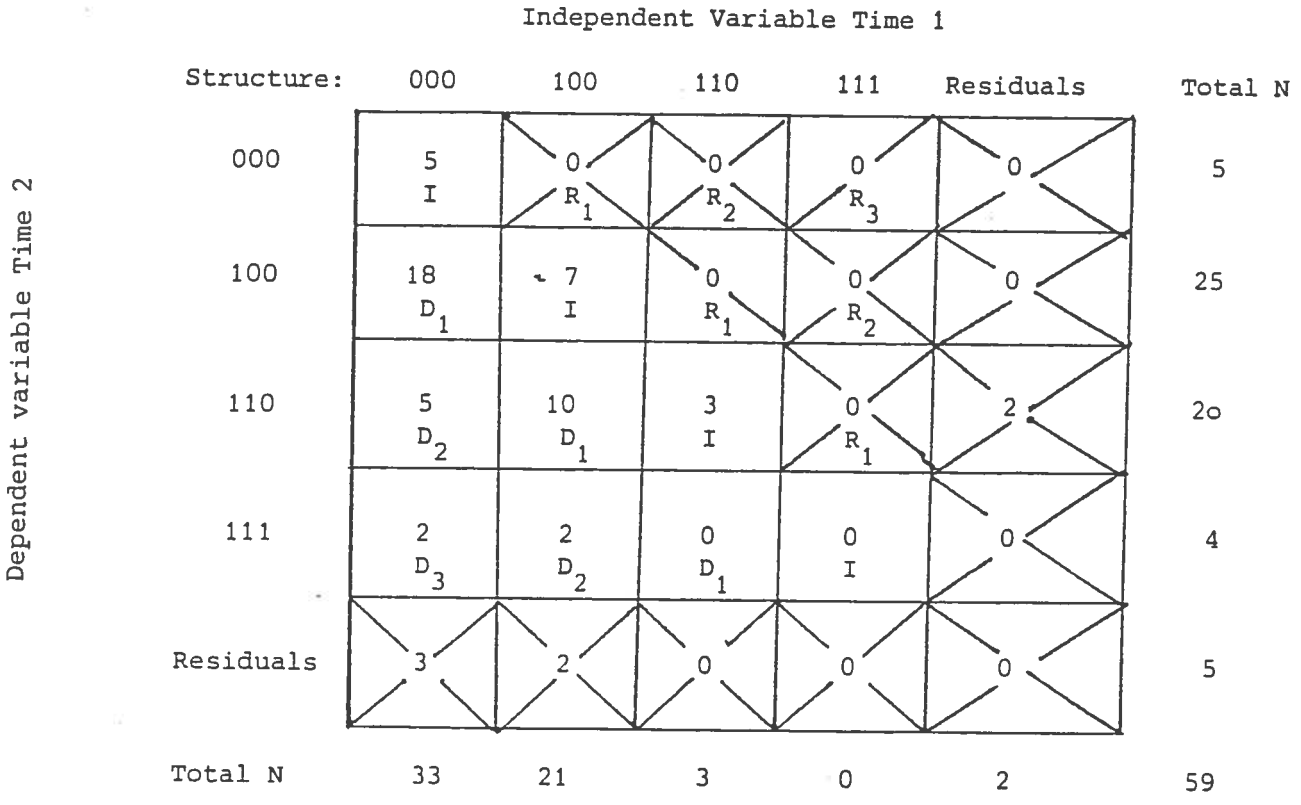
N = 176

Z = -0.52 p = 0.698

Rule Unknown = 0.656

Rule Known = 0.670

Figure 4: Design assessing "individual development"



DEL = 0.31 Variance-DEL = 0.0154

N = 59

Z = 2.49 p = .006

Rule Unknown = 0.172

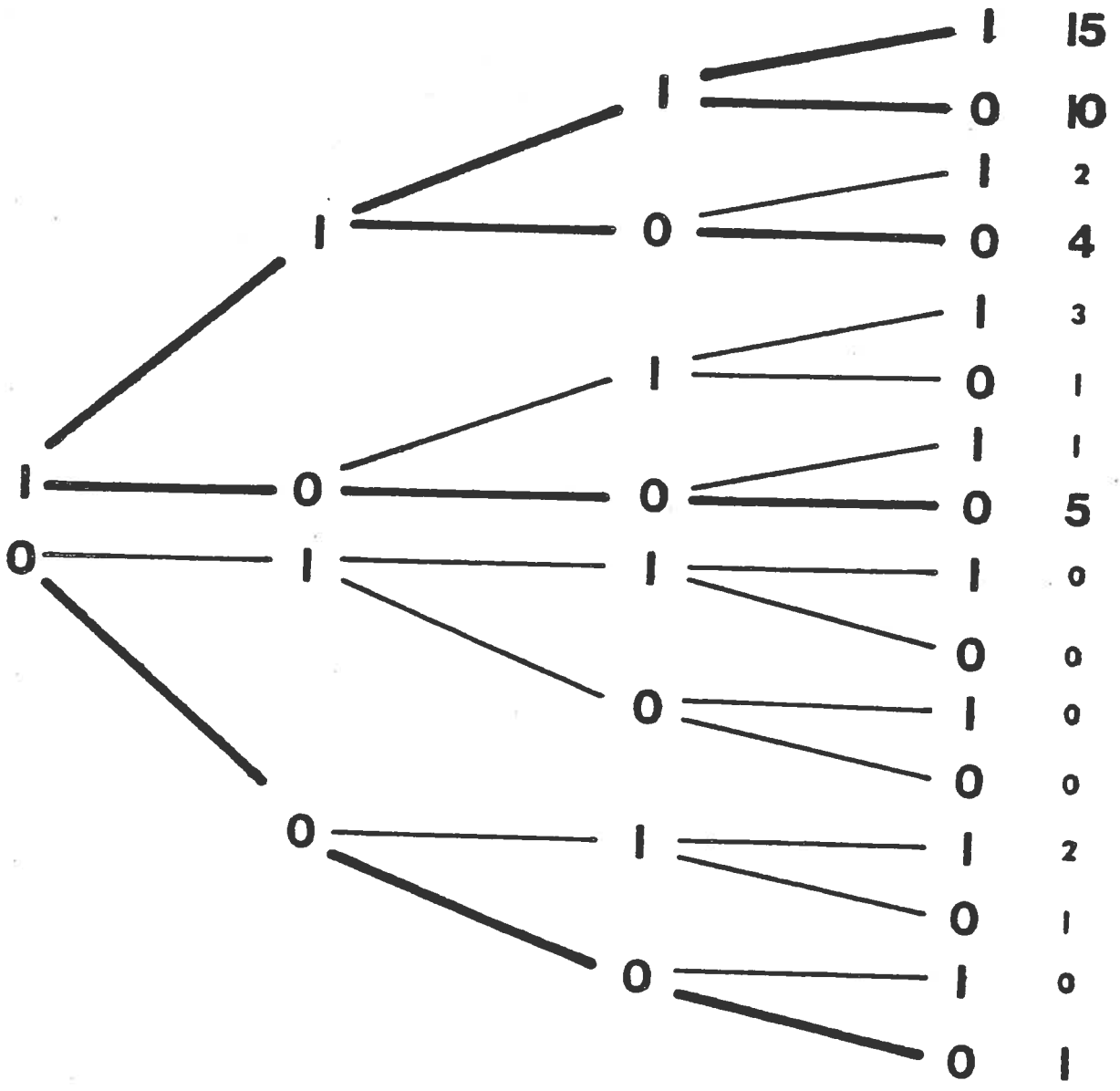
Rule Known = 0.119

I: Identity

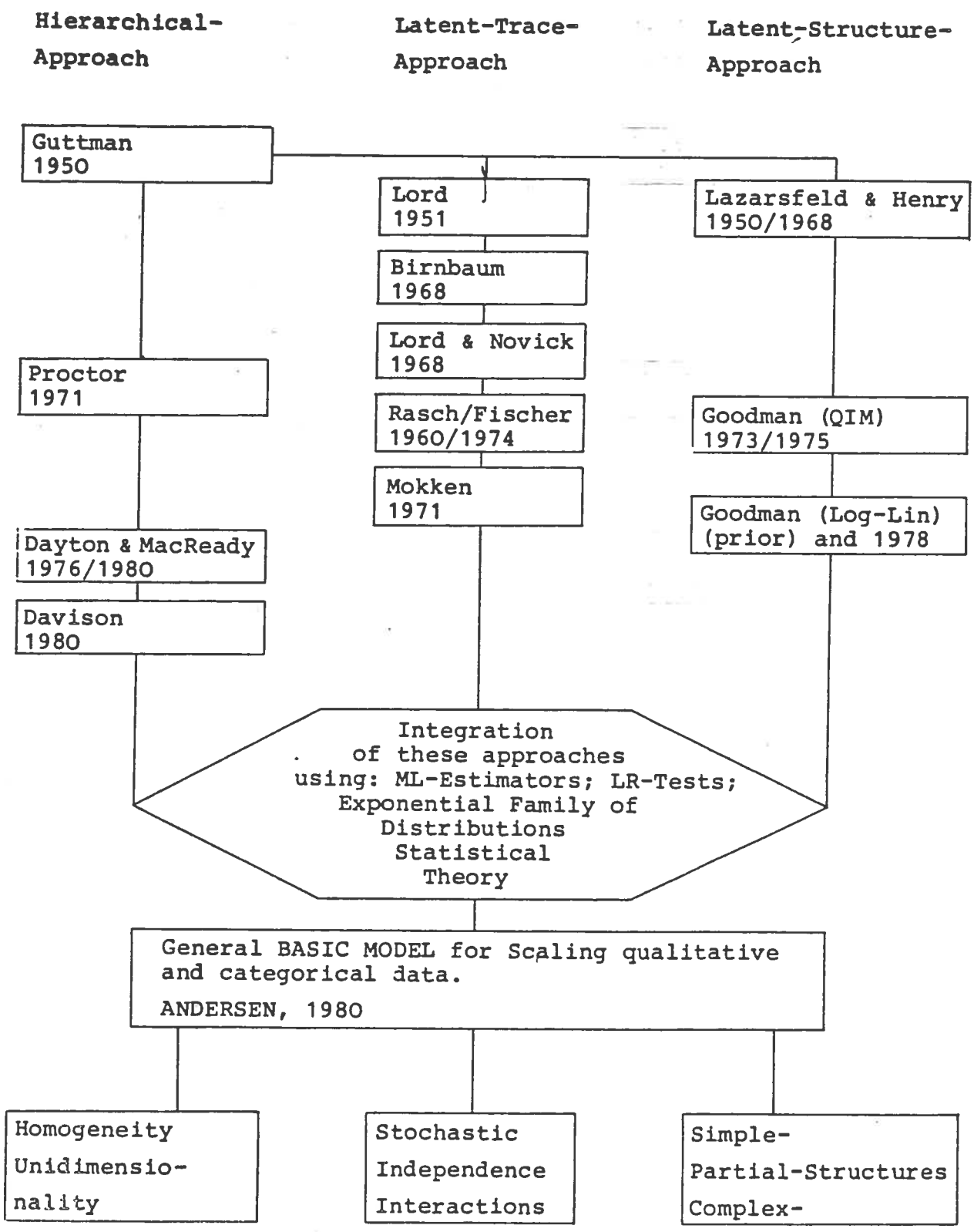
R_i: stage of regression

D_i: stage of development

~~for figure 5 (p. 45) see next page~~



Figur 8: Sources and traditions of scaling and latent structure models



Fields of methodological applications