

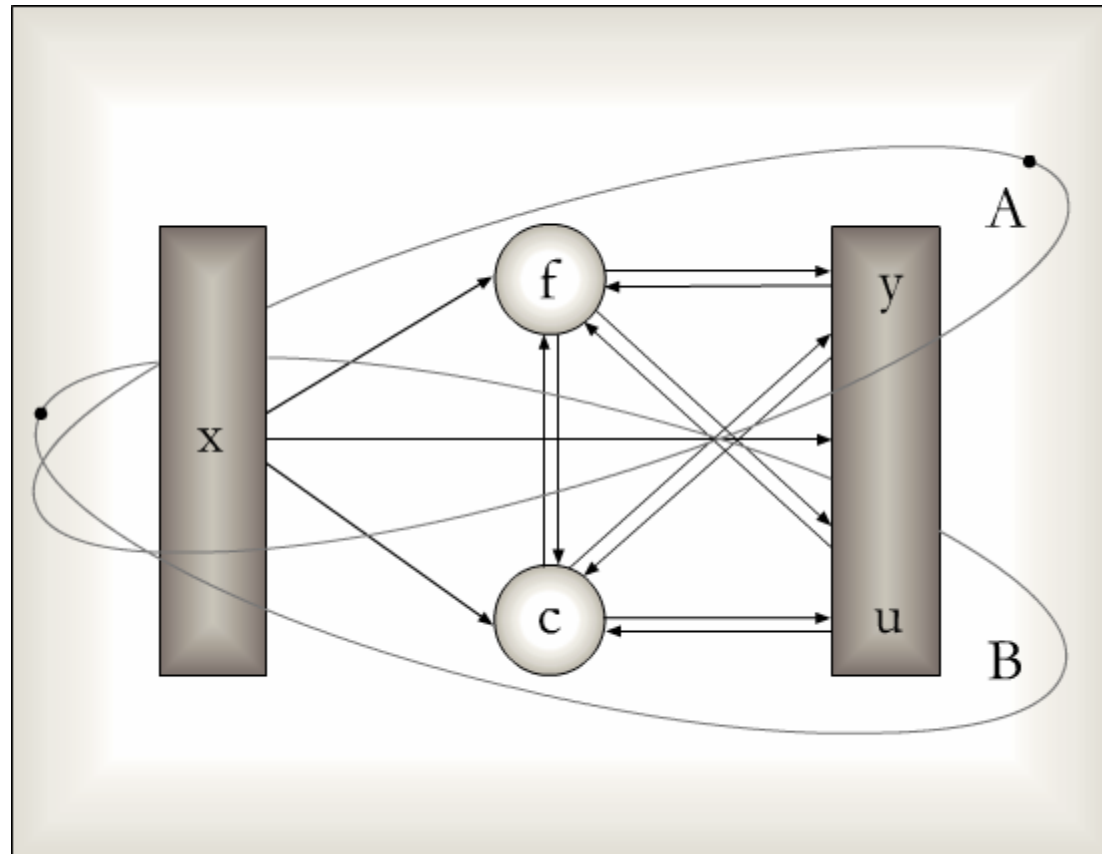
New Latent Variable Methods

Bengt Muthén
bmuthen@ucla.edu

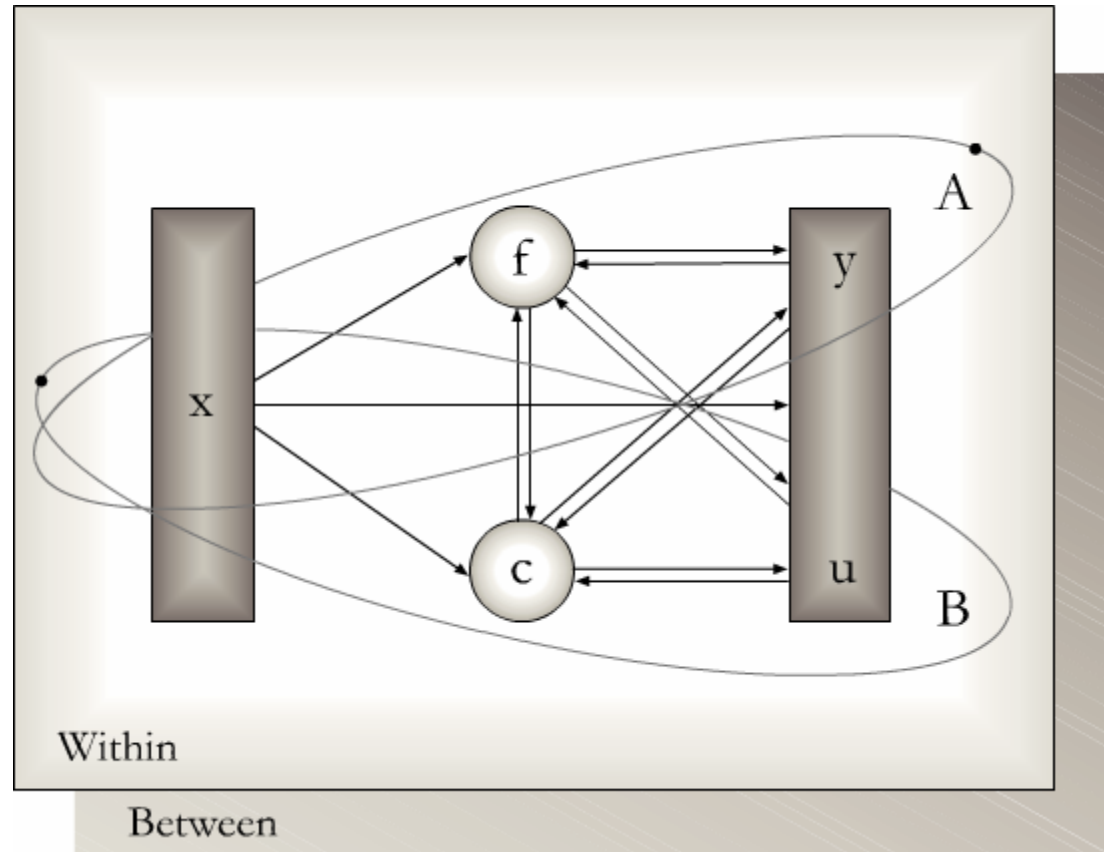
To Learn More

- Watch the movie at
Mplus Web Seminars: www.statmodel.com
- Attend the Thursday workshop

General Latent Variable Modeling Framework



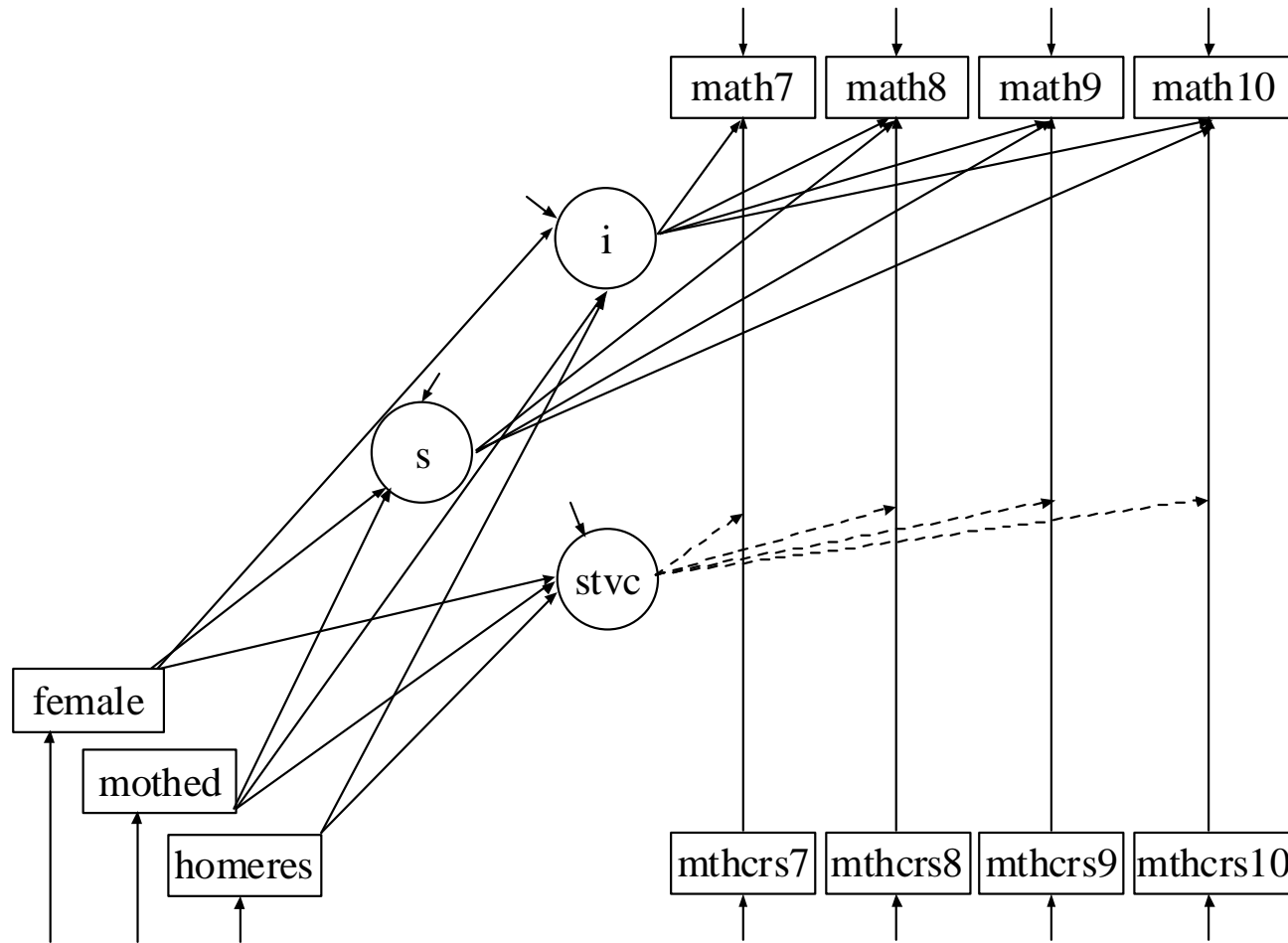
General Latent Variable Modeling Framework



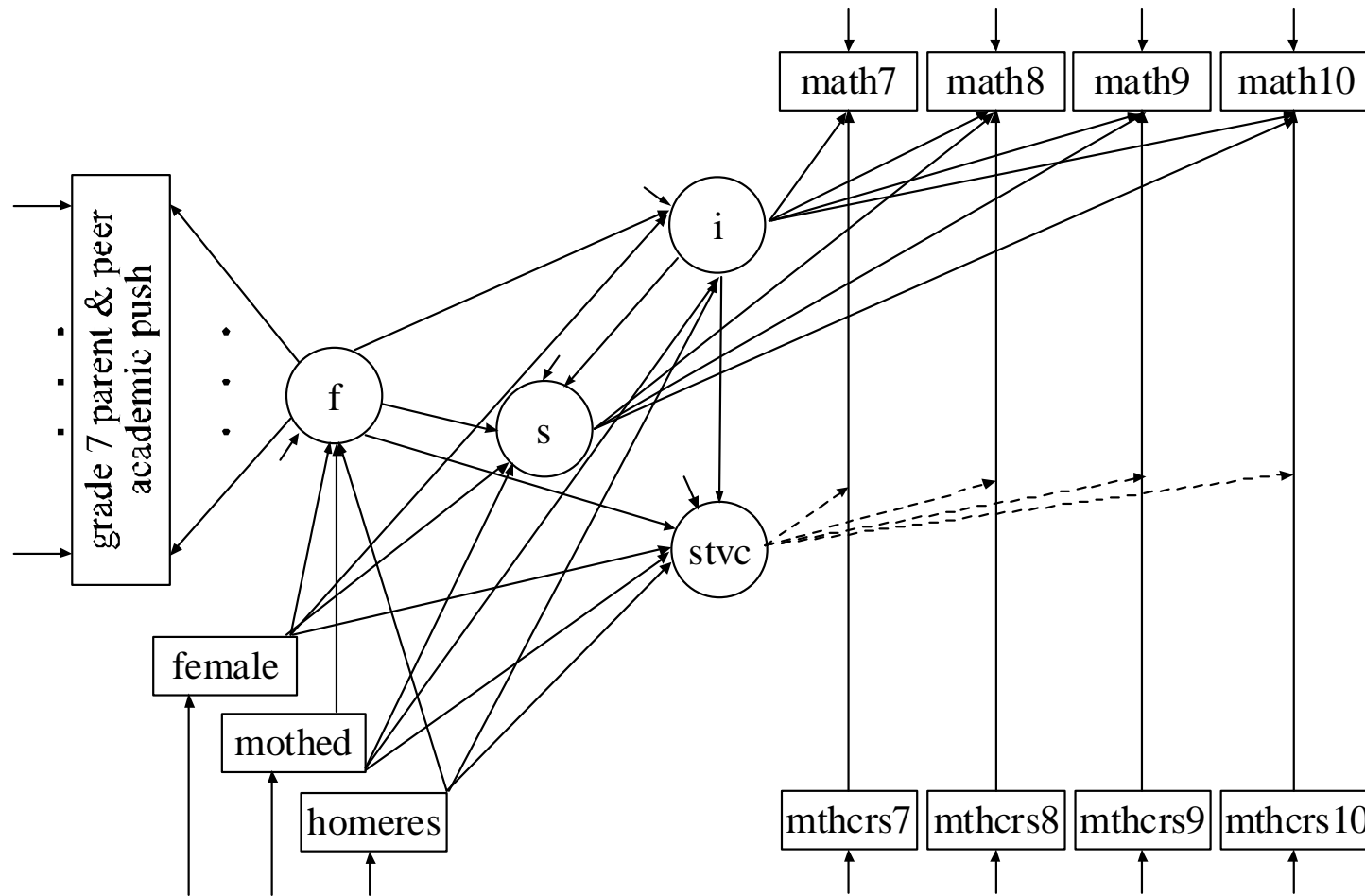
General Latent Variable Modeling Framework

- Muthén, B. (2002). Beyond SEM: General latent variable modeling. *Behaviormetrika*, 29, 81-117
- Asparouhov & Muthen (2004). Maximum-likelihood estimation in general latent variable modeling
- Muthen & Muthen (1998-2004). Mplus Version 3
- Mplus team: Linda Muthen, Bengt Muthen, Tihomir Asparouhov, Thuy Nguyen, Michelle Conn
(see www.statmodel.com)

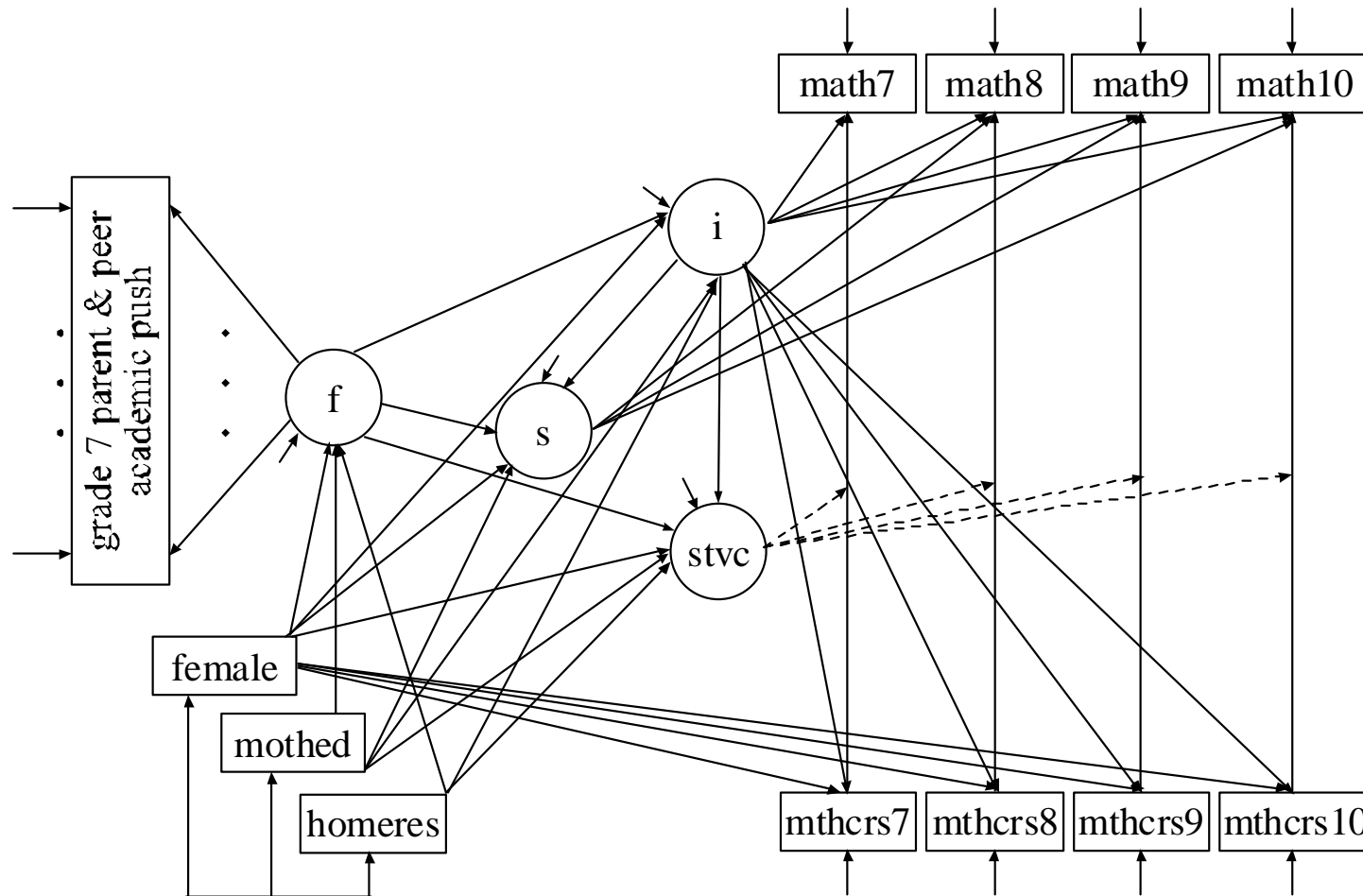
Growth Modeling with Time-Varying Covariates



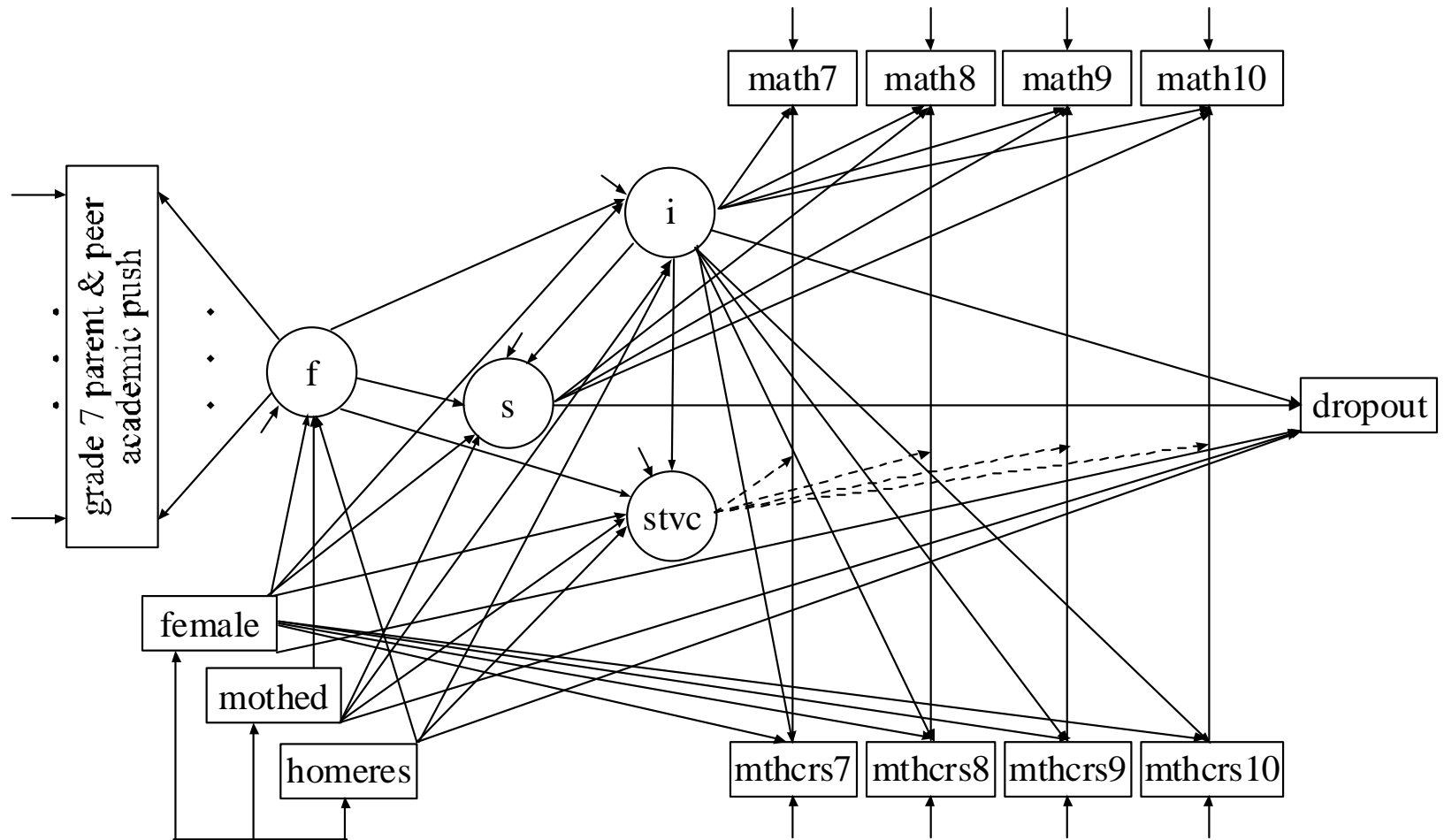
A Generalized Growth Model



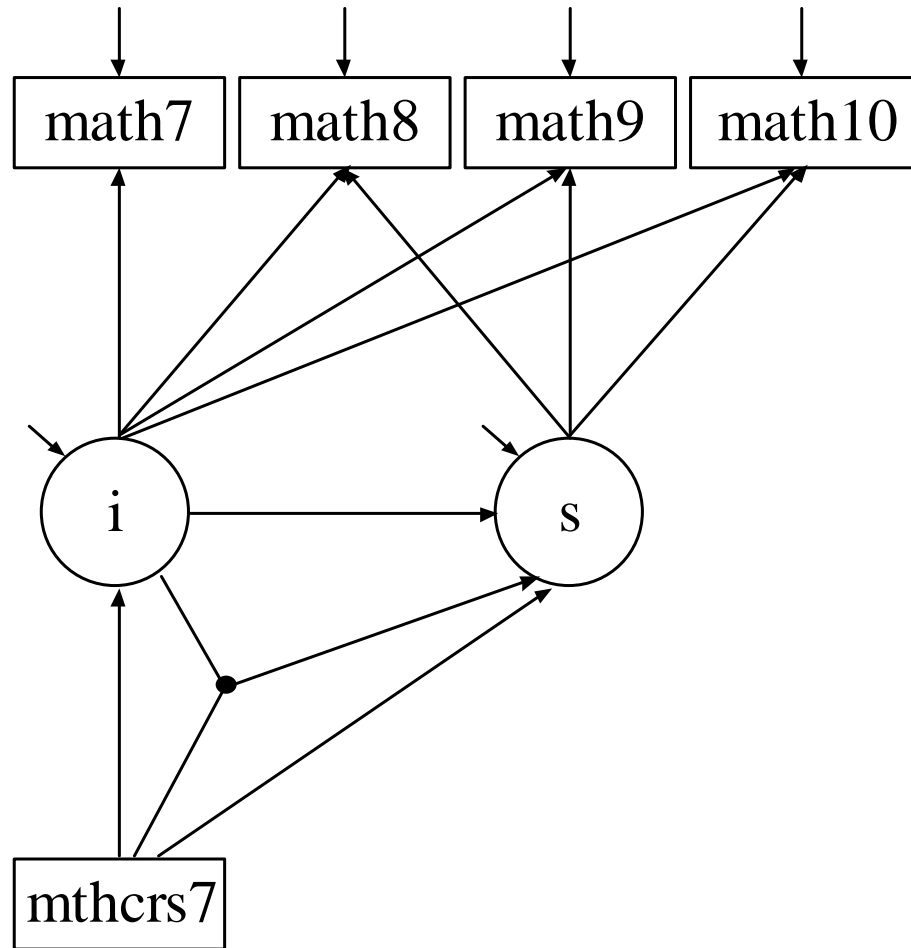
A Generalized Growth Model



A Generalized Growth Model



Growth Modeling with a Latent Variable Interaction



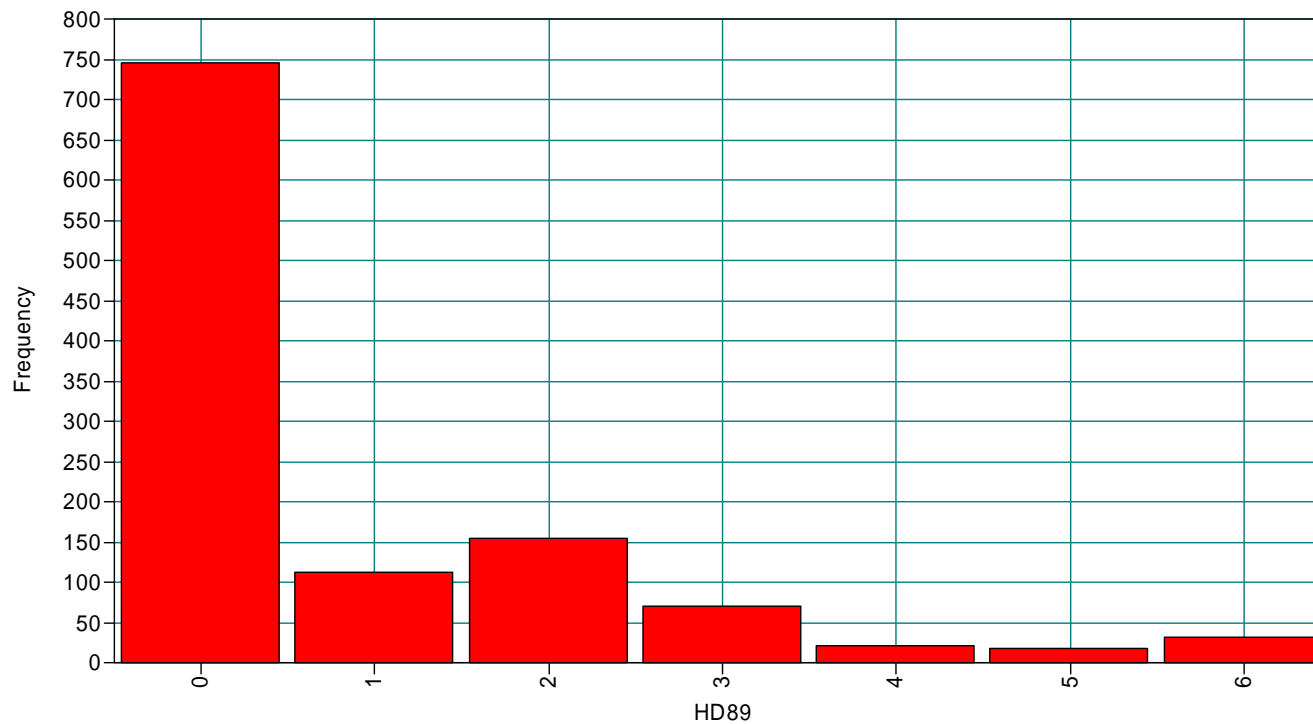
**NLSY: Heavy Drinking
General Population Sample
Ages 18-30 (cohort 64)**

“How often have you had 6 or more drinks on one occasion during the last 30 days”

- 0 – Never
- 1 – Once
- 2 – 2 or 3 times
- 3 – 4 or 5 times
- 4 – 6 or 7 times
- 5 – 8 or 9 times
- 6 – 10 or more times

NLSY HD89: Heavy Drinking at Age 25

63% at zero



Model Estimates Comparing Censored and Censored-Inflated Models of the NLSY HD

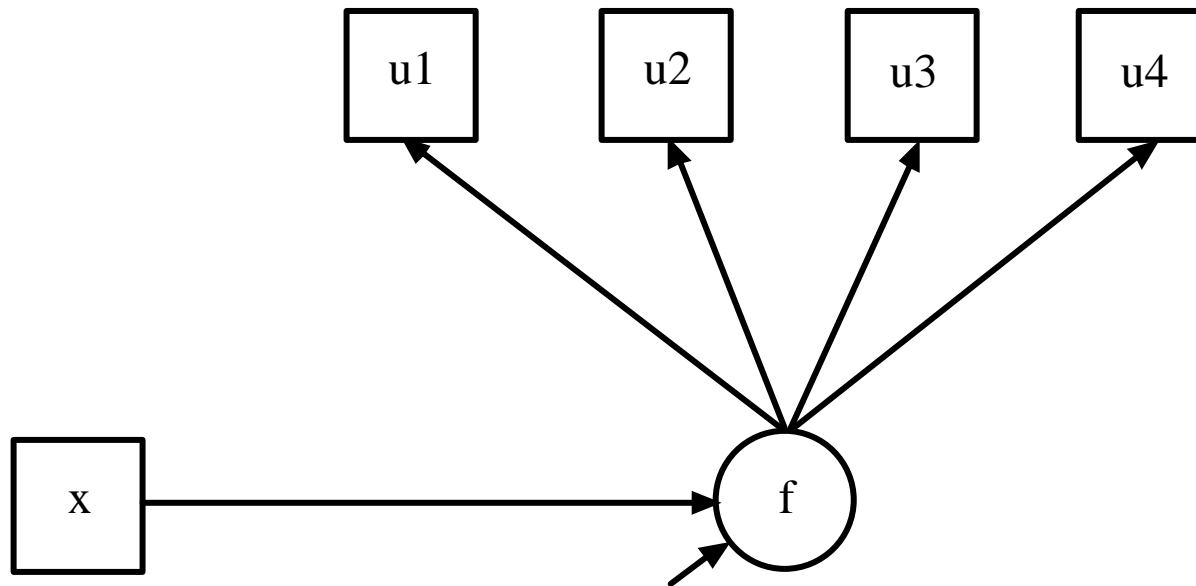
N=1172, ages 18 - 30, centering at age 25

	Censored			Censored-Inflated			
	Est	S.E.	Est/S.E.		Est	S.E.	Est/S.E.
I ON				I ON			
MALE	2.363	0.178	13.284	MALE	1.324	0.220	6.033
BLACK	-0.973	0.203	-4.799	BLACK	0.078	0.189	0.414
HISP	-0.590	0.234	-2.517	HISP	-0.210	0.205	-1.022
ES	0.521	0.240	2.173	ES	0.188	0.213	0.883
FH123	0.858	0.283	3.030	FH123	0.540	0.259	2.085
HSDRP	0.398	0.208	1.909	HSDRP	0.662	0.195	3.391
				II ON (prob of being zero)			
				MALE	-1.574	0.175	-8.968
				BLACK	1.472	0.225	6.542
				HISP	0.637	0.220	2.901
				ES	-0.687	0.228	-3.009
				FH123	-0.596	0.280	-2.126
				HSDRP	0.168	0.180	0.932

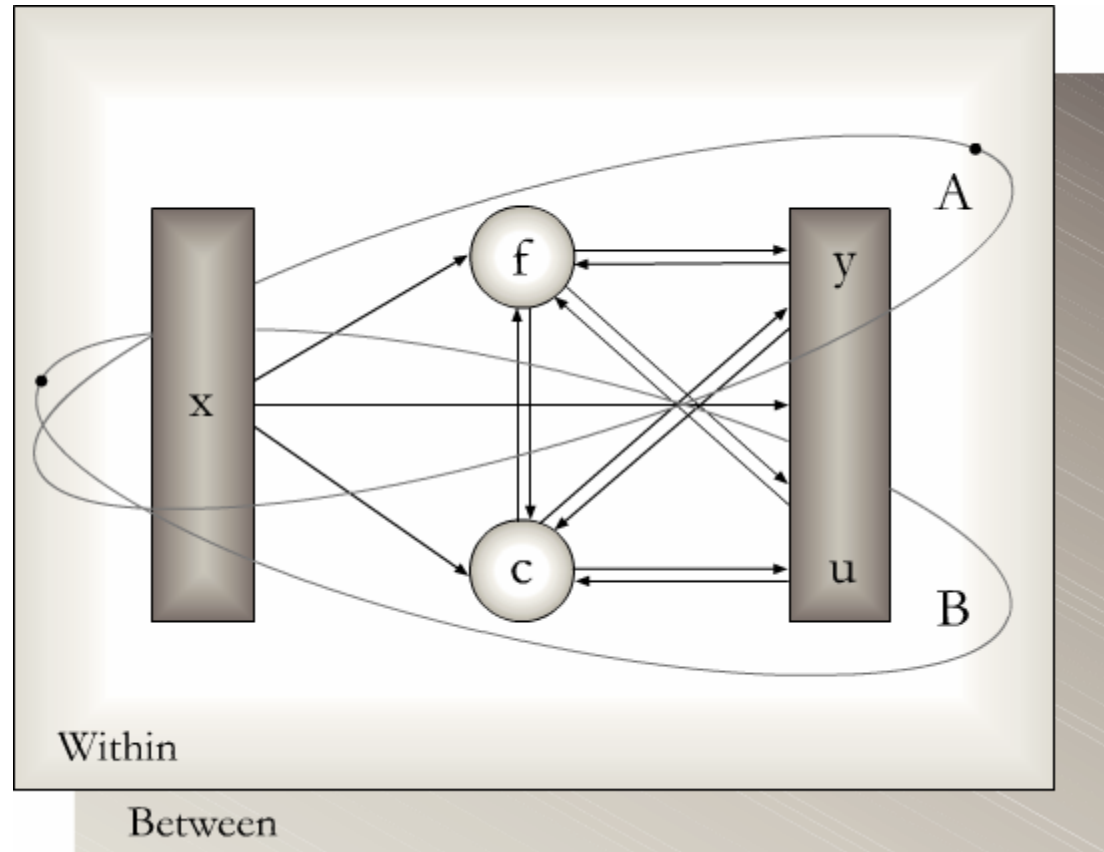
Censored logL = -7464 (30 parameters)

Censored-inflated logL = -7304 (42 parameters)

Discrete-Time Survival Analysis With A Random Effect (Frailty)

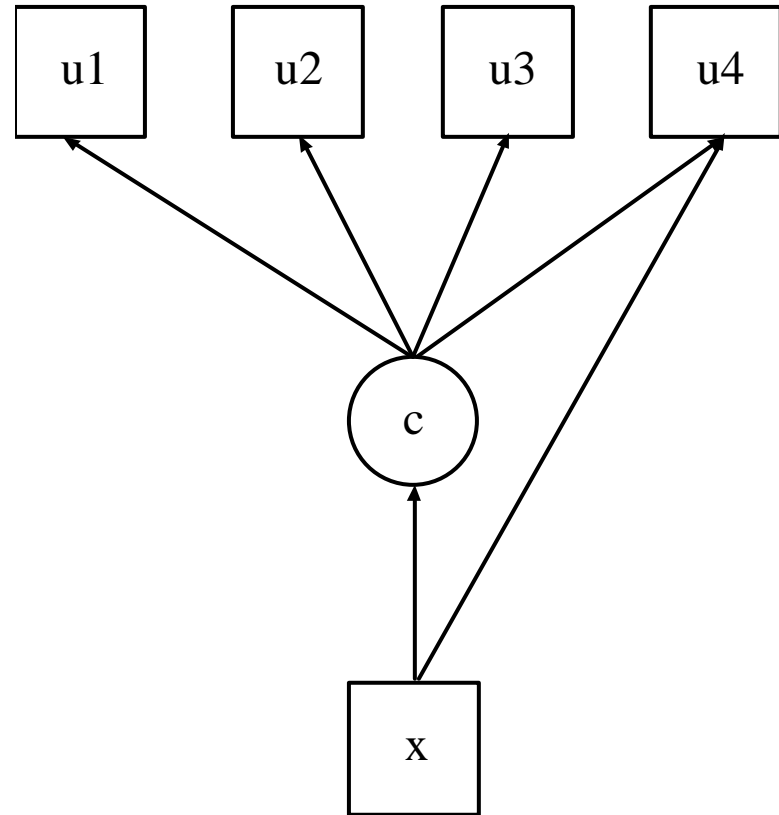
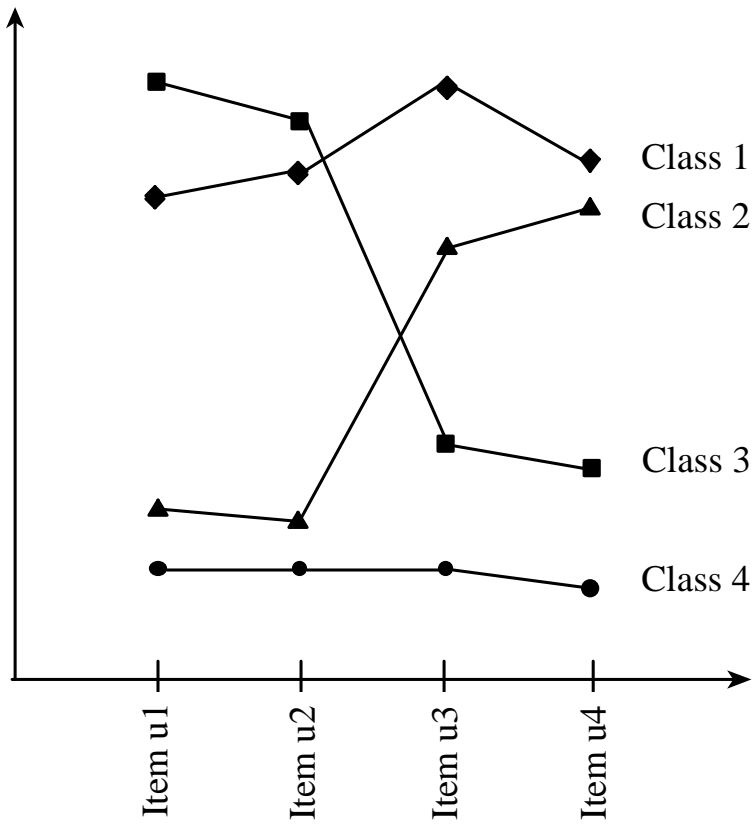


General Latent Variable Modeling Framework

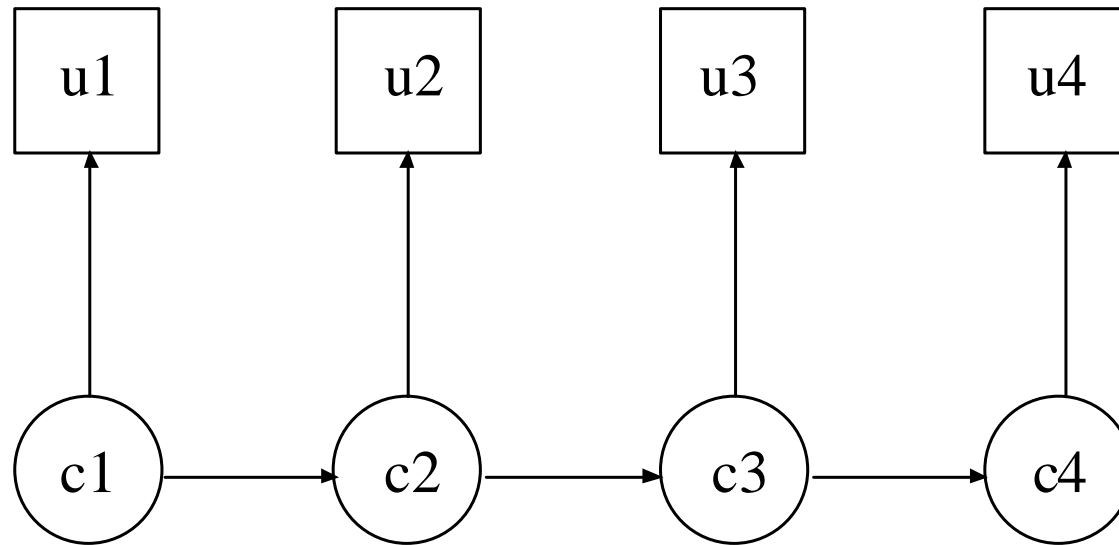


Latent Class Analysis

Item Profiles



Hidden Markov Modeling

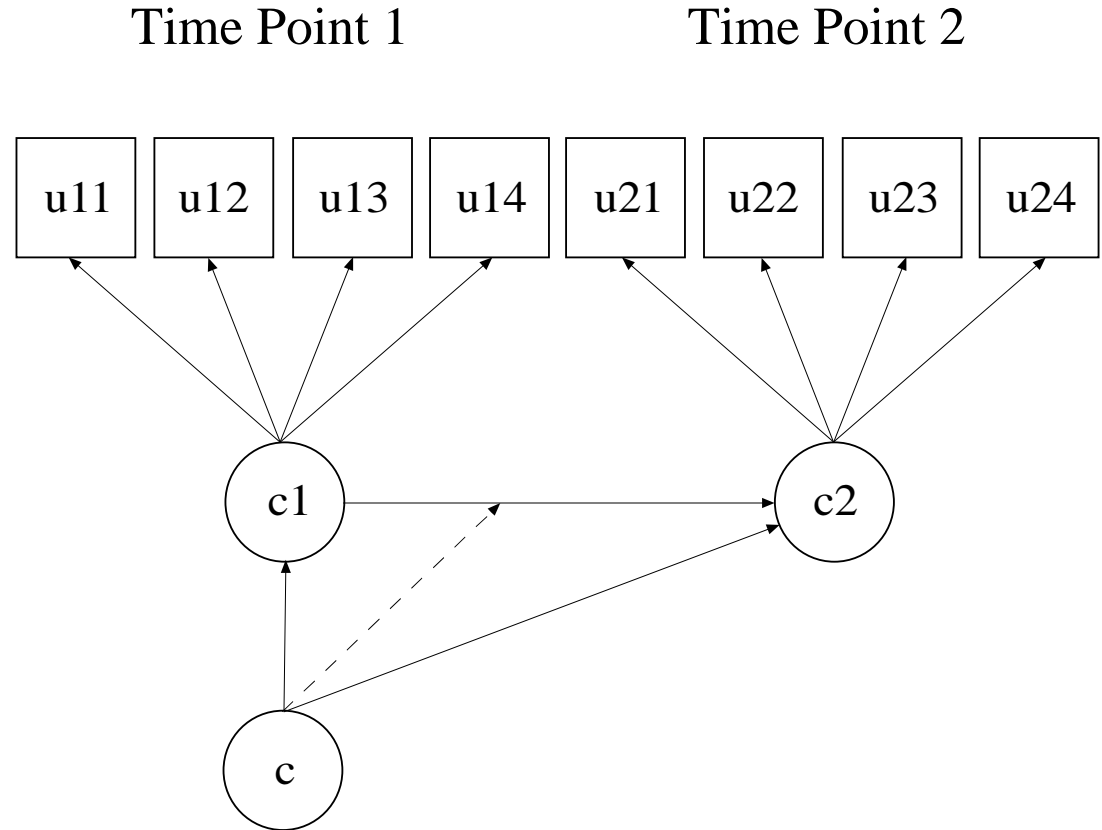


Latent Transition Analysis

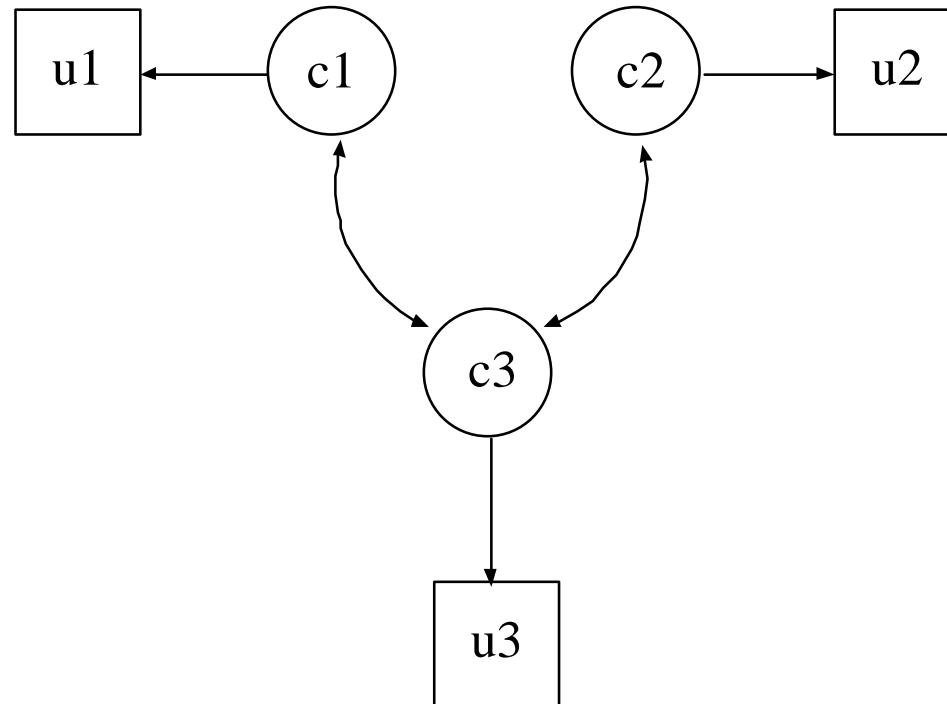
Transition Probabilities

Mover Class (c=1)		c2	
		1	2
c1	1	0.6	0.4
	2	0.3	0.7

Stayer Class (c=2)		c2	
		1	2
c1	1	0.90	0.10
	2	0.05	0.95



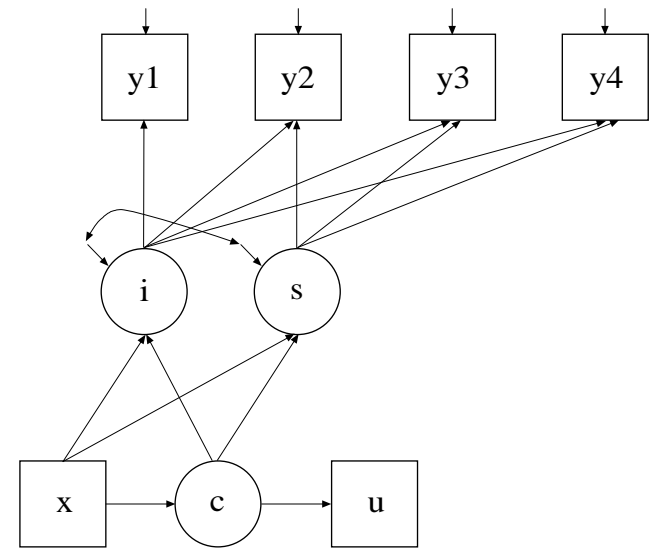
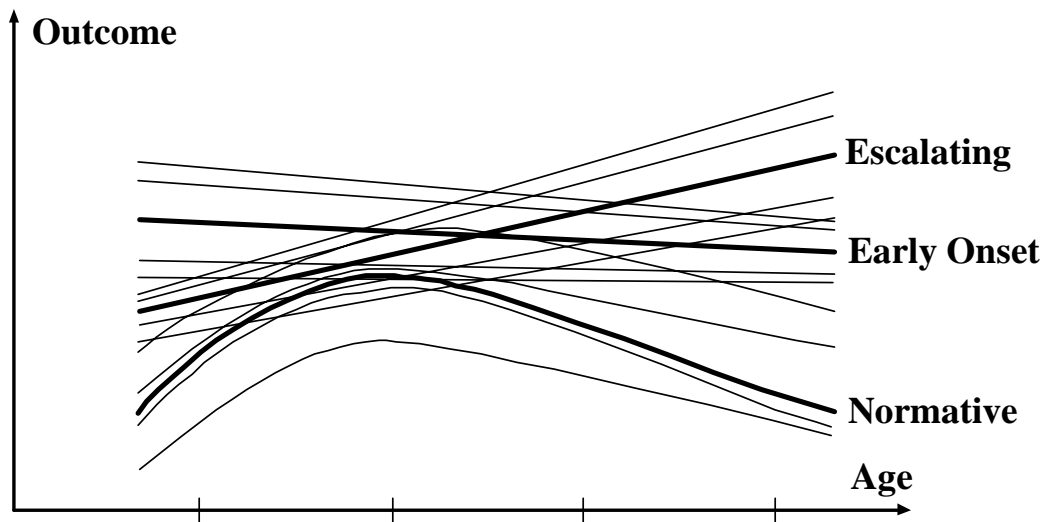
Loglinear Modeling of Frequency Tables



Growth Mixture Modeling

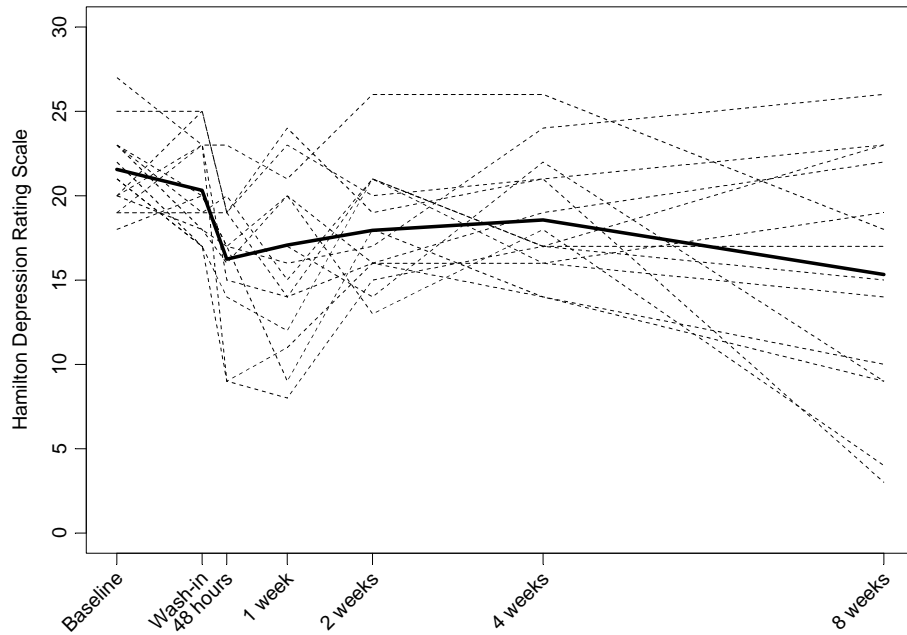
- Muthén, B. & Shedden, K. (1999). Finite mixture modeling with mixture outcomes using the EM algorithm. **Biometrics**, 55, 463-469.
- Muthén, B., Brown, C.H., Masyn, K., Jo, B., Khoo, S.T., Yang, C.C., Wang, C.P., Kellam, S., Carlin, J., & Liao, J. (2002). General growth mixture modeling for randomized preventive interventions. **Biostatistics**, 3, 459-475.

Growth Mixture Modeling

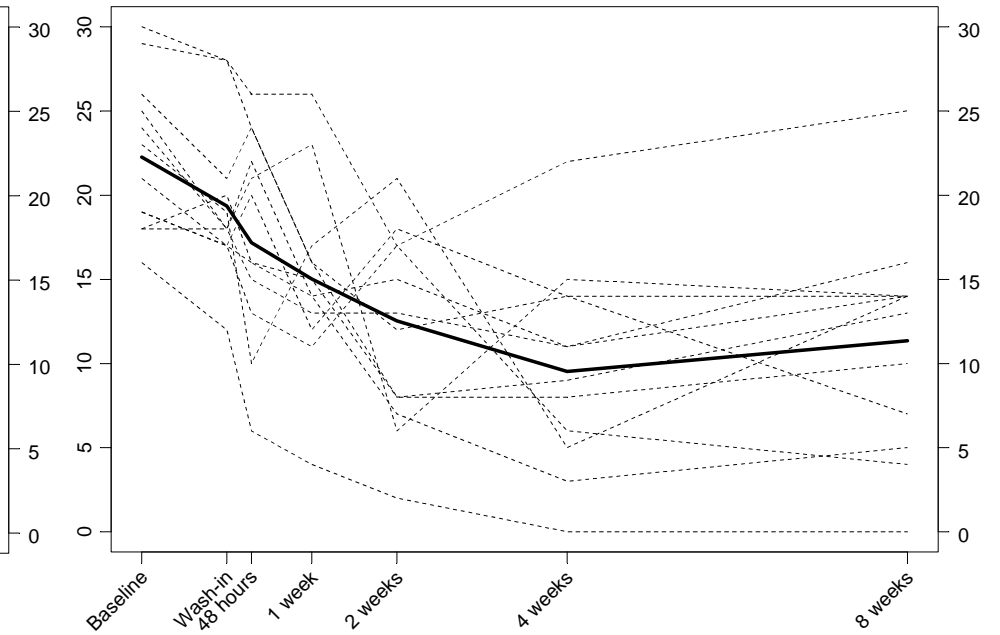


A Clinical Trial of Depression Medication: 2-Class Growth Mixture Modeling

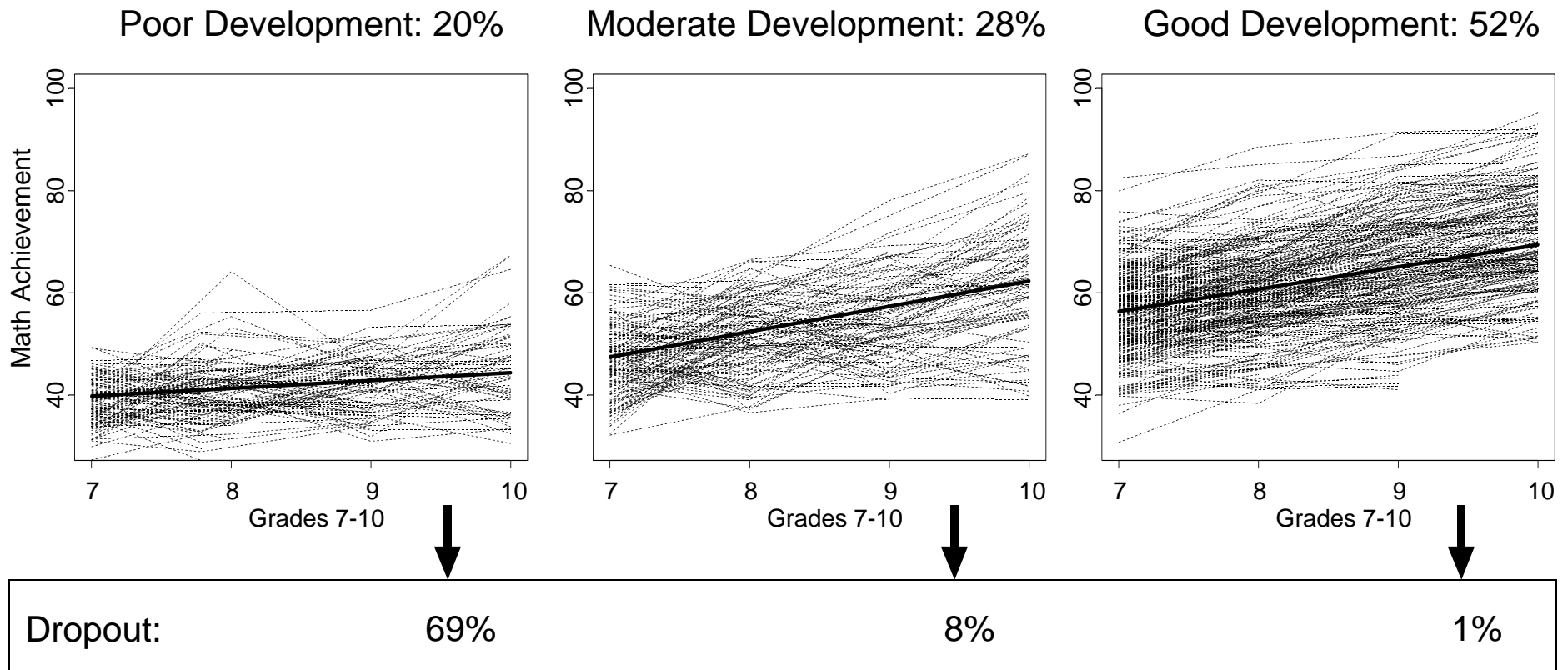
Placebo Non-Responders, 55%

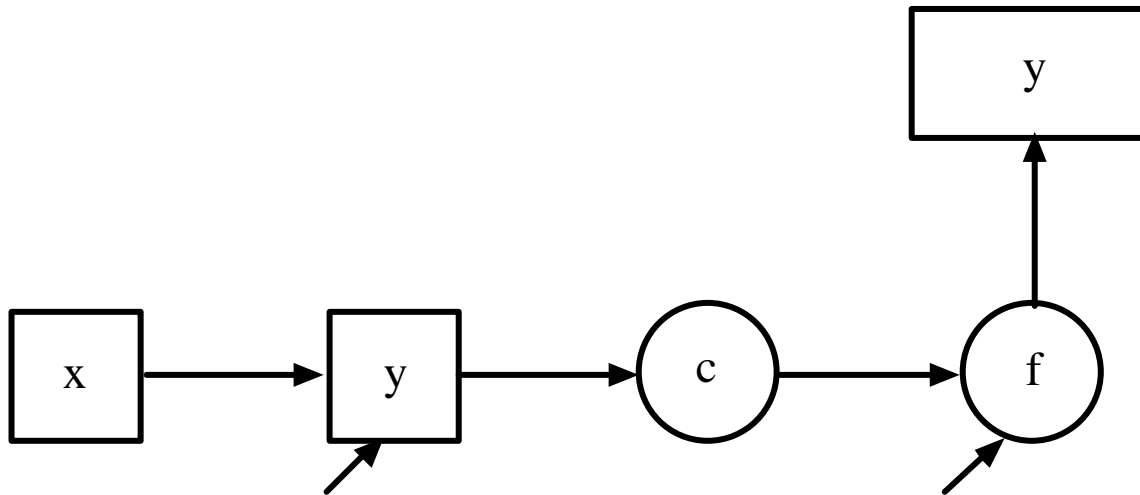


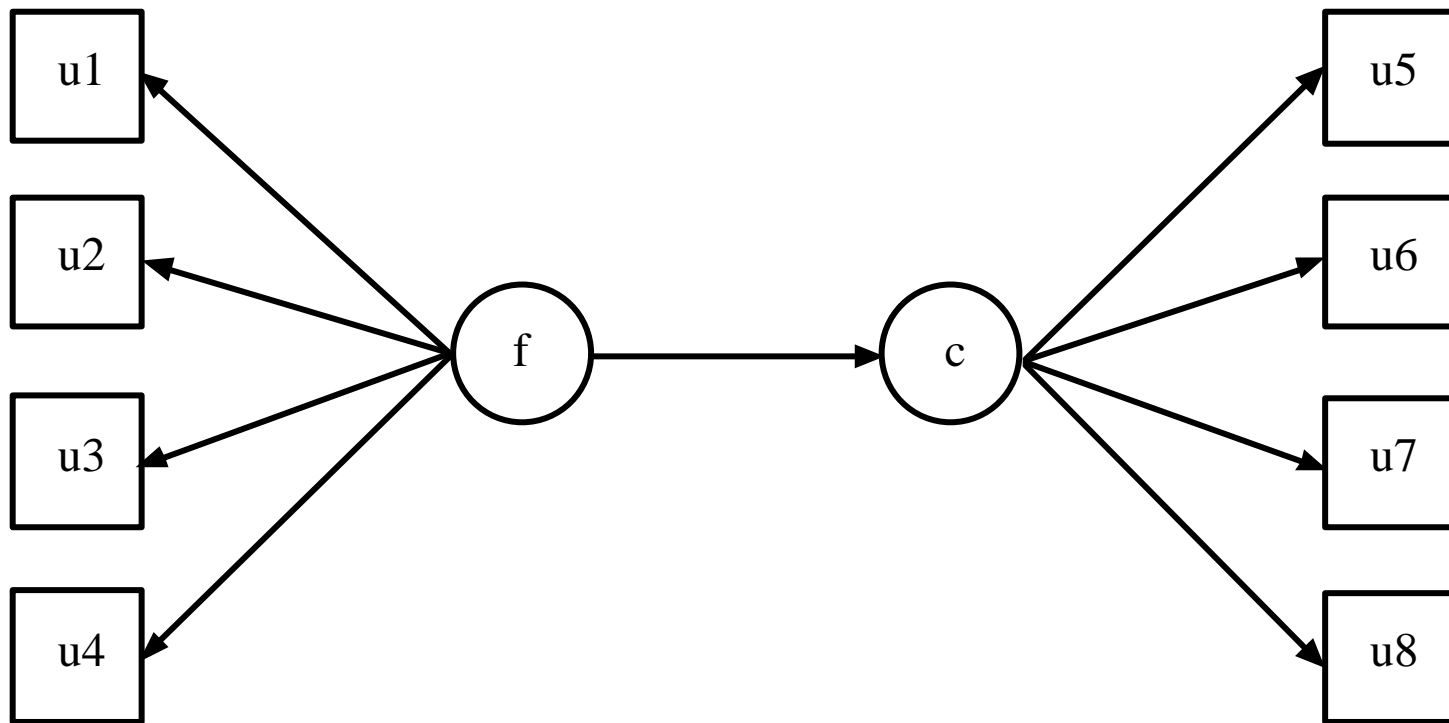
Placebo Responders, 45%



Growth Mixture Modeling: LSAY Math Achievement Trajectory Classes and the Prediction of High School Dropout





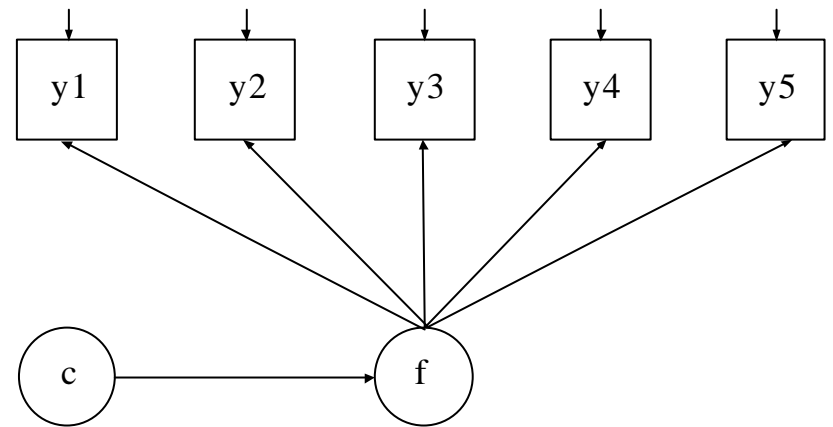
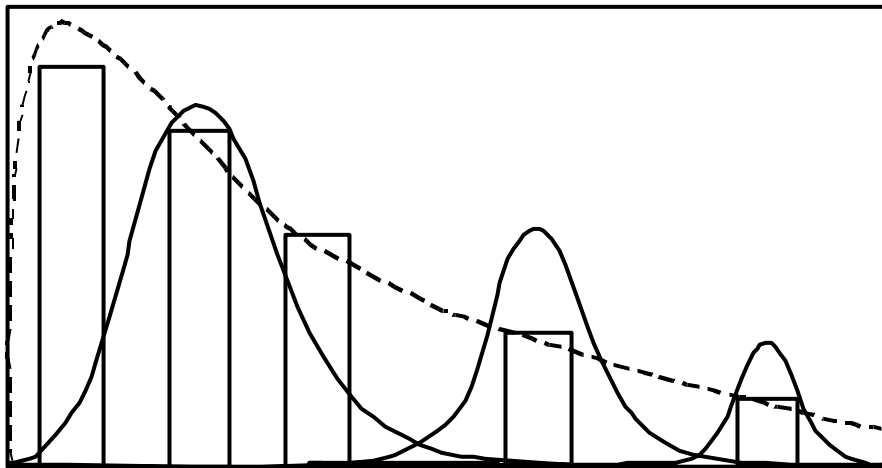


Non-Parametric Factor Analysis

Factor Analysis Of Categorical Outcomes

- **Regular factor analysis**
 - Normal random effects (continuous latent variables)
 - Numerical integration needed for ML
 - Normality is hard to check
 - Heavy computations with ML
- **Non-parametric (semi-parametric) ML factor analysis**
 - Non-parametric random effect modeling via latent classes with class-invariant loadings and thresholds, and class-varying factor means
 - Avoids distributional assumptions
 - Lighter computations
 - Better cut points (the best of both worlds: LCA-FA)
- **Factor mixture analysis**
 - Substantively meaningful classes
 - Class-varying parameters
 - Within-class variation possible

Factor Mixture - Non-Parametric Factor Modeling



Antisocial Behavior (ASB) Data (Continued)

Damaged property

Fighting

Shoplifting

Stole < \$50

Stole > \$50

Use of force

Seriously threaten

Intent to injure

Use marijuana

Use other drugs

Sold marijuana

Sold hard drugs

“Con” someone

Take auto

Broken into building

Held stolen goods

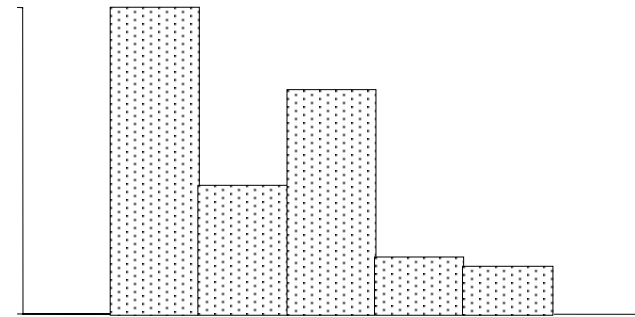
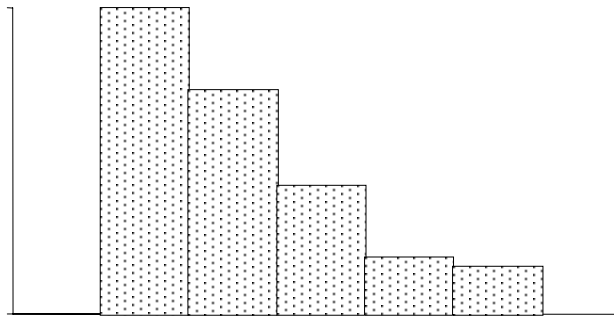
Gambling operation

Binary Items

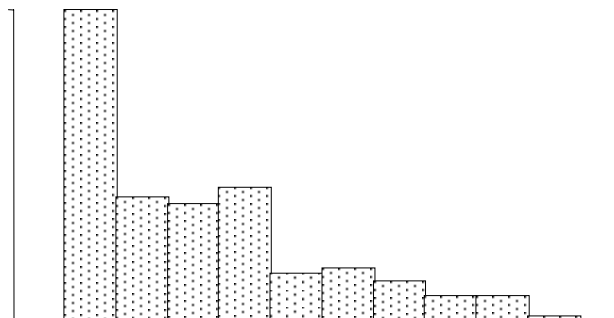
EFA Finds 3 factors: property offense, person offense, and drug offense

Univariate Factor Distributions From Non-Parametric Factor Analysis

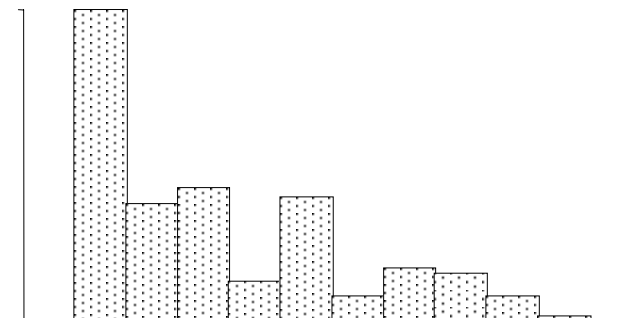
5-Class



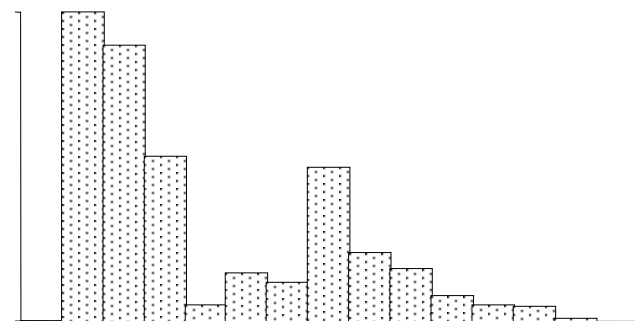
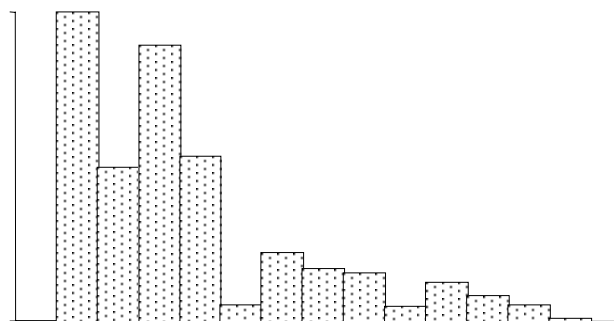
10-Class



F2



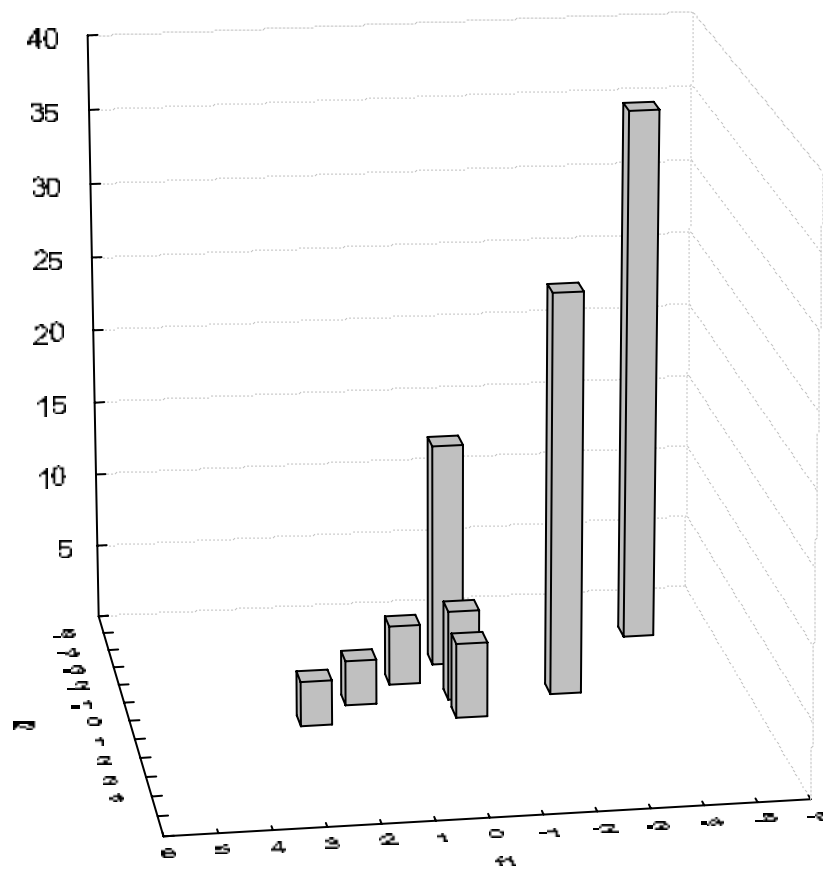
15-Class



F1

F2

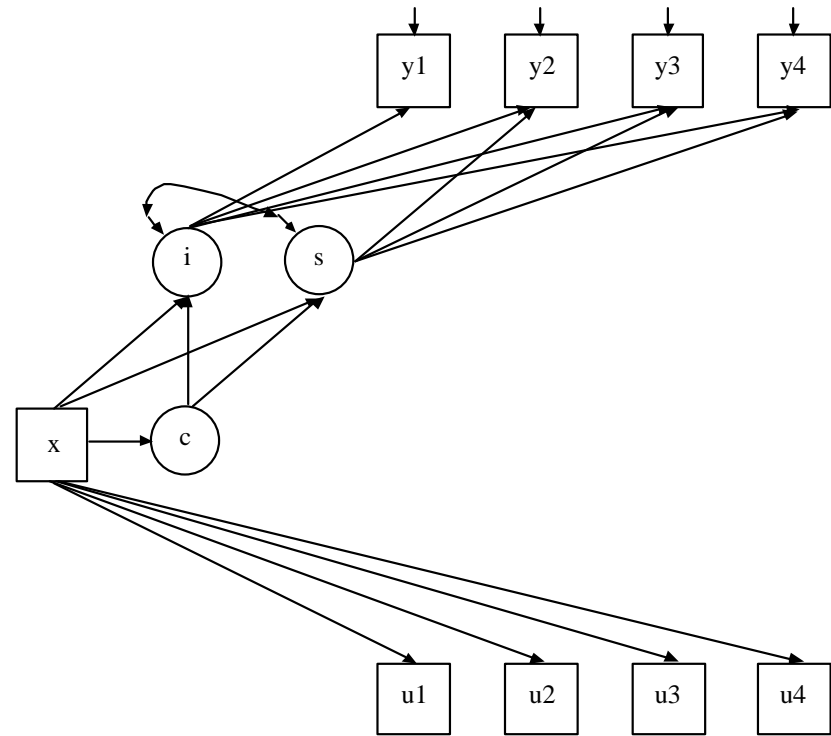
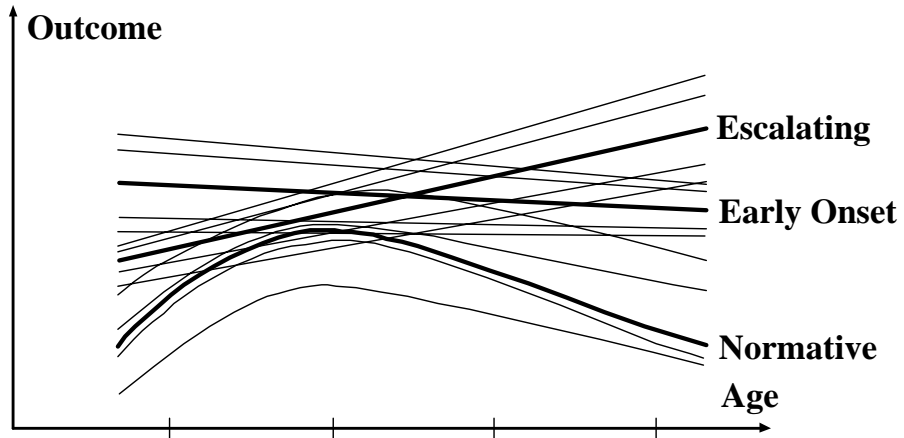
10-Class Non-Parametric Factor Analysis Distribution for F1 And F2



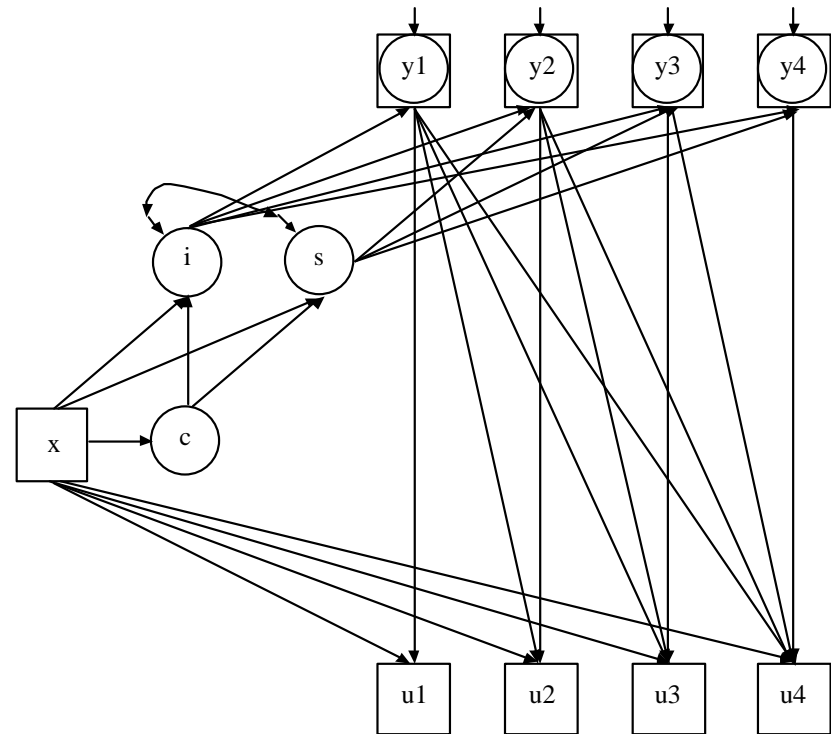
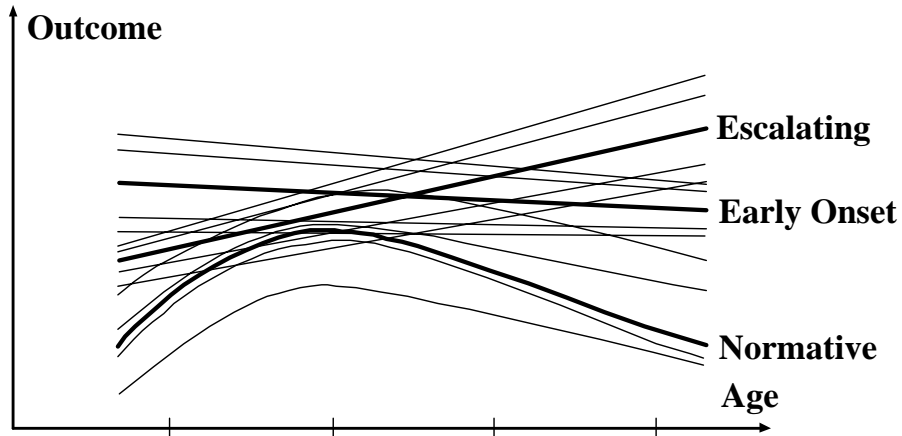
Four Uses For U's

- Categorical variable
- Indicator of being at zero in two-part modeling
- Event history indicator in survival analysis
- Missing data indicator

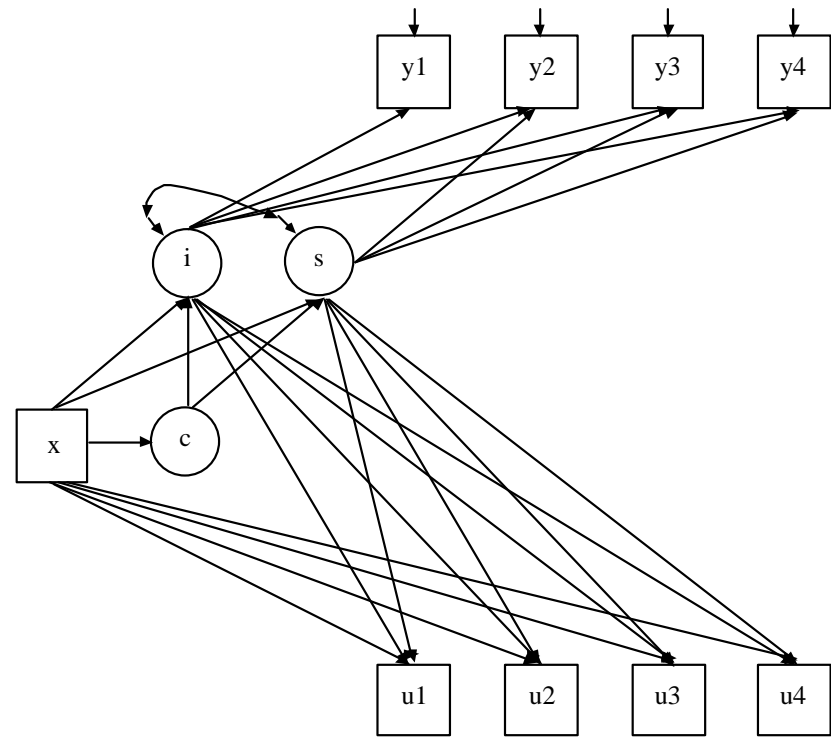
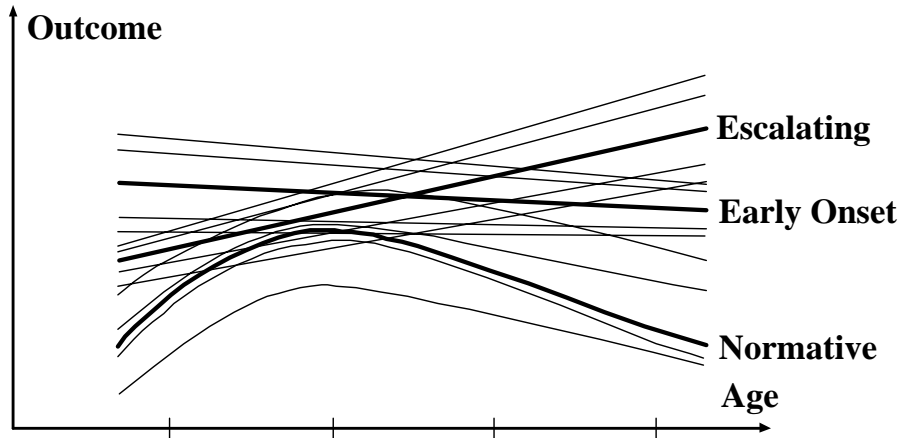
Growth Mixture Modeling with Ignorable Missingness



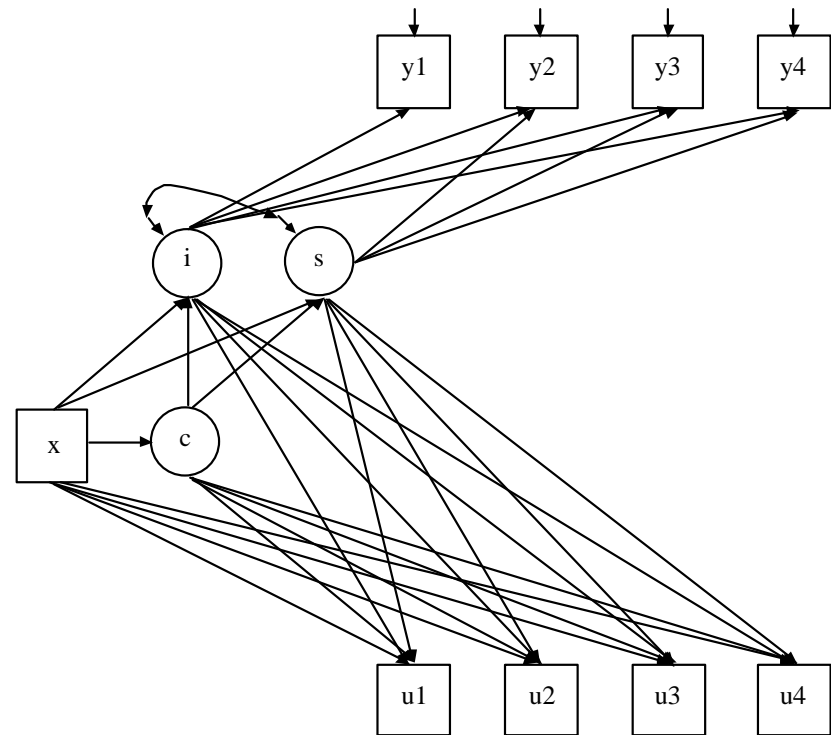
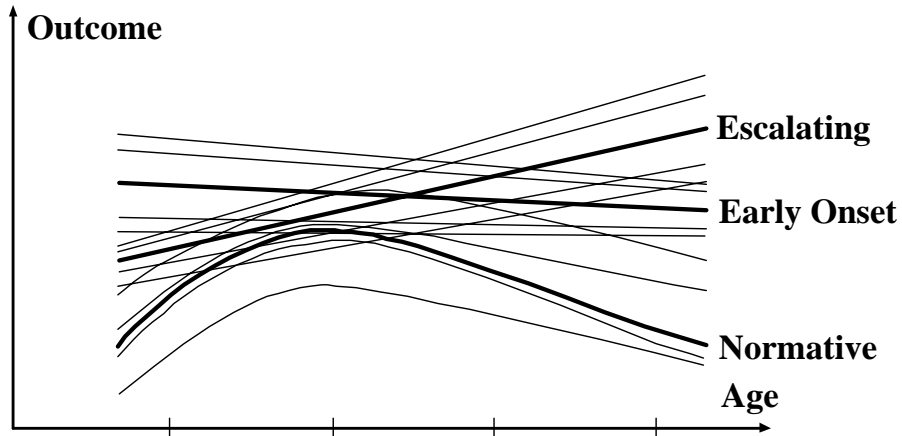
Growth Mixture Modeling with Non-Ignorable Missingness as a Function of y



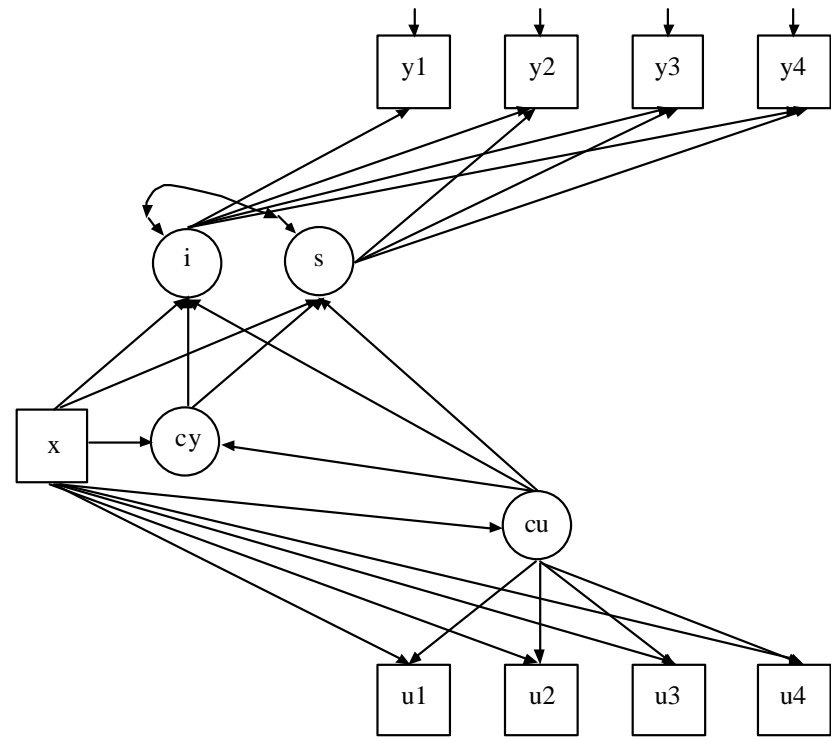
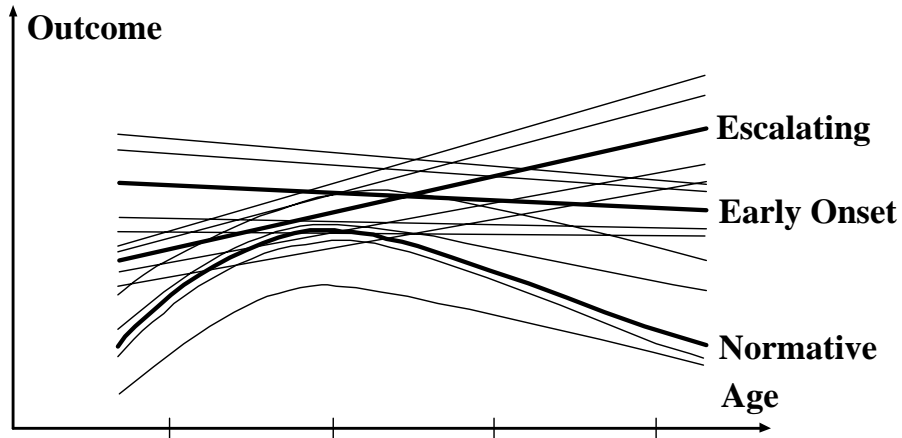
Growth Mixture Modeling with Non-Ignorable Missingness as a Function of s



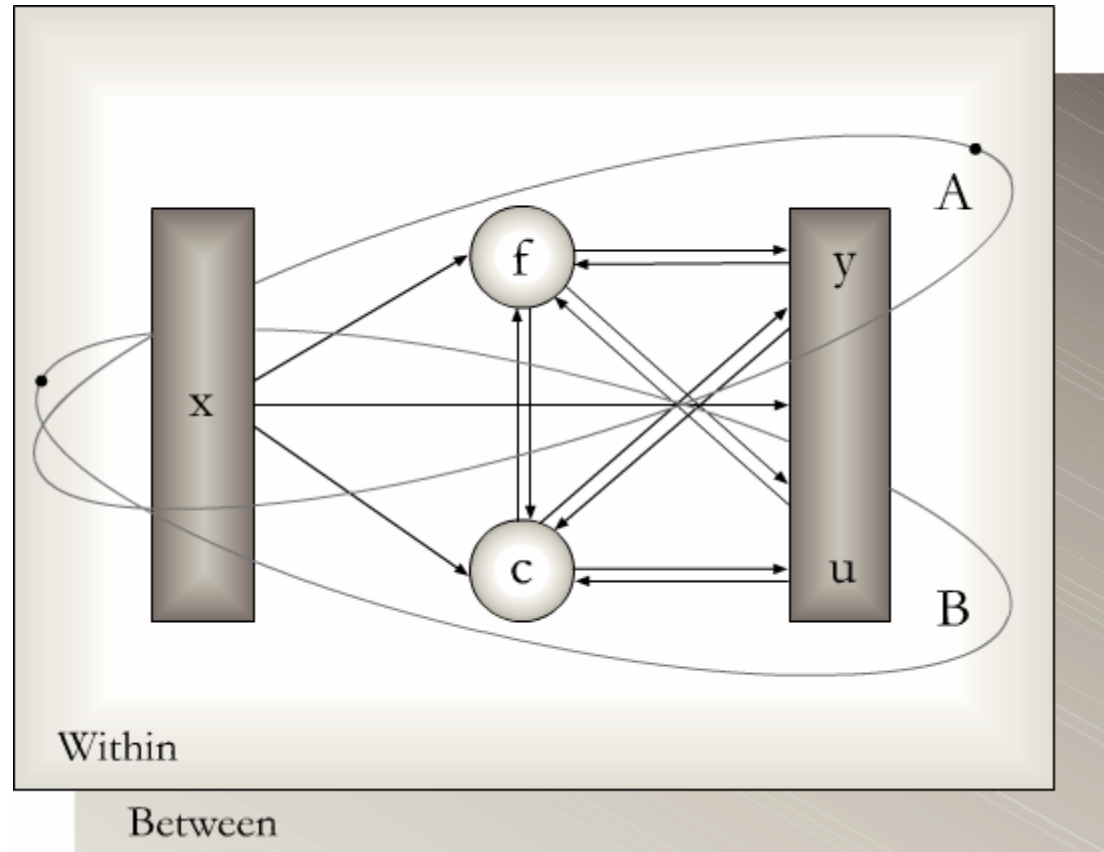
Growth Mixture Modeling with Non-Ignorable Missingness as a Function of c



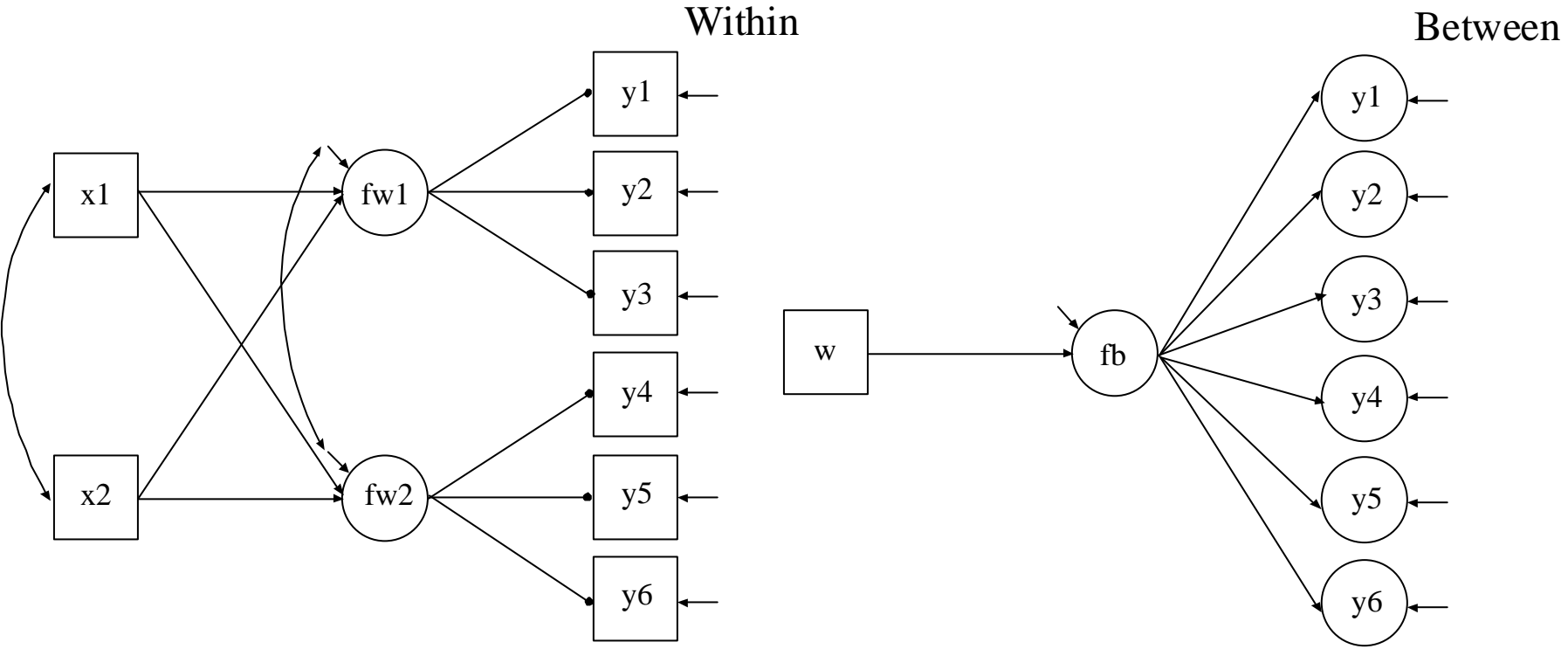
Growth Mixture Modeling with Non-Ignorable Missingness as a Function of cu



General Latent Variable Modeling Framework

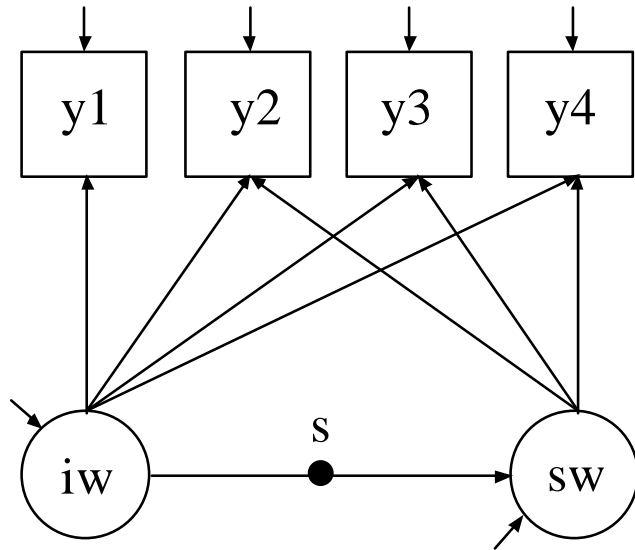


Two-Level Factor Analysis with Covariates

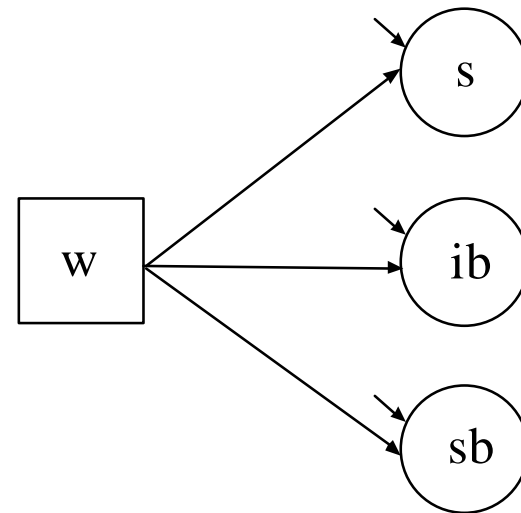


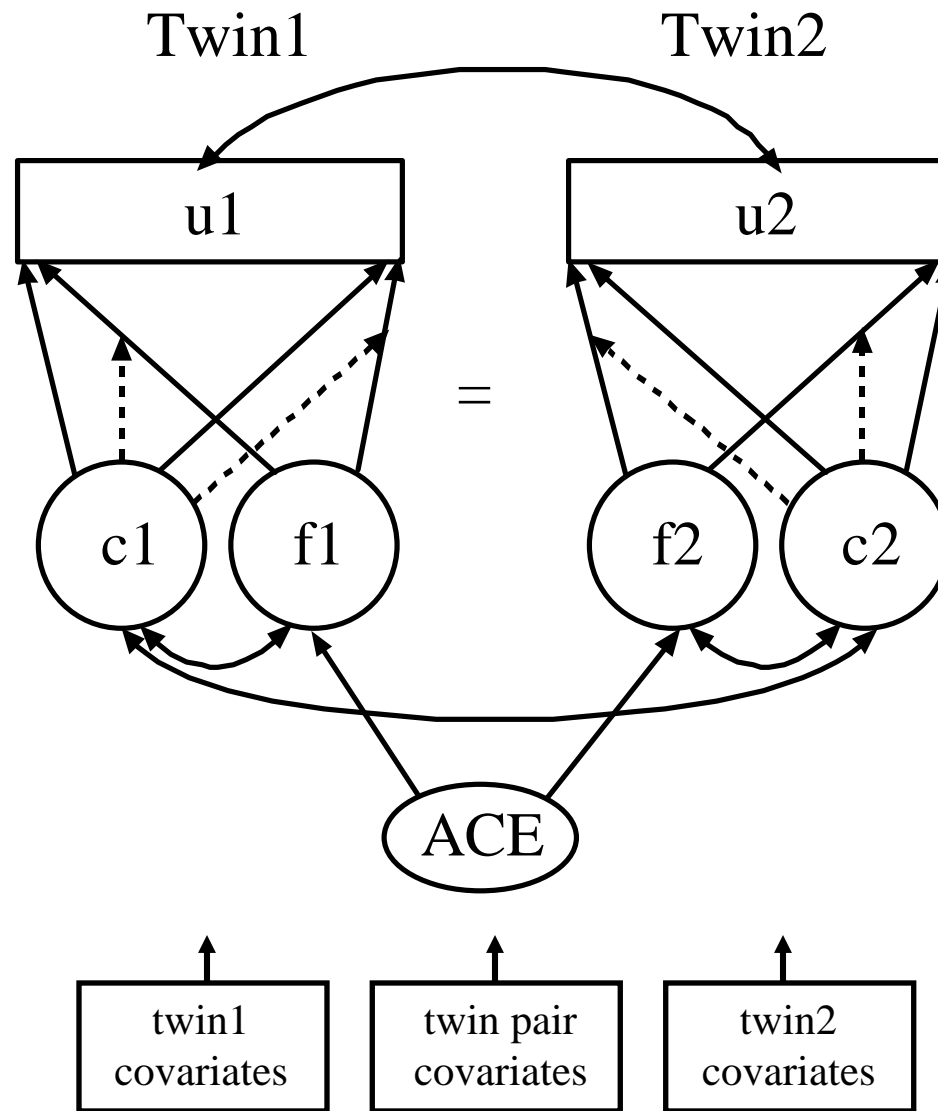
Multilevel Modeling with a Random Slope for Latent Variables

Student (Within)

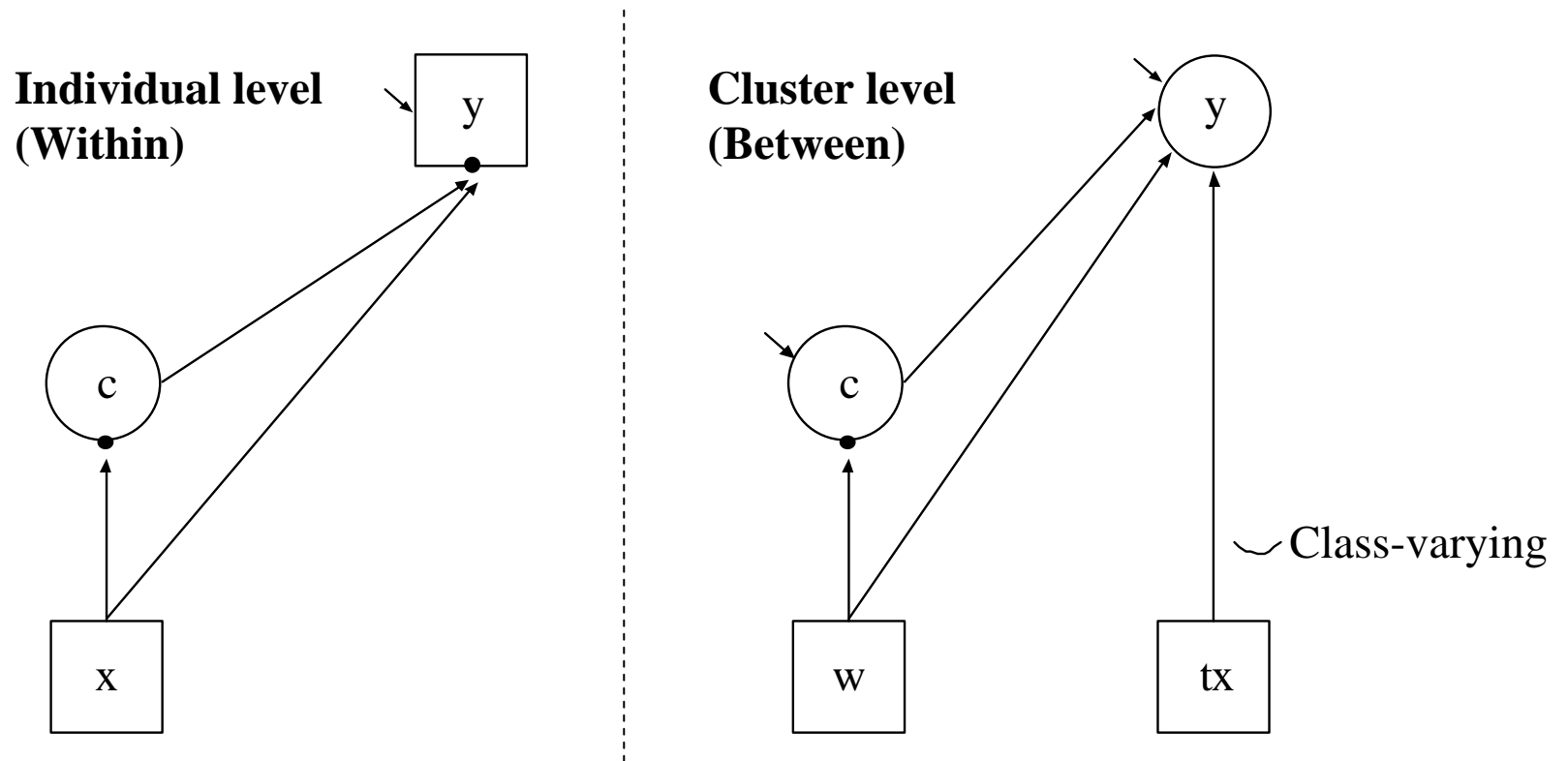


School (Between)

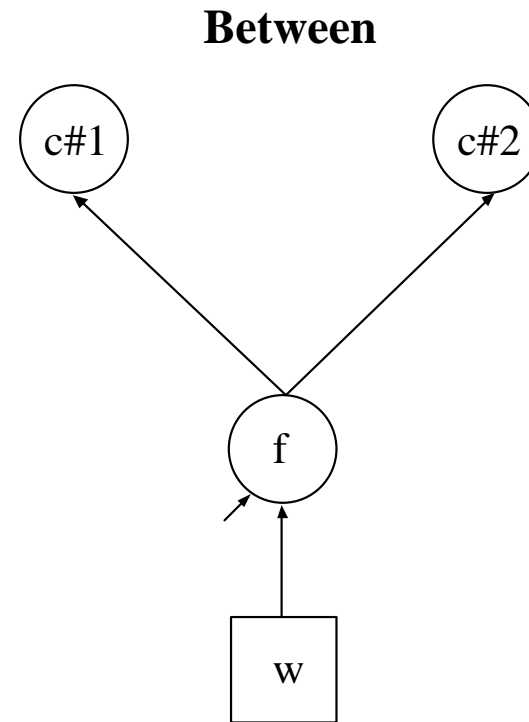
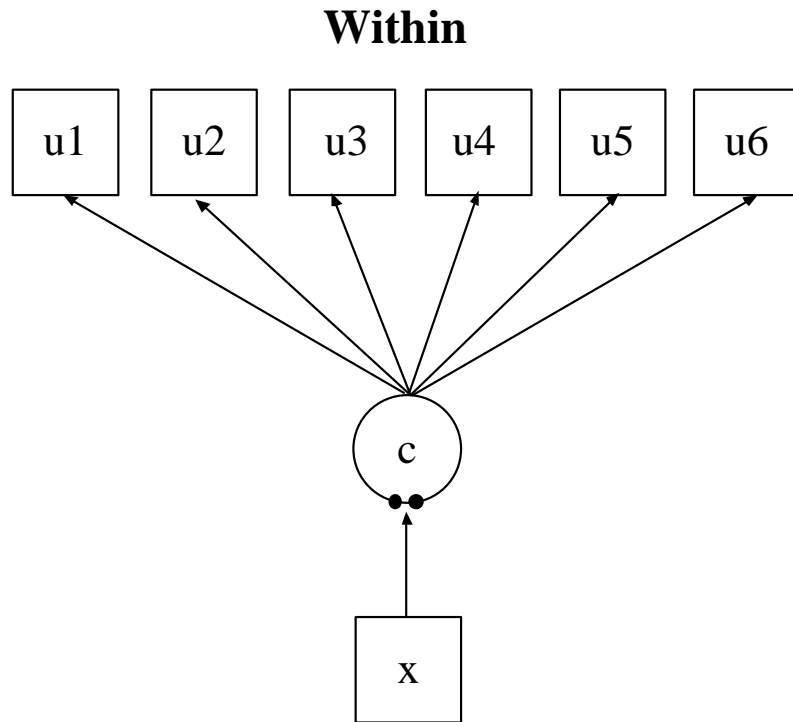




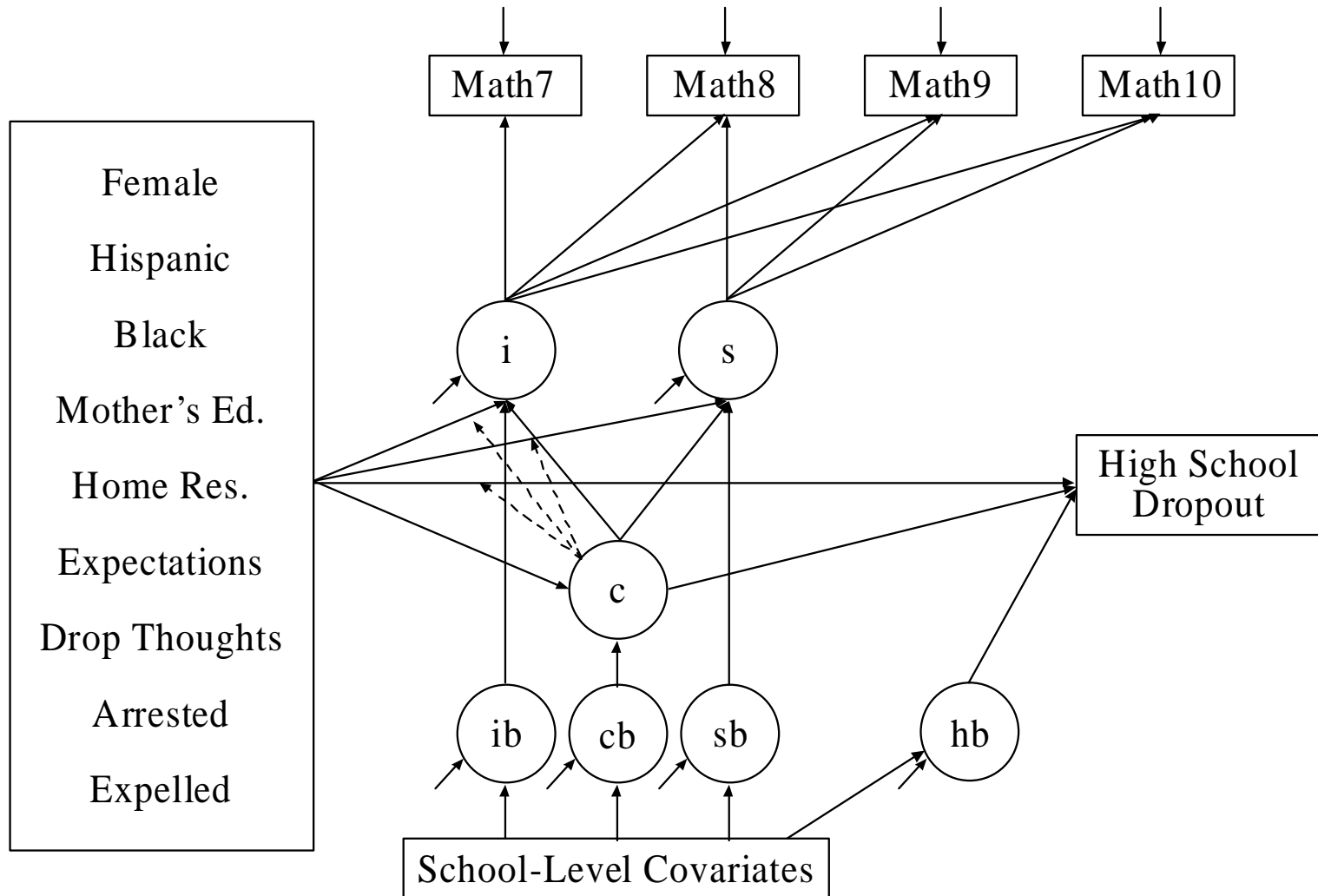
Two-Level CACE Mixture Modeling



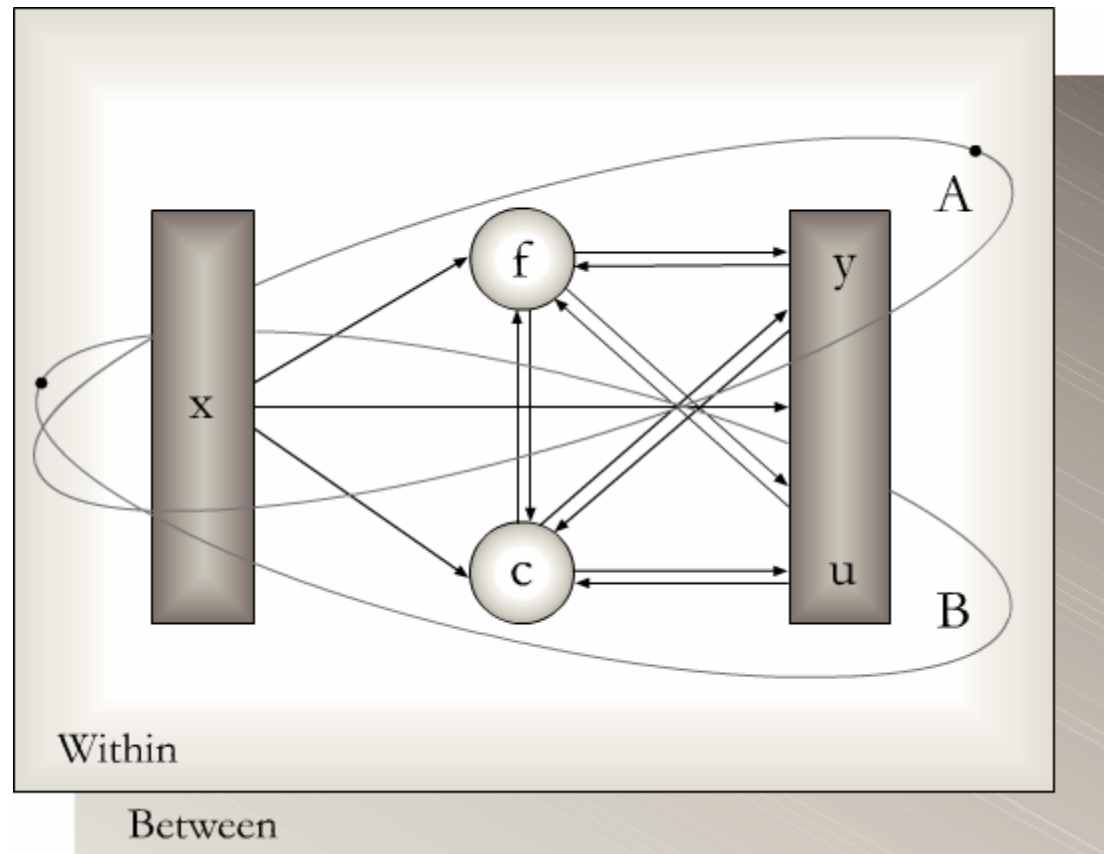
Two-Level Latent Class Analysis



Multilevel Growth Mixture Modeling



General Latent Variable Modeling Framework



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