

Intro to SEM

with examples from Stata and Mplus

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What is SEM

- **Structural** – human built, constructed
- **Equation**
 - a logical statement (“=”)
 - a mathematical statement ($5x=2y$)
 - statistical in some way

What is SEM

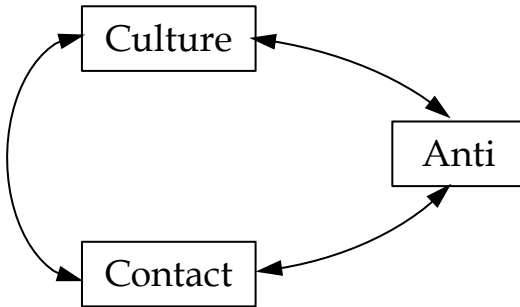
- **Structural** – human built, constructed
- **Equation**
 - a logical statement (“=”)
 - a mathematical statement ($5x=2y$)
 - statistical in some way
- **Structural Equation** – one equation dependent on others
- **Models** – descriptions of theory in mathematical terms

What is SEM

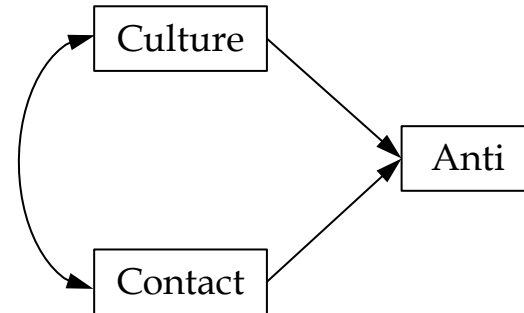
Model 1. Same Variables. Alternative Models.

Anti-immigrant attitudes
Culture: value of cultural diversity
Contact with immigrants

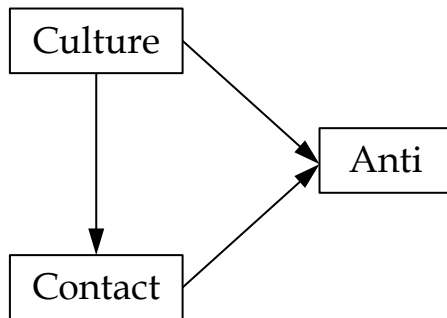
(a)



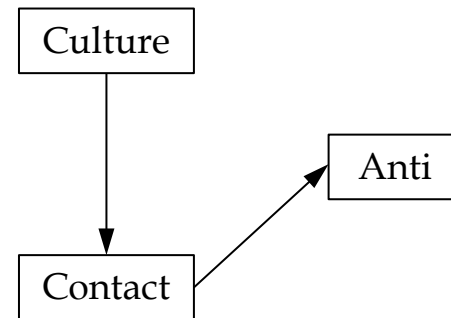
(b)



(c)



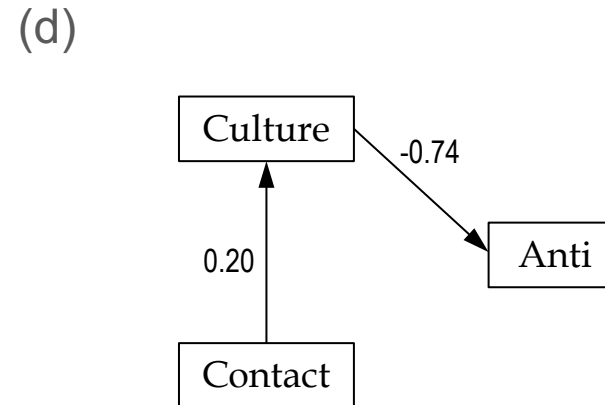
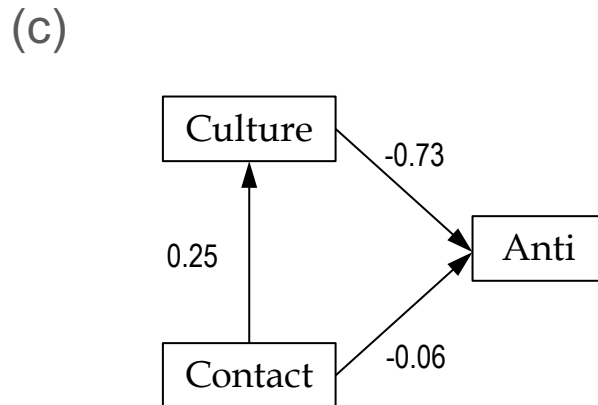
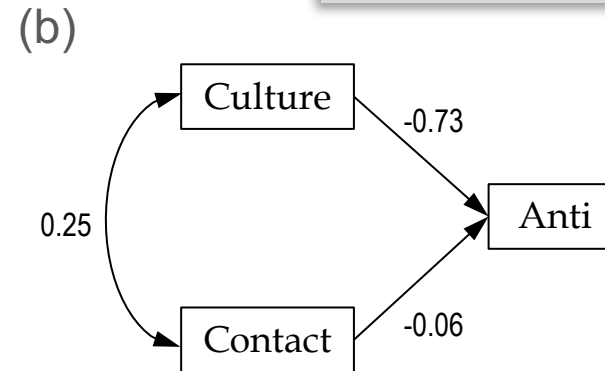
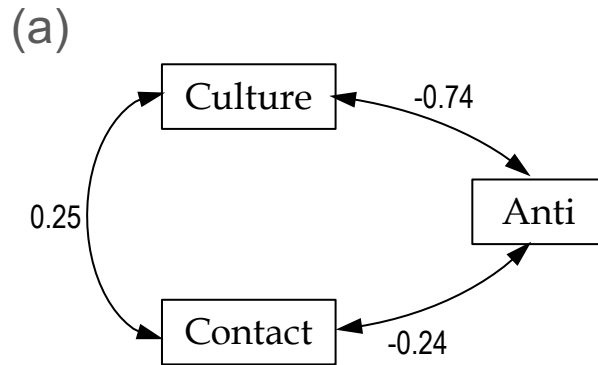
(d)



What is SEM

Model 1. Same Variables. Alternative Models.

Anti-immigrant attitudes
Culture: value of cultural diversity
Contact with immigrants

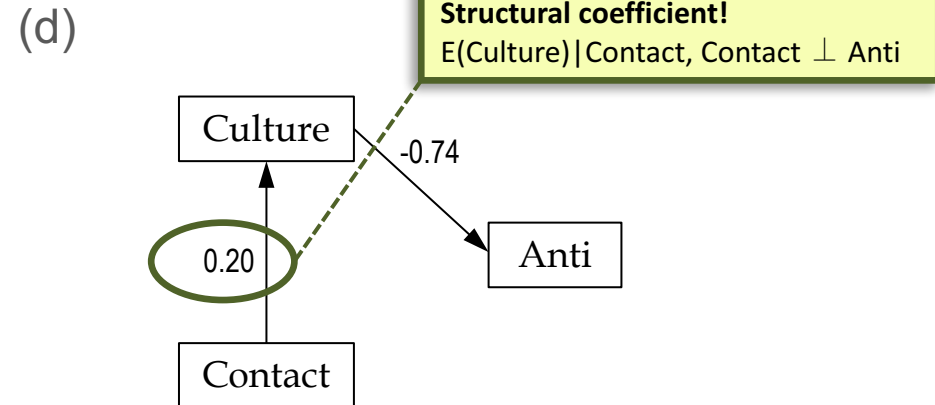
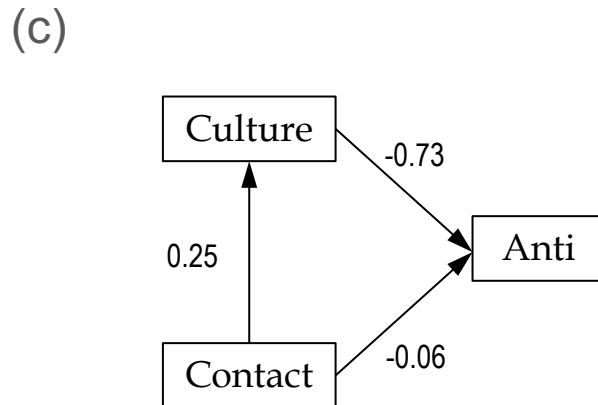
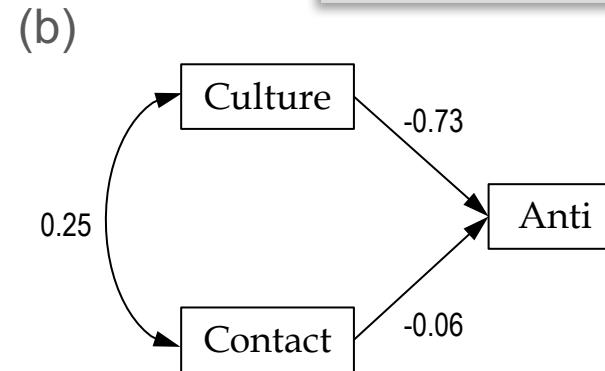
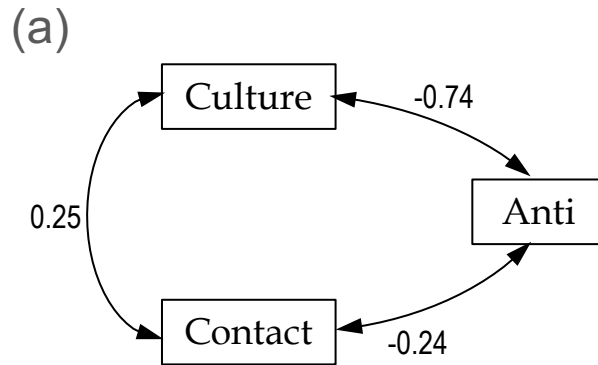


Mplus Code: [M1a](#); [M1b](#); [M1c](#); [M1d](#)

What is SEM

Model 1. Same Variables. Alternative Models.

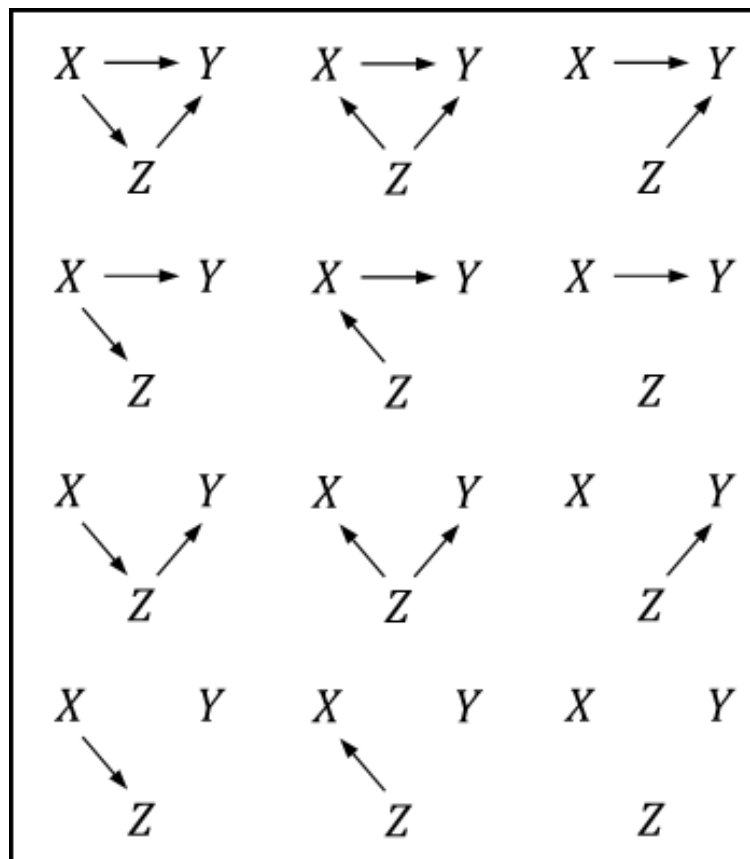
Anti-immigrant attitudes
Culture: value of cultural diversity
Contact with immigrants



Code: [fig1a](#); [fig1b](#); [fig1c](#); [fig1d](#)

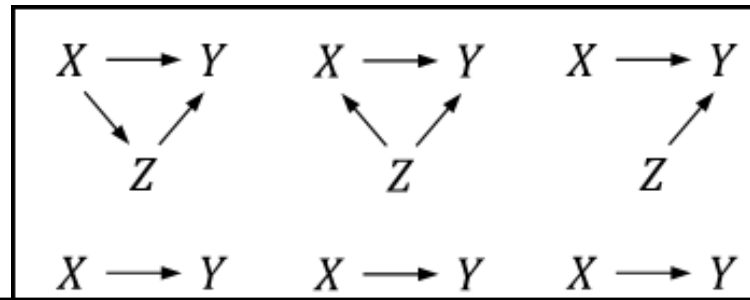
What is SEM

Figure 2. Twelve Alternative Path Models for one Outcome (Y) and two Inputs (X, Z)

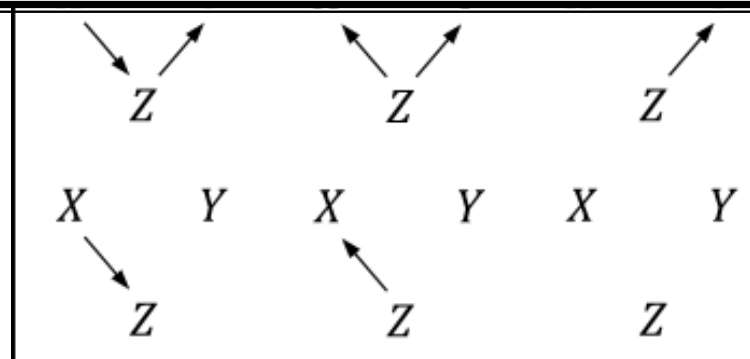


What is SEM

Figure 2. Twelve Alternative Path Models for one Outcome (Y) and two Inputs (X, Z)



264 Models with 4 variables;
11,664 with 5!



Surprising but True. SEM...

- ...is analysis of covariance structures
- ...does not minimize error terms
- ...cannot identify causality
- ...requires qualitative assumptions
- ...'s structural coefficients \neq regression coefficients
- ...*any* model can eventually fit the data perfectly

(Bollen 1989; Bollen and Pearl 2013)

MPLUS

THURSDAY
NOVEMBER 23, 2017

MPLUS
Mplus at a Glance
General Description
Mplus Programs
Pricing
Version History
System Requirements
Platforms
FAQ

MPLUS DEMO VERSION

TRAINING
Short Courses
Short Course Videos
and Handouts
Web Training

DOCUMENTATION
Mplus User's Guide
Mplus Diagrammer
Technical Appendices
Mplus Web Notes
User's Guide Examples
Mplus Book
Mplus Book Examples
Mplus Book Errata

ANALYSES/RESEARCH
Mplus Examples
Papers
References

Mplus

HOME ORDER CONTACT US LOGIN MPLUS DISCUSSION

[Last updated:](#) November 21, 2017

Mplus Version 8 Available Now!!!

Latest News

- Mplus Version 8 is now available. Mplus Version 8 includes corrections to minor problems that have been found since the release of Version 7.4 in November 2015 and the following new features listed on our [Version History](#) page. Registered users who purchased Mplus within the last year and those with a current Mplus Upgrade and Support Contract can download Version 8 at no cost by logging into their [customer account](#).

Mplus [Papers](#)
Using Special Mplus Features

Mplus Demo Version

The Mplus Demo version is available for download at no cost. Click [here](#) to download the demo. The demo version contains all of the capabilities of the regular version of Mplus and is only limited by the number of observed variables that can be used in an analysis.

Student Pricing for Mplus Version 8

Special student pricing is available for Mplus. The student version of the program is identical to the regular version. Click [here](#) for more information.

Mplus Version 8 User's Guide and Examples

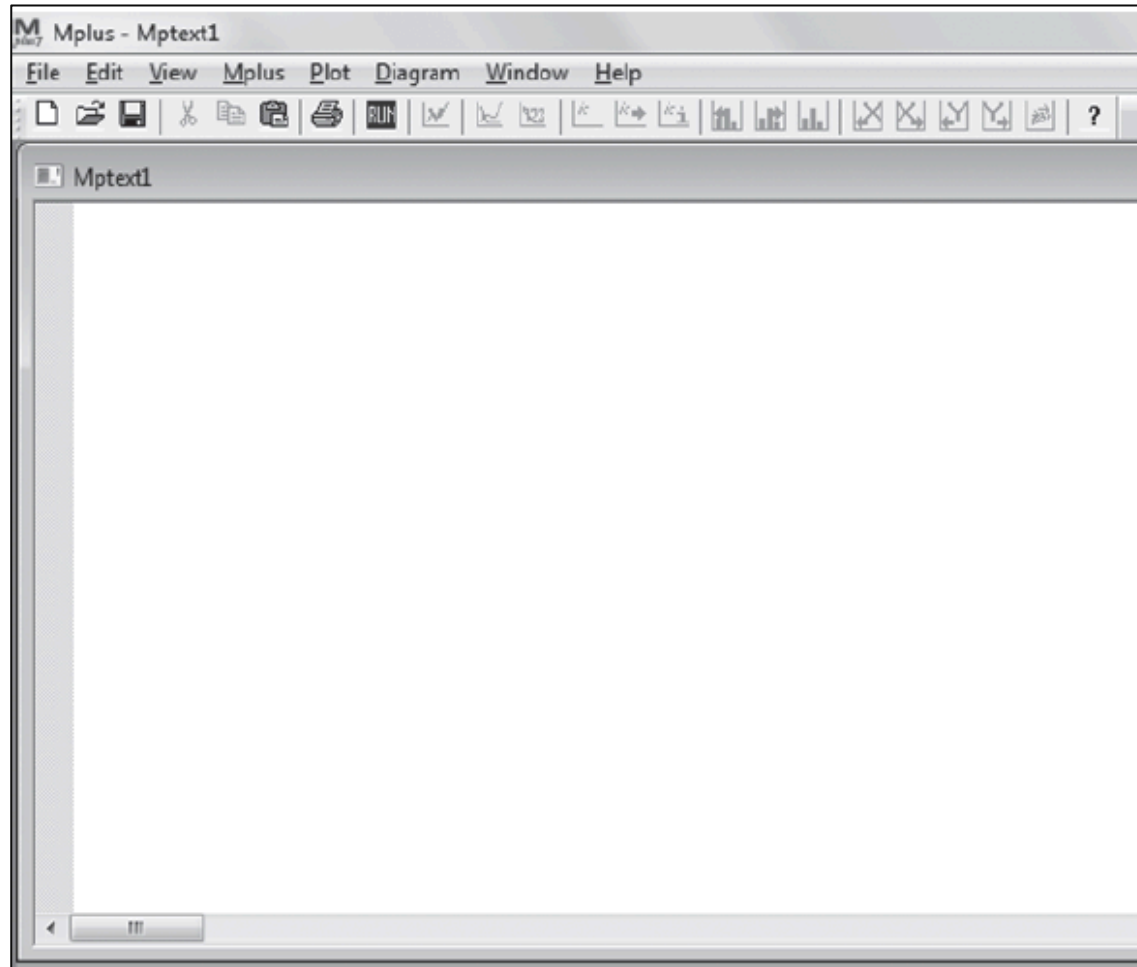
Click [here](#) for the Mplus User's Guide and to download the in the Mplus User's Guide

www.statmodel.com

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MPLUS

- Mplus editor
- Mplus input file: *.inp
- Mplus output file: *.out
- Input data file: *.dat
 - Define missings!
- Other software runs Mplus
 - runmplus (Stata)
 - MplusAutomation (R)



MPLUS Syntax

Command block	Options	Command block	Options
DATA	FILE IS	ANALYSIS	TYPE IS
	FORMAT IS		ESTIMATOR IS
	TYPE IS	MODEL	BY ON
VARIABLE	NAMES ARE		WITH
	USEVARIABLES	OUTPUT	STDYX RESIDUAL
	USEOBSERVATIONS		MODINDICES
	CATEGORICAL, COUNT etc.		CINTERVAL
DEFINE			

MPLUS Syntax

```
TITLE:      Einlesen des Datensatzes "GMF05_Querschnitt_CFA.dat"

DATA:       FILE IS GMF05_Querschnitt_CFA.dat;

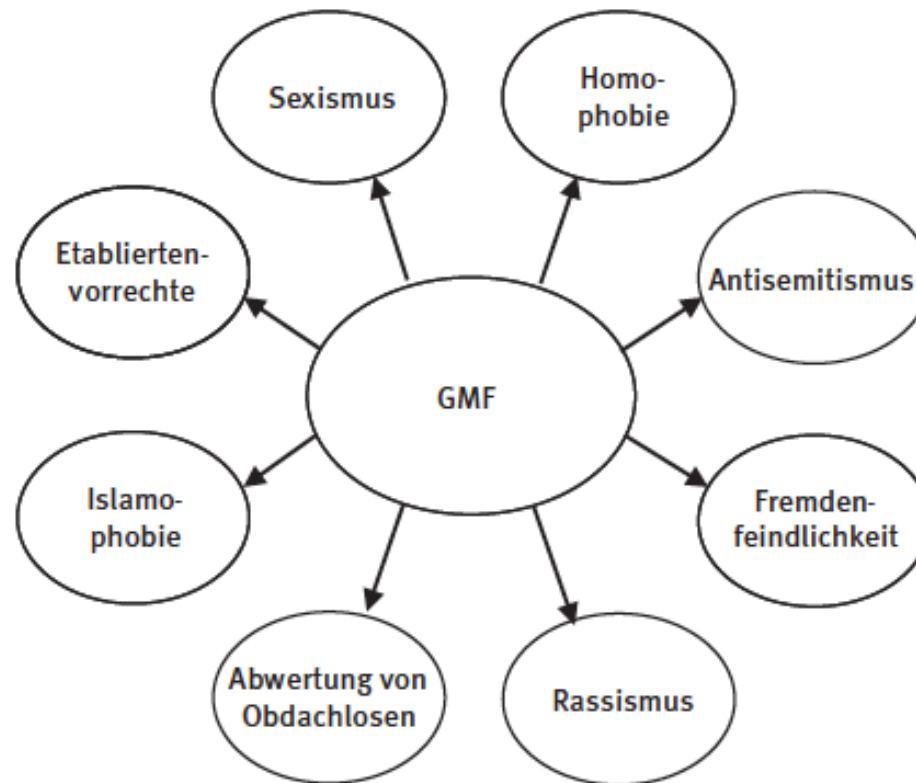
VARIABLE:   NAMES ARE qcp_ser he01hq4 sx03q4r sx04q4r he01oq4r
             he02oq4r he02hq4r ff04dq4r ff08dq4r ev03q4r ev04q4r
             ra01q4r ra03q4r as01q4r as02q4r he05mq4r he12mq4r
             ka05q4r zu01q4k;

             USEVARIABLES ARE he01hq4 sx03q4r sx04q4r he01oq4r
             he02oq4r he02hq4r ff04dq4r ff08dq4r ev03q4r ev04q4r
             ra01q4r ra03q4r as01q4r as02q4r he05mq4r he12mq4r
             ka05q4r zu01q4k;

             MISSING ARE he01oq4r he02oq4r (99) zu01q4k (9 99);

ANALYSIS:   TYPE IS BASIC;
```

Factor Analysis



(Kleinke et al 2017: Figure 2.1)

Factor Analysis

Element von GMF (in Klammern der Name der latenten Variablen in Mplus)	Indikatoren
Sexismus (sexism)	sx03q4r, sx04q4r
Homophobie (homoph)	he01hq4, he02hq4r
Antisemitismus (antisem)	as01q4r, as02q4r
Fremdenfeindlichkeit (fremdenf)	ff04dq4r, ff08dq4r
Rassismus (rass)	ra01q4r, ra03q4r
Abwertung von Obdachlosen (obdachl)	he01oq4r, he02oq4r
Islamophobie (islamph)	he05mq4r, he12mq4r
Etabliertenvorrechte (etabl)	ev03q4r, ev04q4r

Factor Analysis

Exploratory Factor Analysis	Confirmatory Factor Analysis
no theoretical model Number of factors are extracted by statistical criteria Factors are usually uncorrelated Matrix of factor loadings are estimated without restrictions	theoretical model Number of factors are restricted before the analysis Factors are usually correlated Matrix of factor loadings are estimated with restrictions

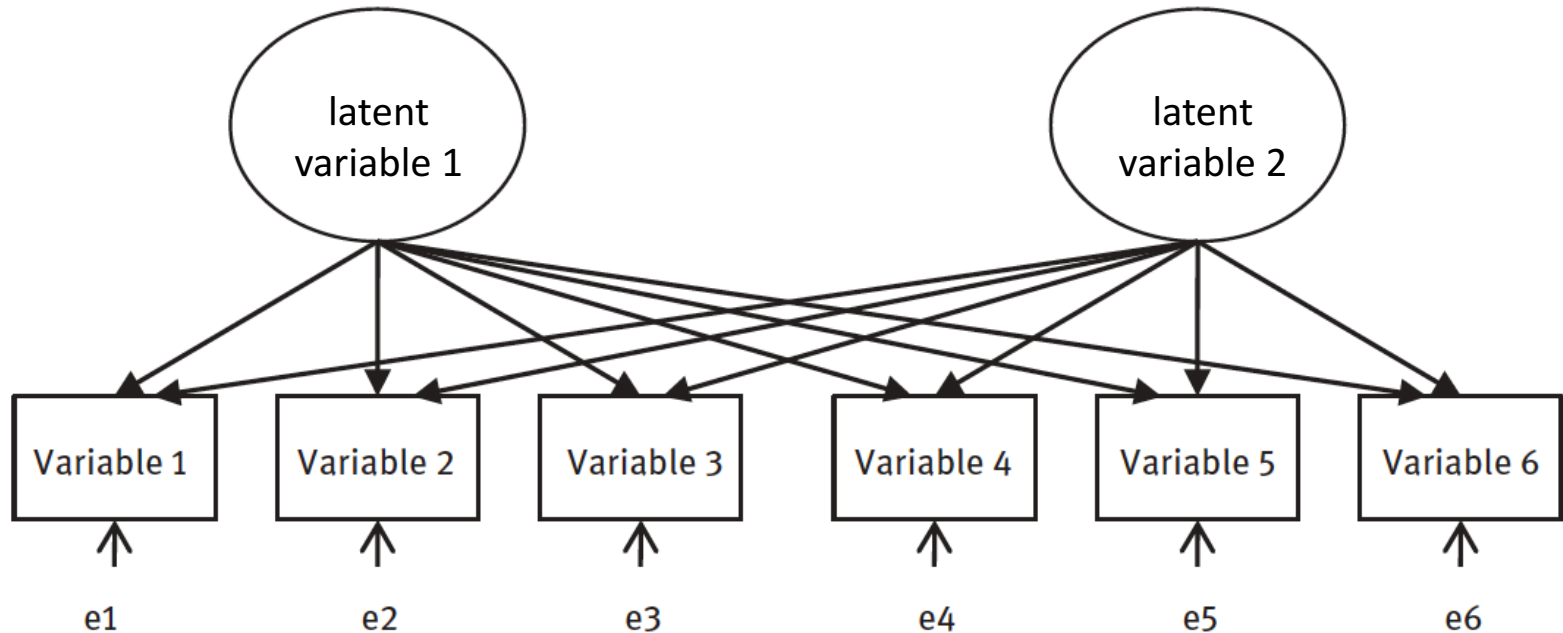
Exploratory Factor Analysis

- Exploratory factor analysis (EFA) is used to determine the number of continuous latent variables that are needed to explain the correlations among a set of observed variables.
- The continuous latent variables are referred to as factors, and the observed variables are referred to as factor indicators (manifest variables). In EFA, factor indicators can be continuous, censored, binary, ordered categorical (ordinal), counts, or combinations of these variable types.

Exploratory Factor Analysis

- Two main questions can be answered with exploratory factor analysis:
- How many factors are needed to explain the associations between the measurements (manifest variables)?
- How strong are the relationships between the factors and the measurements (manifest variables)?

Exploratory Factor Analysis



(Kleinke et al 2017: Figure 2.2)

Exploratory Factor Analysis

```
TITLE:      EFA basierend auf den Elementen Fremdenfeindlichkeit,  
            Rassismus und Islamophobie  
  
DATA:       FILE IS GMF05_Querschnitt_CFA.dat;  
  
VARIABLE:   NAMES ARE qcp_ser he01hq4 sx03q4r sx04q4r he01oq4r  
            he02oq4r he02hq4r ff04dq4r ff08dq4r ev03q4r ev04q4r  
            ra01q4r ra03q4r as01q4r as02q4r he05mq4r he12mq4r  
            ka05q4r zu01q4k;  
  
            USEVARIABLES ARE as01q4r as02q4r ra01q4r ra03q4r  
            he05mq4r he12mq4r;  
  
ANALYSIS:   TYPE IS EFA 1 3;
```

Note: oblique rotation of geomin per default

Specification of rotation:

ANALYSIS: ROTATION = GEOMIN (OBLIQUE, .5);

ANALYSIS: ROTATION = CF-VARIMAX (ORTHOGONAL);

Exploratory Factor Analysis

Model 2. Results for Exploratory Factor Analysis

EIGENVALUES FOR SAMPLE CORRELATION MATRIX					
	1	2	3	4	5
1	<u>2.702</u>	<u>0.921</u>	<u>0.881</u>	<u>0.606</u>	<u>0.499</u>

EIGENVALUES FOR SAMPLE CORRELATION MATRIX	
	6
1	<u>0.390</u>

Code: [M2](#), taken from Kleinke (et al 2017).

Exploratory Factor Analysis

EXPLORATORY FACTOR ANALYSIS WITH 1 FACTOR(S):

MODEL FIT INFORMATION

Number of Free Parameters 18

Loglikelihood

H0 Value -12195.173
H1 Value -11999.859

Information Criteria

Akaike (AIC) 24426.346
Bayesian (BIC) 24525.044
Sample-Size Adjusted BIC 24467.860
(n* = (n + 2) / 24)

Chi-Square Test of Model Fit

Value 390.628
Degrees of Freedom 9
P-Value 0.0000

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.154
90 Percent C.I. 0.142 0.168
Probability RMSEA <= .05 0.000

CFI/TLI

CFI 0.840
TLI 0.734

Chi-Square Test of Model Fit for the Baseline Model

Value 2404.353
Degrees of Freedom 15
P-Value 0.0000

SRMR (Standardized Root Mean Square Residual)

Value 0.061

EXPLORATORY FACTOR ANALYSIS WITH 2 FACTOR(S):

TESTS OF MODEL FIT

Chi-Square Test of Model Fit

Value 98.888
Degrees of Freedom 4
P-Value 0.0000

Chi-Square Test of Model Fit for the Baseline Model

Value 2404.353
Degrees of Freedom 15
P-Value 0.0000

CFI/TLI

CFI 0.960
TLI 0.851

Loglikelihood

H0 Value -12049.303
H1 Value -11999.859

Information Criteria

Number of Free Parameters 23
Akaike (AIC) 24144.606
Bayesian (BIC) 24270.720
Sample-Size Adjusted BIC 24197.651
(n* = (n + 2) / 24)

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.116
90 Percent C.I. 0.096 0.136
Probability RMSEA <= .05 0.000

SRMR (Standardized Root Mean Square Residual)

Exploratory Factor Analysis

GEOMIN ROTATED LOADINGS (* significant at 5% level)

1

AS01Q4R	0.696*	Jews have too much influence
AS02Q4R	0.714*	Jews responsible for own persecution
RA01Q4R	0.413*	German ancestry immigrants should be better off than others
RA03Q4R	0.530*	White people should rule the world
HE05MQ4R	0.542*	Muslims make me feel like a stranger
HE12MQ4R	0.569*	Muslims should be prohibited

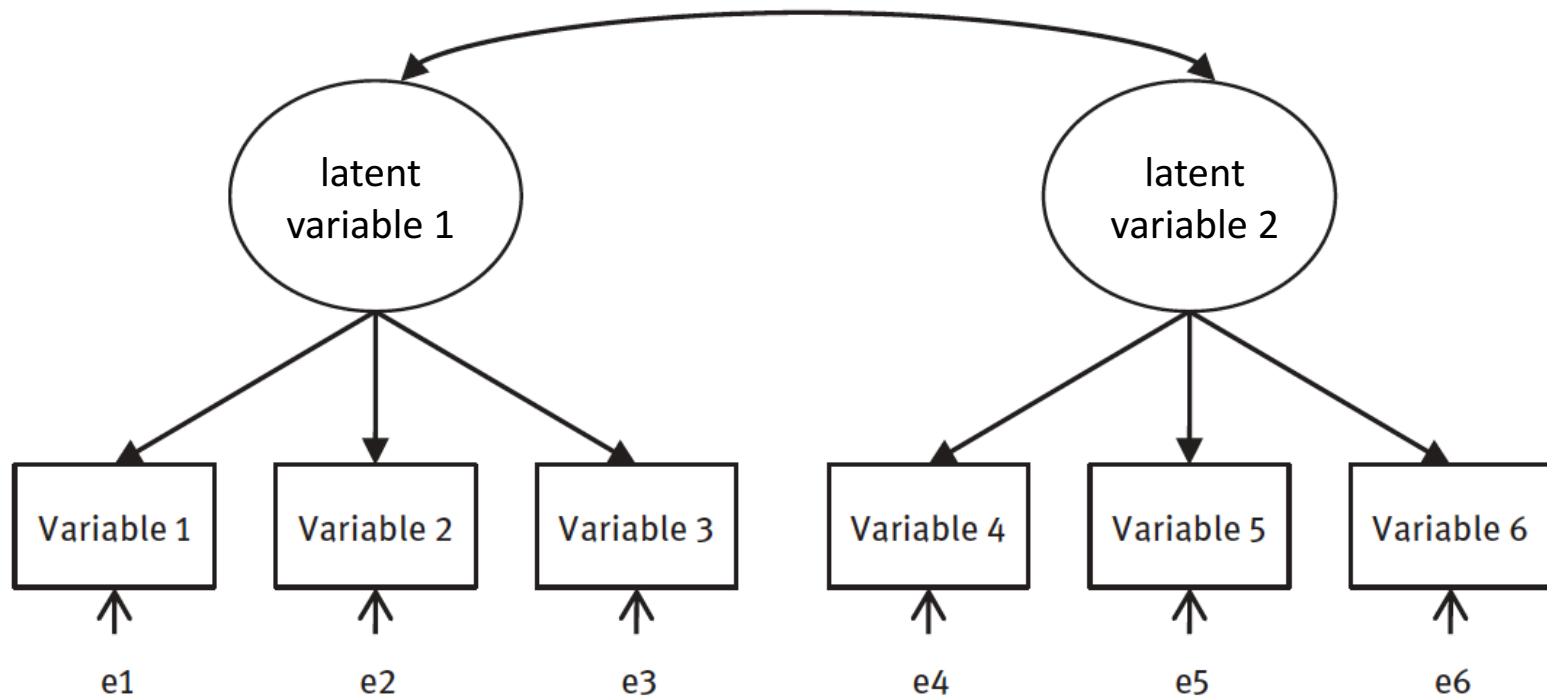
GEOMIN ROTATED LOADINGS (* significant at 5% level)

1

2

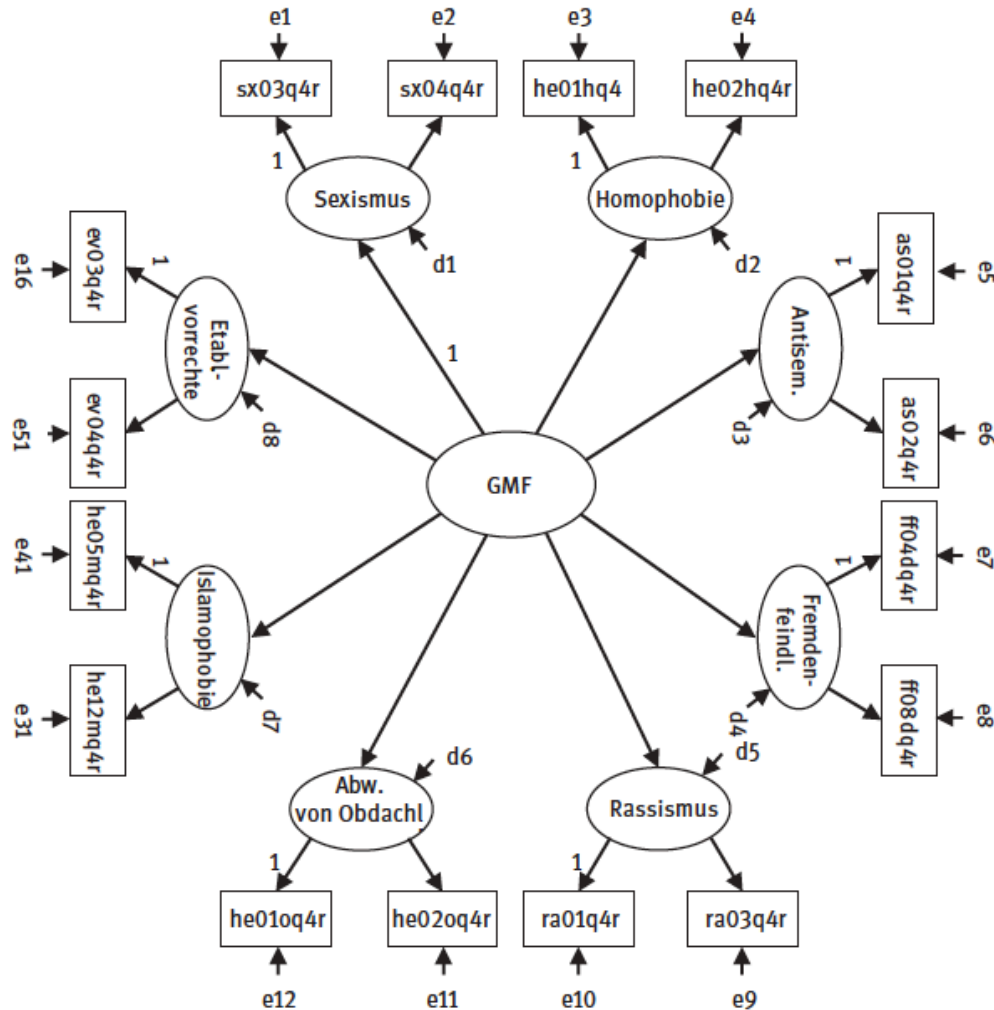
AS01Q4R	0.529*	0.224*
AS02Q4R	0.937*	-0.003*
RA01Q4R	0.101*	0.361*
RA03Q4R	0.248*	0.332*
HE05MQ4R	-0.006	0.677*
HE12MQ4R	0.001	0.719*

Confirmatory Factor Analysis



(Kleinke et al 2017: Figure 2.3)

Confirmatory Factor Analysis



(Kleinke et al 2017: Figure 2.4)

Confirmatory Factor Analysis

Model 3. CFA

```
TITLE:      Konfirmatorische Faktorenanalyse in Mplus

DATA:      FILE IS GMF05_Querschnitt_CFA.dat;

VARIABLE:  NAMES ARE qcp_ser he01hq4 sx03q4r sx04q4r he01oq4r
             he02oq4r he02hq4r ff04dq4r ff08dq4r ev03q4r ev04q4r
             ra01q4r ra03q4r as01q4r as02q4r he05mq4r he12mq4r
             ka05q4r zu01q4k;

             USEVARIABLES ARE he01hq4 sx03q4r sx04q4r he01oq4r
             he02oq4r he02hq4r ff04dq4r ff08dq4r ev03q4r ev04q4r
             ra01q4r ra03q4r as01q4r as02q4r he05mq4r he12mq4r;

             MISSING ARE he01oq4r he02oq4r (99);

MODEL:     sexism BY sx03q4r sx04q4r;           ! Spezifikation der
             homoph BY he01hq4 he02hq4r;         ! Faktoren 1. Ordnung
             antisem BY as01q4r as02q4r;
             fremdenf BY ff04dq4r ff08dq4r;
             rass BY ra01q4r ra03q4r;
             obdachl BY he01oq4r he02oq4r;
             islamph BY he05mq4r he12mq4r;
             etabl BY ev03q4r ev04q4r;

             gmf BY sexism homoph antisem fremdenf ! Spezifikation
             rass obdachl islamph etabl;           ! des Faktors 2. Ordnung

OUTPUT:    STDYX;
```

Code: [M3](#), taken from Kleinke (et al 2017).

Confirmatory Factor Analysis

TESTS OF MODEL FIT

Chi-Square Test of Model Fit

Value	2412.577
Degrees of Freedom	104
P-Value	0.0000

Chi-Square Test of Model Fit for the Baseline Model

Value	9064.830
Degrees of Freedom	120
P-Value	0.0000

CFI/TLI

CFI	0.742
TLI	0.702

Loglikelihood

H0 Value	-34249.455
H1 Value	-33043.166

Information Criteria

Number of Free Parameters	48
Akaike (AIC)	68594.909
Bayesian (BIC)	68858.105
Sample-Size Adjusted BIC	68705.612
(n* = (n + 2) / 24)	

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.112	
90 Percent C.I.	0.108	0.116
Probability RMSEA <= .05	0.000	

SRMR (Standardized Root Mean Square Residual)

Value	0.071
-------	-------

Code: [M3](#), taken from Kleinke (et al 2017).

Confirmatory Factor Analysis

Model 3. Results for Confirmatory Factor Analysis, STDYX

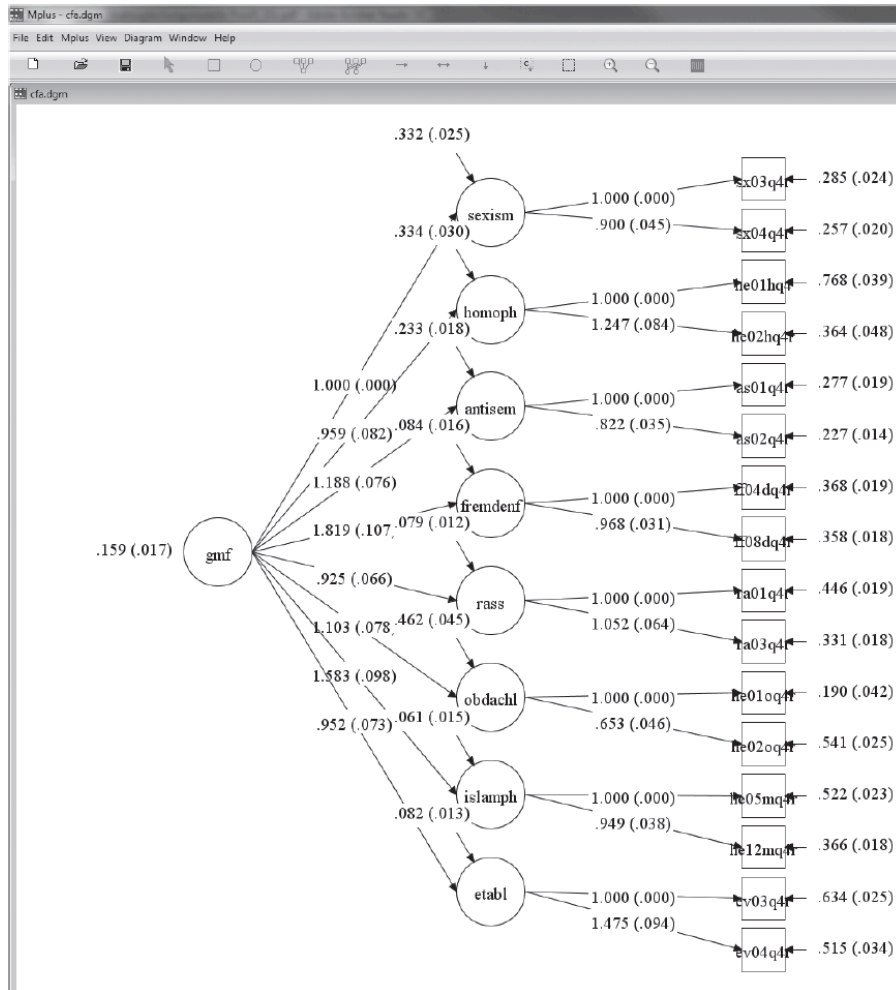
STANDARDIZED MODEL RESULTS

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value					
SEXISM BY									
SX03Q4R	0.795	0.020	39.880	0.000					
SX04Q4R	0.780	0.020	39.196	0.000					
HOMOPH BY					ISLAMPH BY				
HE01HQ4	0.620	0.024	25.773	0.000	HE05MQ4R	0.684	0.017	40.870	0.000
HE02HQ4R	0.820	0.026	30.969	0.000	HE12MQ4R	0.728	0.016	45.036	0.000
ANTISEM BY					ETABL BY				
AS01Q4R	0.789	0.017	46.603	0.000	EV03Q4R	0.512	0.023	22.088	0.000
AS02Q4R	0.760	0.017	44.454	0.000	EV04Q4R	0.699	0.024	29.026	0.000
FREMDENF BY					GMF BY				
FF04DQ4R	0.790	0.013	61.986	0.000	SEXISM	0.569	0.023	25.121	0.000
FF08DQ4R	0.784	0.013	61.090	0.000	HOMOPH	0.552	0.025	21.655	0.000
RASS BY					ANTISEM	0.700	0.019	36.101	0.000
RA01Q4R	0.570	0.023	24.838	0.000	FREMDENF	0.929	0.013	71.190	0.000
RA03Q4R	0.647	0.023	27.860	0.000	RASS	0.795	0.026	30.712	0.000
OBDACHL BY					OBDACHL	0.543	0.026	21.206	0.000
HE01OQ4R	0.880	0.029	30.779	0.000	ISLAMPH	0.931	0.016	56.495	0.000
HE02OQ4R	0.584	0.024	24.001	0.000	ETABL	0.798	0.026	30.399	0.000

Code: [M3](#), taken from Kleinke (et al 2017).

MPLUS Diagrammer



Confirmatory Factor Analysis

Model 4. Alternative CFA

```
TITLE:      Prüfung eines alternativen Messmodells

DATA:      FILE IS GMF05_Querschnitt_CFA.dat;

VARIABLE:  NAMES ARE qcp_ser he01hq4 sx03q4r sx04q4r he01oq4r
            he02oq4r he02hq4r ff04dq4r ff08dq4r ev03q4r ev04q4r
            ra01q4r ra03q4r as01q4r as02q4r he05mq4r he12mq4r
            ka05q4r zu01q4k;

            USEVARIABLES ARE he01hq4 sx03q4r sx04q4r he01oq4r
            he02oq4r he02hq4r ff04dq4r ff08dq4r ev03q4r ev04q4r
            ra01q4r ra03q4r as01q4r as02q4r he05mq4r he12mq4r;

            MISSING ARE he01oq4r he02oq4r (99);

MODEL:     gmf BY sx03q4r sx04q4r          ! Spezifikation einer
            he01hq4 he02hq4r              ! latenten Variablen
            as01q4r as02q4r
            ff04dq4r ff08dq4r
            ra01q4r ra03q4r
            he01oq4r he02oq4r
            he05mq4r he12mq4r
            ev03q4r ev04q4r;

OUTPUT:    STDYX;
```

Code: [M4](#), taken from Kleinke (et al 2017).

Confirmatory Factor Analysis

MODEL FIT INFORMATION

Number of Free Parameters 48

Loglikelihood

H0 Value -34249.455
H1 Value -33043.166

Information Criteria

Akaike (AIC) 68594.909
Bayesian (BIC) 68858.105
Sample-Size Adjusted BIC 68705.612
($n^* = (n + 2) / 24$)

Chi-Square Test of Model Fit

Value 2412.577
Degrees of Freedom 104
P-Value 0.0000

Model 4. Alternative CFA

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.112
90 Percent C.I. 0.108 0.116
Probability RMSEA <= .05 0.000

CFI/TLI

CFI 0.742
TLI 0.702

Chi-Square Test of Model Fit for the Baseline Model

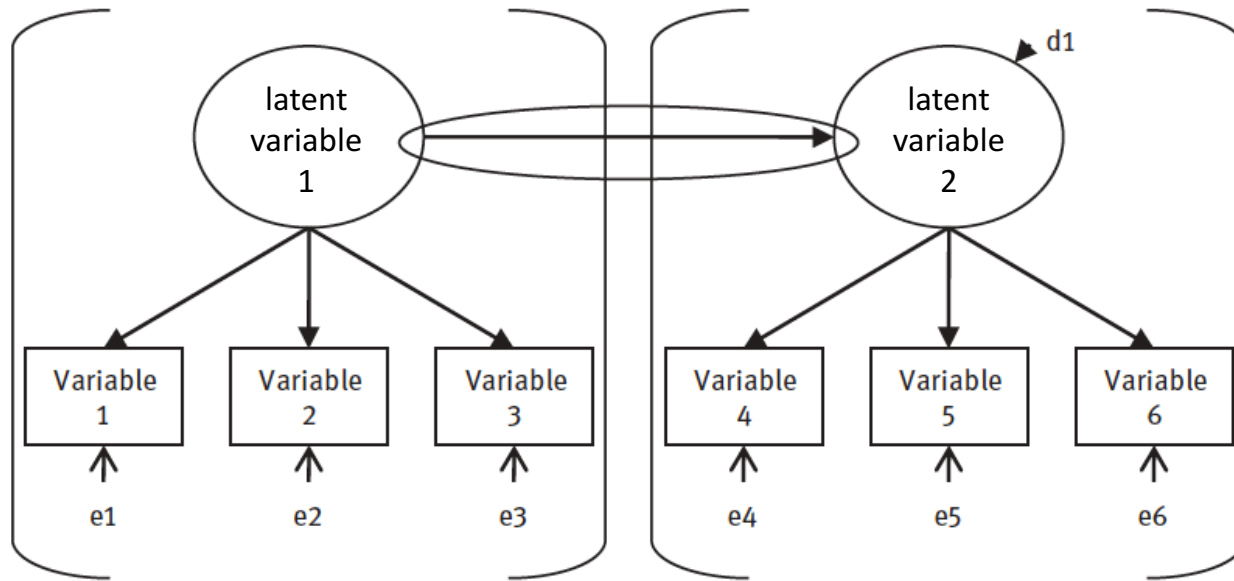
Value 9064.830
Degrees of Freedom 120
P-Value 0.0000

SRMR (Standardized Root Mean Square Residual)

Value 0.071

Code: [M4](#), taken from Kleinke (et al 2017).

Structural Equation Model



(Kleinke et al 2017: Figure 3.1)

Structural Equation Model

Model 5. SEM

```
Title:      SEM Intergruppenkontakt und GMF

Data:      FILE IS GMF07_Querschnitt_SEM.dat;

VARIABLE:  NAMES ARE qcp_ser sx03q6r sx04q6r he01oq6r he02oq6r
             he01hq6 he02hq6r ff04dq6r ff08dq6r he05mq6r he12mq6r
             ev03q6r ev04q6r ra01q6r ra03q6r as01q6r as02q6r
             dy04q6r dy02q6r ka03nq4r;

             USEVARIABLES sx03q6r sx04q6r he01oq6r he02oq6r
             he01hq6 he02hq6r ff04dq6r ff08dq6r he05mq6r he12mq6r
             ev03q6r ev04q6r ra01q6r ra03q6r as01q6r as02q6r ka03nq4r;

             MISSING ARE ALL (99);

MODEL:     sexism BY sx03q6r sx04q6r;  ! Messmodelle für die Elemente
             homoph BY he01hq6 he02hq6r; ! von GMF
             antisem BY as01q6r as02q6r;
             fremdenf BY ff04dq6r ff08dq6r;
             rass BY ra01q6r ra03q6r;
             obdachl BY he01oq6r he02oq6r;
             islamph BY he05mq6r he12mq6r;
             etabl BY ev03q6r ev04q6r;

             GMF BY sexism homoph antisem fremdenf rass ! Messmodell GMF
             obdachl islamph etabl;

             GMF ON ka03nq4r; ! Regression von GMF auf Intergruppenkontakt

OUTPUT:    STDYX MODINDICES;
```

Code: [M5](#), taken from Kleinke (et al 2017).

Structural Equation Model

STANDARDIZED MODEL RESULTS

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
SEXISM BY				
SX03Q6R	0.703	0.034	20.379	0.000
SX04Q6R	0.839	0.037	22.613	0.000
HOMOPH BY				
HE01HQ6	0.732	0.034	21.832	0.000
HE02HQ6R	0.762	0.034	22.395	0.000
ANTISEM BY				
AS01Q6R	0.769	0.028	27.578	0.000
AS02Q6R	0.749	0.028	26.695	0.000
FREMDENF BY				
FF04DQ6R	0.770	0.019	40.122	0.000
FF08DQ6R	0.753	0.020	38.225	0.000
RASS BY				
RA01Q6R	0.529	0.033	16.264	0.000
RA03Q6R	0.667	0.033	20.253	0.000
OBDACHL BY				
HE01OQ6R	0.789	0.040	19.567	0.000
HE02OQ6R	0.588	0.036	16.232	0.000
ISLAMPH BY				
HE05MQ6R	0.698	0.022	31.579	0.000
HE12MQ6R	0.831	0.019	43.408	0.000
ETABL BY				
EV03Q6R	0.615	0.032	19.149	0.000
EV04Q6R	0.655	0.032	20.304	0.000
GMF BY				
SEXISM	0.485	0.036	13.428	0.000
HOMOPH	0.532	0.035	15.174	0.000
ANTISEM	0.643	0.031	20.852	0.000
FREMDENF	0.972	0.019	51.173	0.000
RASS	0.853	0.037	22.820	0.000
OBDACHL	0.560	0.038	14.820	0.000
ISLAMPH	0.896	0.021	43.371	0.000
ETABL	0.760	0.035	21.674	0.000
GMF ON				
KA03NQ4R	-0.244	0.035	-7.015	0.000

Model 5. Full SEM – Measurement plus Path Model

Code: [M5](#), taken from Kleinke (et al 2017).

Structural Equation Model

MODEL FIT INFORMATION

Number of Free Parameters 57

Loglikelihood

H0 Value -15742.260
H1 Value -15552.900

Information Criteria

Akaike (AIC) 31598.519
Bayesian (BIC) 31869.929
Sample-Size Adjusted BIC 31688.912
($n^* = (n + 2) / 24$)

Chi-Square Test of Model Fit

Value 378.719
Degrees of Freedom 111
P-Value 0.0000

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.053
90 Percent C.I. 0.047 0.059
Probability RMSEA \leq .05 0.205

CFI/TLI

CFI 0.937
TLI 0.923

Chi-Square Test of Model Fit for the Baseline Model

Value 4397.721
Degrees of Freedom 136
P-Value 0.0000

SRMR (Standardized Root Mean Square Residual)

Value 0.045

Code: [M5](#), taken from Kleinke (et al 2017).

Structural Equation Model

MODEL MODIFICATION INDICES

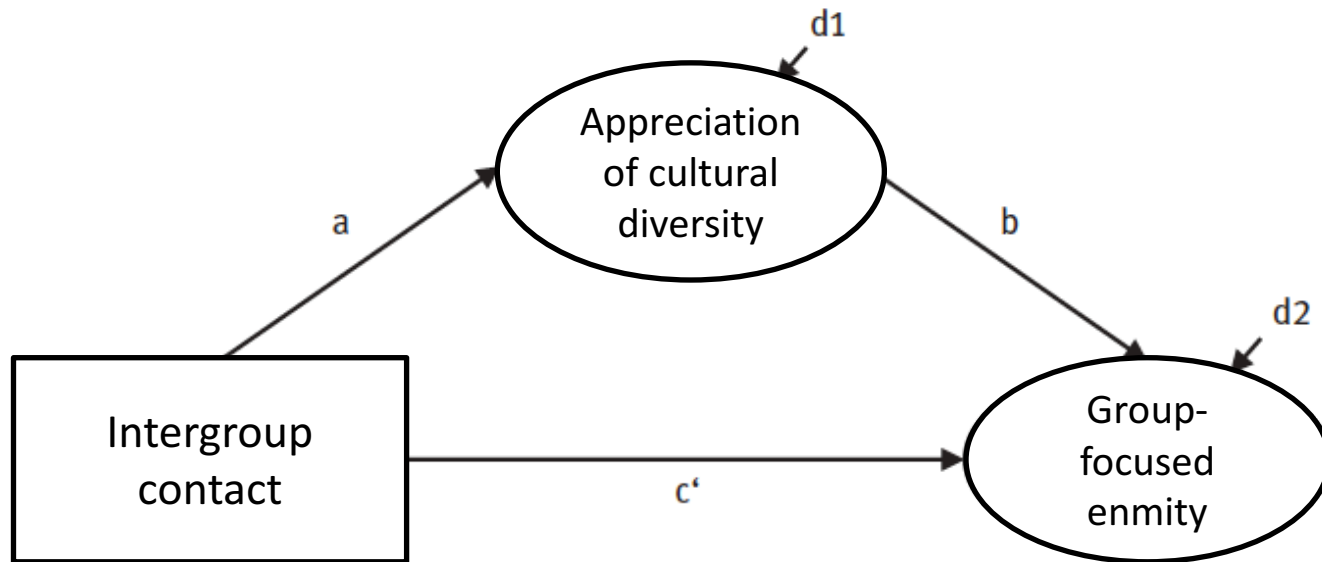
NOTE: Modification indices for direct effects of observed dependent variables regressed on covariates may not be included. To include these, request MODINDICES (ALL).

Minimum M.I. value for printing the modification index 10.000

		M.I.	E.P.C.	Std E.P.C.	StdYX E.P.C.
BY Statements					
SEXISM	BY HE01HQ6	23.846	0.322	0.192	0.186
SEXISM	BY FF04DQ6R	11.084	-0.188	-0.112	-0.117
SEXISM	BY FF08DQ6R	17.361	-0.218	-0.129	-0.148
HOMOPH	BY SX03Q6R	25.657	0.234	0.176	0.208
FREMDENF	BY SX04Q6R	25.445	-2.074	-1.527	-2.059
FREMDENF	BY HE05MQ6R	17.292	2.580	1.900	1.911
FREMDENF	BY HE12MQ6R	23.200	2.620	1.930	2.155
RASS	BY EV04Q6R	24.957	1.430	0.601	0.608
OBDACHL	BY HE02HQ6R	12.285	0.206	0.158	0.155
ISLAMPH	BY HE02HQ6R	14.116	-0.652	-0.452	-0.445
ISLAMPH	BY FF04DQ6R	28.100	0.925	0.642	0.671
ISLAMPH	BY FF08DQ6R	14.995	0.620	0.430	0.493
ETABL	BY RA01Q6R	42.358	0.701	0.425	0.535
ON/BY Statements					
SEXISM	ON HOMOPH /				
HOMOPH	BY SEXISM	60.058	0.330	0.418	0.418
SEXISM	ON FREMDENF /				
FREMDENF	BY SEXISM	40.796	-2.869	-3.553	-3.553
SEXISM	ON RASS /				
RASS	BY SEXISM	14.219	0.788	0.557	0.557

Code: [M5](#), taken from Kleinke (et al 2017).

Mediation Model: Indirect and Direct Effects



(Kleinke et al 2017: Figure 3.2)

Mediation Model: Indirect and Direct Effects

Model 6. Direct and Indirect

```
Title:      SEM Intergruppenkontakt und GMF, Model Indirect
           Sobel-Test

Data:      FILE IS GMF07_Querschnitt_SEM.dat;

VARIABLE:  NAMES ARE qcp_ser sx03q6r sx04q6r he01oq6r he02oq6r
           he01hq6 he02hq6r ff04dq6r ff08dq6r he05mq6r he12mq6r
           ev03q6r ev04q6r ra01q6r ra03q6r as01q6r as02q6r
           dy04q6r dy02q6r ka03nq4r;

           USEVARIABLES sx03q6r sx04q6r he01oq6r he02oq6r
           he01hq6 he02hq6r ff04dq6r ff08dq6r he05mq6r he12mq6r
           ev03q6r ev04q6r ra01q6r ra03q6r as01q6r as02q6r ka03nq4r
           dy04q6r dy02q6r;

           MISSING ARE ALL (99);

MODEL:     sexism BY sx03q6r sx04q6r;    ! Messmodelle für die Elemente
           homoph BY he01hq6 he02hq6r;  ! von GMF
           antisem BY as01q6r as02q6r;
           fremdenf BY ff04dq6r ff08dq6r;
           rass BY ra01q6r ra03q6r;
```

Code: [M6](#), taken from Kleinke (et al 2017).

Mediation Model: Indirect and Direct Effects

Model 6

```
obdachl BY he01oq6r he02oq6r;
islamph BY he05mq6r he12mq6r;
etabl BY ev03q6r ev04q6r;

GMF BY sexism homoph antisem fremdenf rass ! Messmodell GMF
obdachl islamph etabl;

wertsch BY dy04q6r dy02q6r;    ! Messmodell für Wertschätzung
                                ! kultureller Vielfalt

GMF ON ka03nq4r;                ! Direkter Effekt von Kontakt auf GMF (c')
wertsch ON ka03nq4r;            ! Effekt von Kontakt auf Wertschätzung
                                ! kultureller Vielfakt (a)

GMF ON wertsch;                 ! Effekt von Wert. kultureller Vielfalt
                                ! auf GMF (b)

MODEL INDIRECT:
GMF IND ka03nq4r;               ! Prüfung des indirekten Effekts von Kontakt
                                ! auf GMF

OUTPUT: STDYX;
```

Mediation Model: Indirect and Direct Effects

Model 6. Direct and Indirect Effects

STANDARDIZED TOTAL, TOTAL INDIRECT, SPECIFIC INDIRECT, AND DIRECT EFFECTS

STDYX Standardization

	Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Effects from KA03NQ4R to GMF				
Total	-0.245	0.035	-7.074	0.000
Total indirect	-0.162	0.025	-6.467	0.000
Specific indirect				
GMF WERTSCH KA03NQ4R	-0.162	0.025	-6.467	0.000
Direct				
GMF KA03NQ4R	-0.083	0.033	-2.484	0.013

Code: [M6](#), taken from Kleinke (et al 2017).

Model Fit

MODEL FIT INFORMATION

Number of Free Parameters	65
Loglikelihood	
H0 Value	-15751.784
H1 Value	-15545.122
Information Criteria	
Akaike (AIC)	31633.569
Bayesian (BIC)	31936.172
Sample-Size Adjusted BIC	31729.766
(n* = (n + 2) / 24)	
Chi-Square Test of Model Fit	
Value	413.324
Degrees of Freedom	142
P-Value	0.0000
RMSEA (Root Mean Square Error Of Approximation)	
Estimate	0.050
90 Percent C.I.	0.044 0.055
Probability RMSEA <= .05	0.538
CFI/TLI	
CFI	0.940
TLI	0.928
Chi-Square Test of Model Fit for the Baseline Model	
Value	4684.962
Degrees of Freedom	171
P-Value	0.0000
SRMR (Standardized Root Mean Square Residual)	
Value	0.044

Model 7. Exact Fit Test. Fit Statistics for Mediation Model

Models must be nested for chi-square tests!

Code: [M7](#), data from Kleinke (et al 2017).

Model Fit

MODEL FIT INFORMATION

Number of Free Parameters 65

Loglikelihood

H0 Value -15751.784
H1 Value -15545.122

Information Criteria

Akaike (AIC) 31633.569
Bayesian (BIC) 31936.172
Sample-Size Adjusted BIC 31729.766
($n^* = (n + 2) / 24$)

Chi-Square Test of Model Fit

Value 413.324
Degrees of Freedom 142
P-Value 0.0000

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.050
90 Percent C.I. 0.044 0.055
Probability RMSEA <= .05 0.538

CFI/TLI

CFI 0.940
TLI 0.928

Chi-Square Test of Model Fit for the Baseline Model

Value 4684.962
Degrees of Freedom 171
P-Value 0.0000

SRMR (Standardized Root Mean Square Residual)

Value 0.044

Model 7. Exact Fit Test. Fit Statistics for Mediation Model

Code: [M7](#), data from Kleinke (et al 2017).

Model Fit

MODEL FIT INFORMATION

```

Number of Free Parameters              65

Loglikelihood

    H0 Value              -15751.784
    H1 Value              -15545.122

Information Criteria

    Akaike (AIC)          31633.569
    Bayesian (BIC)        31936.172
    Sample-Size Adjusted BIC 31729.766
      (n* = (n + 2) / 24)

Chi-Square Test of Model Fit

    Value              413.324
    Degrees of Freedom      142
    P-Value              0.0000

RMSEA (Root Mean Square Error Of Approximation)

    Estimate              0.050
    90 Percent C.I.        0.044  0.055
    Probability RMSEA <= .05 0.538

CFI/TLI

    CFI              0.940
    TLI              0.928

Chi-Square Test of Model Fit for the Baseline Model

    Value              4684.962
    Degrees of Freedom      171
    P-Value              0.0000

SRMR (Standardized Root Mean Square Residual)

    Value              0.044
  
```

Model 7. Exact Fit Test. Fit Statistics for Mediation Model

Chi-Square (χ^2)

Degrees of Freedom

Significance – Tests whether this model fits the data *worse* than the baseline model. A significant p means *it does not fit worse*.

Code: [M7](#), data from Kleinke (et al 2017).

Model Fit

RASS	ON WERTSCH	/				
WERTSCH	BY RASS		12.885	0.166	0.254	0.254
OBDACHL	ON ISLAMPH	/				
ISLAMPH	BY OBDACHL		11.405	-0.842	-0.784	-0.784
ISLAMPH	ON FREMDENF	/				
FREMDENF	BY ISLAMPH		26.270	3.866	4.056	4.056
ISLAMPH	ON OBDACHL	/				
OBDACHL	BY ISLAMPH		11.403	-0.149	-0.160	-0.160
ISLAMPH	ON ETABL	/				
ETABL	BY ISLAMPH		14.083	-0.372	-0.319	-0.319
ISLAMPH	ON WERTSCH	/				
WERTSCH	BY ISLAMPH		34.958	-0.334	-0.311	-0.311
ETABL	ON RASS	/				
RASS	BY ETABL		30.631	1.248	0.885	0.885
ETABL	ON ISLAMPH	/				
ISLAMPH	BY ETABL		14.083	-0.781	-0.912	-0.912
GMF	ON RASS	/				
RASS	BY GMF		11.604	0.434	0.708	0.708
GMF	ON ISLAMPH	/				
ISLAMPH	BY GMF		30.548	-0.650	-1.744	-1.744
WERTSCH	ON RASS	/				
RASS	BY WERTSCH		11.949	1.172	0.766	0.766
WERTSCH	ON ISLAMPH	/				
ISLAMPH	BY WERTSCH		33.683	-1.795	-1.930	-1.930

WITH Statements

HE01HQ6	WITH SX03Q6R		17.478	0.086	0.086	0.201
HE02HQ6R	WITH HE02OQ6R		12.866	0.084	0.084	0.169
FF08DQ6R	WITH SX04Q6R		15.463	-0.051	-0.051	-0.240
EV03Q6R	WITH HE01OQ6R		12.072	0.088	0.088	0.185
RA01Q6R	WITH EV04Q6R		33.236	0.122	0.122	0.250
AS02Q6R	WITH RA03Q6R		11.293	0.040	0.040	0.163
DY04Q6R	WITH HE02HQ6R		11.931	0.065	0.065	0.182
HOMOPH	WITH SEXISM		43.934	0.115	0.366	0.366
FREMDENF	WITH SEXISM		30.182	-0.070	-0.951	-0.951
ISLAMPH	WITH FREMDENF		26.283	0.082	2.134	2.134
ISLAMPH	WITH OBDACHL		11.403	-0.058	-0.354	-0.354
ETABL	WITH RASS		30.632	0.065	0.748	0.748
ETABL	WITH ISLAMPH		14.083	-0.054	-0.539	-0.539
GMF	WITH RASS		11.605	0.023	0.506	0.506
GMF	WITH ISLAMPH		30.545	-0.045	-0.872	-0.872
WERTSCH	WITH RASS		11.948	0.061	0.426	0.426
WERTSCH	WITH ISLAMPH		33.685	-0.125	-0.750	-0.750

Model 7. Exact Fit Test. Fit Statistics for Mediation Model

Modification Indices
(‘MODINDICES’)

Savedata: ‘DIFFTEST’
(for MLMV WLSMV)

OUTPUT: STDYX MODINDICES;
SAVEDATA: DIFFTEST is semindir.dat;

Code: [M7](#), data from Kleinke (et al 2017).

Model Fit

MODEL FIT INFORMATION

Number of Free Parameters 76

Loglikelihood

H0 Value -16467.809
H1 Value -16375.733

Information Criteria

Akaike (AIC) 33087.619
Bayesian (BIC) 33441.432
Sample-Size Adjusted BIC 33200.095
(n* = (n + 2) / 24)

Chi-Square Test of Model Fit

Value 184.153
Degrees of Freedom 133
P-Value 0.0022

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.022
90 Percent C.I. 0.014 0.030
Probability RMSEA <= .05 1.000

CFI/TLI

CFI 0.989
TLI 0.985

Chi-Square Test of Model Fit for the Baseline Model

Value 4684.962
Degrees of Freedom 171
P-Value 0.0000

Model 8. Equal Fit Test after Modifications

Table 1. Chi-Square Tests for M7 and M8

χ^2	M7	M8	M7-M8
value	413.3	184.2	229.2
df	142	133	9
p-value	0.0000	0.0022	0.0000
test type	Exact	Exact	Equal

Table 1. [Excel Chi-Square Calculator](#)

Model Fit

MODEL FIT INFORMATION

Number of Free Parameters 76

Loglikelihood

H0 Value -16467.809
H1 Value -16375.733

Information Criteria

Akaike (AIC) 33087.619
Bayesian (BIC) 33441.432
Sample-Size Adjusted BIC 33200.095
(n* = (n + 2) / 24)

Chi-Square Test of Model Fit

Value 184.153
Degrees of Freedom 133
P-Value 0.0022

RMSEA (Root Mean Square Error Of Approximation)

Estimate 0.022
90 Percent C.I. 0.014 0.030
Probability RMSEA <= .05 1.000

CFI/TLI

CFI 0.989
TLI 0.985

Chi-Square Test of Model Fit for the Baseline Model

Value 4684.962
Degrees of Freedom 171
P-Value 0.0000

Model 8. Equal Fit Test after Modifications

Table 1. Chi-Square Tests for M7 and M8

χ^2	M7	M8	M7-M8
value	413.3	184.2	229.2
df	142	133	9
p-value	0.0000	0.0022	0.0000
test type	Exact	Exact	Equal

Exact Fit Hypothesis:

That the tested model is significantly different from the baseline ($p > 0.05$ rejects; supports tested model)

Equal Fit Hypothesis:

That the larger model (less df) is significantly better fitting than the smaller model (more df) ($p > 0.05$ rejects; supports the smaller model)

Model Fit

MODEL FIT INFORMATION

Number of Free Parameters 76

Loglikelihood

H0 Value	-16467.809
H1 Value	-16375.733

Information Criteria

Akaike (AIC)	33087.619
Bayesian (BIC)	33441.432
Sample-Size Adjusted BIC	33200.095
(n* = (n + 2) / 24)	

Chi-Square Test of Model Fit

Value	184.153
Degrees of Freedom	133
P-Value	0.0022

RMSEA (Root Mean Square Error Of Approximation)

Estimate	0.022	
90 Percent C.I.	0.014	0.030
Probability RMSEA <= .05	1.000	

CFI/TLI

CFI	0.989
TLI	0.985

Chi-Square Test of Model Fit for the Baseline Model

Value	4684.962
Degrees of Freedom	171
P-Value	0.0000

Model 8. Equal Fit Test after Modifications

Thank You

- [Technical appendix](#) with Stata syntax and a dictionary of SEM terms (still under construction)
- Follow all hyperlinks in the slides, or find all examples in [this folder](#)
- [SEMNET](#), a vibrant listserv for SEM questions and discussion
- Mplus discussion forum at www.statmodel.com

References

- Bollen, Kenneth A. 1989. *Structural Equations with Latent Variables*. New York, NY: John Wiley & Sons.
- Bollen, Kenneth A, and Judea Pearl. 2013. “Eight Myths about Causality and Structural Equation Models.” In *Handbook of Causal Analysis for Social Research*, ed. Stephen L. Morgan. Dordrecht, Netherlands: Springer Science & Business Media, 301–28.
- Kline, Rex B. 2016. *Principles and Practice of Structural Equation Modeling*. 4th Edition. New York and London: Guilford Press.
- Kleinke, Kristian, Elmar Schlüter, and Oliver Christ. 2017. *Strukturgleichungsmodelle Mit Mplus: Eine Praktische Einführung*. Oldenburg: Walter de Gruyter.

(Kleinke et al 2017)

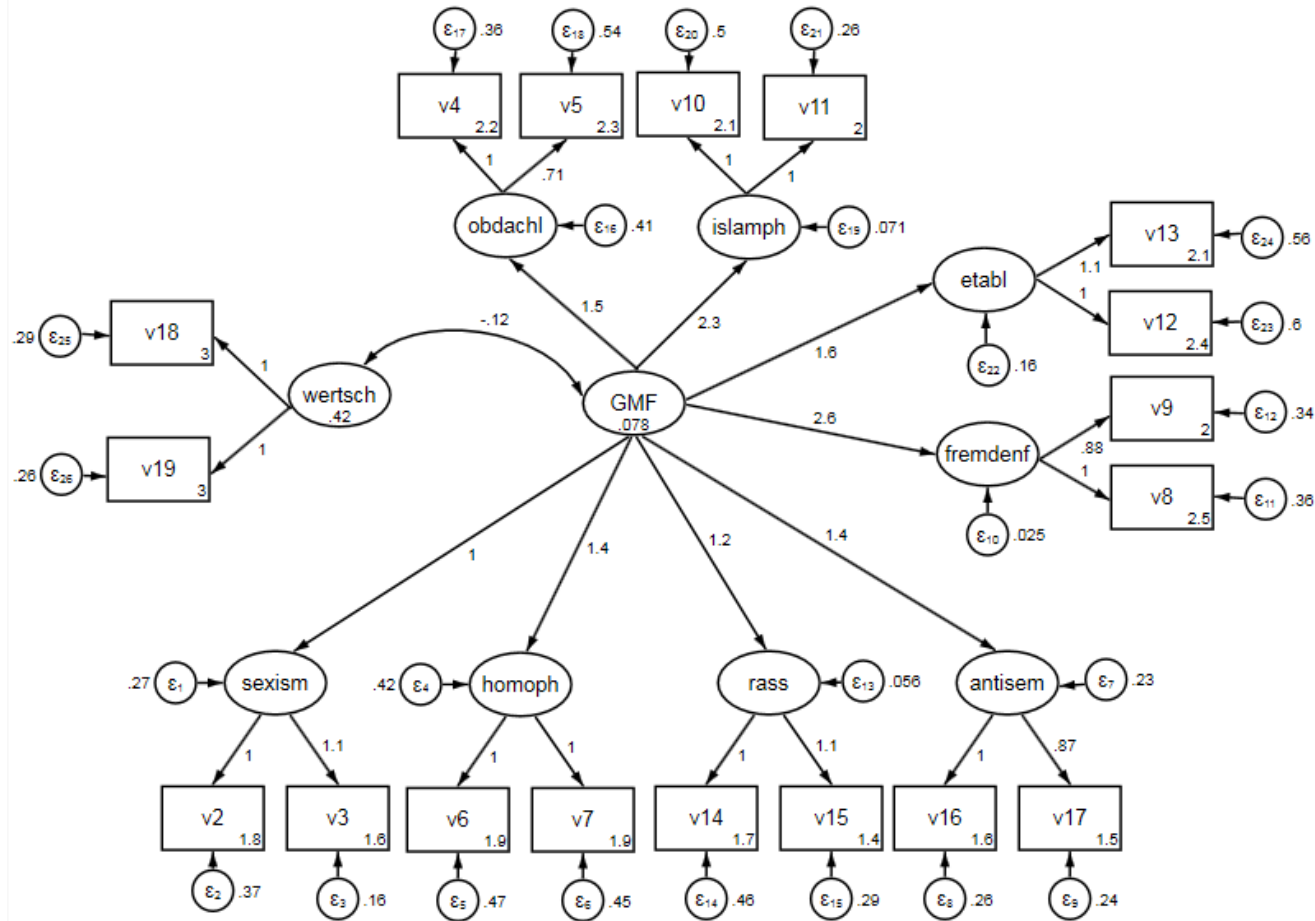
Tabelle 2.1: Variablennamen und Variablenlabels des Datensatzes „GMF05_Querschnitt_CFA.sav“

Variablenname		Variablenlabel
qcp_ser	v1	Id-Nr. des Datensatzes
he01hq4	*	Gleichgeschlechtliche Ehen erlaubt
sx03q4r	v2	Frauen wieder Rolle der Ehefrau u. Mutter
sx04q4r	v3	Für Frau sollte es wichtiger sein, dem Mann bei der Karriere zu helfen
he01oq4r	v4	Obdachlose aus Fußgängerzonen entfernen
he02oq4r	v5	Obdachlose in den Städten unangenehm
he02hq4r	v6	Ekelhaft, wenn Homosexuelle sich in der Öffentlichkeit küssen
ff04dq4r	v8	Es leben zu viele Ausländer in Deutschland
ff08dq4r	v9	Wenn Arbeitsplätze knapp werden, sollte man die Ausländer in die Heimat schicken
ev03q4r	v12	Wer neu ist, sollte sich mit weniger zufrieden geben
ev04q4r	v13	Wer schon immer hier lebt, sollte mehr Rechte haben
ra01q4r	v14	Aussiedler sollten besser gestellt werden als Ausländer, da deutscher Abstammung
ra03q4r	v15	Die Weißen sind zurecht führend in der Welt
as01q4r	v16	Juden haben in Deutschland zu viel Einfluss
as02q4r	v17	Juden sind an ihren Verfolgungen mitschuldig
he05mq4r	v10	Durch die vielen Muslime fühle ich mich wie ein Fremder
he12mq4r	v11	Muslimen sollte die Zuwanderung untersagt werden
ka05q4r	v20	Hatten Sie schon einmal Kontakt zu Ausländern?
zu01q4k	.	Schulabschluss, gruppiert nach 3 Kategorien

dy04q6r v18 – different cultures enrich German culture

dy02q6r v19 – appreciation of different cultures

A Stata Example



Code: [StataModel](#), or see Technical Appendix,
data from Kleinke (et al 2017).