## Introduction

This document shows how you can replicate the popularity data multilevel models from Multilevel analysis: Techniques and applications (Hox, J. J., Moerbeek, M., & van de Schoot, R, 2018), Chapter 2. In this manual the software package HLM7 for Windows was used. Results should be very similar to results obtained with other software packages, however due to convergence and rounding issues, you might notice minor differences. This tutorial is based on earlier versions of similar manuals and made by Laurent Smeets.

## STEP 1: Downloading the data.

To download the popularity data go to <u>https://multilevel-analysis.sites.uu.nl/datasets/</u> and follow the links to <u>https://github.com/MultiLevelAnalysis/Datasets-third-edition-Multilevel-book/blob/master/chapter%202/popularity/SPSS/popular2.sav</u>. We will use the .sav file in HLM, which can be found in the SPSS folder.

## STEP 2: Loading the data.

1) To load the SPSS datafile go to File > Make new MDM file > Stat package input. In the new window that appears, select HLM2 and press OK.

	HLM for Windows	-	- 🗆	×	Select MDM type
File	Basic Settings Other Settings Run Analysis Help				
	Create a new model using an existing MDM file			^	^ Nested Models
	Edit/Run old command(.hlm/.mlm) file				
	Manually edit command(.hlm/.mlm) file	Develophent			○ HLM2 ○ HLM3 ○ HLM4
	Save	nen Raudenbush	1		
	Save As	Richard Congdo	r		
	Save model as .emf				Hierarchical Multivariate Linear Models
	Save mixed model as .emf				
	Make new MDM file >	ASCII input			
	Make new MDM from old MDM template(.mdmt) file	Stat package input			
	Display MDM stats				Cross-classified Models
	View Output				
	Graph Equations >				O HCM2 O HLM-HCM O HCM3
	Graph Data >	linear Medeling			
	Preferences	ninear modeling			
	Exit				OK Cancel
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Both our level 1 and level 2 variables are in one and the same file (they can also be in two separate files as long as there is a common identifying variable for the level 2 units). Therefore, in the new window that appears, select the popular2.sav data-file for both levels (In this example level 1 and 2 by pressing **Browse**). Now simply look for the file and select it.

Make MDM - HLM2	Make MDM - HLM2
MDM template file MDM File Name (use .mdm suffix)	MDM template file MDM File Name (use .mdm suffix)
File Name:	File Name:
Open mdmt file Save mdmt file Edit mdmt file Input File Type SPSSM/indows 💌	Open mdmt file Save mdmt file Edit mdmt file Input File Type SPSSAVindows
Structure of Data - this affects the notation only	Structure of Data - this affects the notation only!
© cross sectional (persons within groups) O measures within groups	<ul> <li>cross sectional (persons within groups)</li> <li>C measures within groups</li> </ul>
C longitudinal (occasions within persons)	C longitudinal (occasions within persons)
Level-1 Specification	Level-1 Specification
Browse Level-1 File Name: Choose Variables	Browse Level-1 File Name: C:\Users\laure\Desktop\popular2.sav Choose Variables
Missing Data? Delete missing level-1 data when:	Missing Data? Delete missing level-1 data when:
No C Yes C making mdm C running analyses	No C Yes C making mdm C running analyses
Level-2 Specification	Level-2 Specification
Browse Choose Variables	Browse Level-2 File Name: C:\Users\\aure\Desktop\popular2.sav Choose \Variables
Spatial Dependence Specification	Spatial Dependence Specification
Include spatial dependence matrix	Include spatial dependence matrix
Browse Spatial Dep. File Name: Choose Variables	Browse Spatial Dep. File Name: Choose Variables
Make MDM Check Stats Done	Make MDM Check Stats Done

Next, we specify the 'grouping' variable (or identification variable), and which variables belong to which level. We start with **level one**. Press **Choose Variables** to open the variables window. The 'grouping' variable (ID), in a two level analysis is the identification variable at the second level (in a three level model there are two ID variables: one on the second level and one on the third level). There can only be one grouping variable per level and the first level (in this example the pupil level) does not need an ID variable. The ID variable is the only variable that we need to select in both level 1 and level 2. Since our second level is the class level, the CLASS variable is our ID variable. All the other variables are selected only once together with the level at which they were measured. In the window that appears we select the grouping variable and the level 1 variables. The grouping variable is **CLASS**. Therefore we select the **ID checkbox** for this variable. The level 1 variables are **EXTRAV**, **SEX** and **POPULAR**. Select the **in MDM** checkbox for these variables. When you are done, press **OK**.

The dataset also includes Z-transformed variables, but these will be ignored in this example.

Make MDM - HLM2	
MDM template file MD	M File Name (use .mdm suffix)
File Name:	
Open mdmt file Save mdmt file Edit mdmt file Input File	Type SPSS/Windows
-Structure of Data - this affects the notation only!	
<ul> <li>cross sectional (persons within groups)</li> <li>C measures within</li> </ul>	in groups
C longitudinal (occasions within persons)	
Level-1 Specification	
Browse Level-1 File Name: C:\Users\\aure\Desktop\popular2 say	Choose Variables
	Choose valiables
Missing Data? Delete missing level-1 data when:	
No C Yes C making mdm C running analyses	
Level-2 Specification	
Browse Level-2 File Name: C:\Users\laure\Desktop\popular2.sav	Choose Variables
Spatial Dependence Specification	
Include spatial dependence matrix	
Browce Spatial Dep File Name:	Choose Variables
	Choose valiables
Make MDM Check Stats	Done

PUPIL	D in MDM	CEXTRAV	D in MDI
CLASS	D in MDM	CTEXP	
EXTRAV	D 🔽 in MDM	CSEX	
SEX	D 🔽 in MDM		D ID 🗖 in MDN
TEXP	D in MDM		D ID 🗖 in MDN
POPULAR	D 🔽 in MDM		D D D in MDN
POPTEACH			ID ID II in MDN
ZEXTRAV	D in MDM		D ID 🗖 in MDN
ZSEX			D ID 🗖 in MDN
ZTEXP			D D D in MDN
ZPOPULAR	D in MDM		ID 🗖 in MDN
ZPOPTEAC	D in MDM		D D D in MDN

In a similar way, we select the variables for Level 2. Press the lower Choose Variables button to specify level 2 variables.

Make MDM - HLM2	
MDM template file	MDM File Name (use .mdm suffix)
File Name:	
Open mdmt file Save mdmt file Edit mdmt file	Input File Type SPSS/Windows
Structure of Data - this affects the notation only!	
<ul> <li>cross sectional (persons within groups)</li> <li>C means</li> </ul>	asures within groups
C longitudinal (occasions within persons)	
Level-1 Specification	
Browse Level-1 File Name: C:\Users\laure\Desktop\po	opular2.sav Choose Variables
Missing Date2 Delete missing level 1 date when:	
No O Yes O making mdm O running ar	nalyses
Level-2 Specification	
Browse Level-2 File Name: C:\Users\\aure\Desktop\po	Choose Variables
Spatial Dependence Specification	
Include spatial dependence matrix	
Browse Spatial Dep. File Name:	Choose Variables
Make MDM Check Stats	Done

Choose variables	- HLM2		
PUPIL		CEXTRAV	D in MDM
CLASS	D in MDM	CTEXP	D in MDM
EXTRAV	D ID II in MDM	CSEX	D in MDM
SEX	D in MDM		ID 🗖 in MDM
TEXP	DV in MDM		ID 🗖 in MDM
POPULAR	D ID in MDM		ID 🗖 in MDM
POPTEACH			ID 🗖 in MDM
ZEXTRAV			ID 🗖 in MDM
ZSEX			🔲 ID 🔲 in MDM
ZTEXP			ID 🗖 in MDM
ZPOPULAR	D in MDM		ID 🗖 in MDM
ZPOPTEAC	D ID in MDM		ID 🗖 in MDM
Page 1 o	of 1		OK Cancel

Once all variables have been specified, it is time to save the file. First specify a **filename** in the upper right box, and then press **Save mdmt file**. HLM will create multiple files (often with the same name) while doing your analysis, it is thus advised to create a new folder for each project you are working on, to prevent cluttering and confusion.

After the file has been saved successfully, you can generate the actual multilevel file. First press **Make MDM**. This will show a terminal window for a few seconds. Then Press **Check Stats**. This will open a text file with some descriptive statistics from your variables. Verify that these are correct, and then press **Done**.

Make MDM - HLM2	
MDM template file 1	MDM File Name (use .mdm suffix)
File Name: 2	popularity.mdm
Open mdmt file Save mdmt file Edit mdmt file	Input File Type SPSS/Windows
Structure of Data - this affects the notation only!	
<ul> <li>cross sectional (persons within groups)</li> </ul>	sures within groups
C longitudinal (occasions within persons)	
Level-1 Specification	
Browse Level-1 File Name: C:\Users\laure\Desktop\po	pular2.sav Choose Variables
Missing Data? Delete missing level-1 data when:	
No C Yes C making mdm C running an	alyses
Level-2 Specification	
Browse Level-2 File Name: C:\Users\laure\Desktop\po	pular2.sav Choose Variables
Spatial Dependence Specification	
Include spatial dependence matrix	
Browse Spatial Dep. File Name:	Choose Variables
Make MDM Check Stats	Done

I HLM2MDM - K	ladblok				- 0	×	WHLM: hlm2 MDM File: popularity.mdm	-	$\times$
Bestand Bewerker	n Opmaak Beeld	d Help					File Basic Settings Other Settings Run Analysis Help		
VARIABLE NAMI EXTRAV SEX POPULAR	LEVE E N 2000 2000 2000	L-1 DESCRIPT MEAN 5.21 0.51 5.08	TIVE STATIST SD 1.26 0.50 1.38	ICS MINIMUM 1.00 0.00 0.00	MAXIMUM 10.00 1.00 9.50	^	Outcome >> Level-1 << Level-2 INTRCPT1 EXTRAV SEX POPULAR		
	LEVE	L-2 DESCRIPT	IVE STATIST	ICS					
VARIABLE NAM	E N 100	MEAN 14.30	SD 6.61	MINIMUM 2.00	MAXIMUM 25.00				
MDM template: MDM file name Date: Time:	C:\Users\la : popularity. Apr 15, 201 11:42:09	ure\Desktop\ mdm 8	popularity\	popularity.mdm	nt	Ŷ			
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## **STEP 3: Model properties and options**

Now that we have successfully loaded the data into the program, we can start building multilevel models. The first thing that has to be done is specifying the outcome variable. Press **POPULAR** and select **Outcome Variable**.

WHLM: hlm2 MDM File: popularity.mdm -	×	WHLM: hlm2 MDM File: popularity.mdm -		×
File Basic Settings Other Settings Run Analysis Help		File Basic Settings Other Settings Run Analysis Help		
File       Basic Settings       Other Settings       Run Analysis       Hep         Outcome       >> LeveF1 <		File Basic Settings Other Settings Run Analysis Help         Outcome         >>> Level-1         Level-2         INTRCPT1         EXTRAV         SEX         POPULAR $\ell_0 = \gamma_{00} + u_0$		~
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We can now start building models. However, there are a few options we want to change first. In the HLM7 menu bar, go to **Other Settings** > **Estimation Settings**. In the window that pops up, select **Full Maximum Likelihood**, and then press OK.

🗮 WHLM: hlm2 ME	DM File: popularity.mdm	-	- 🗆 X
File Basic Settings	Other Settings Run Analysis Help	E	Estimation Settings - HLM2
Outcome	Iteration Settings	bold italic; grand-me	Type of Likelihood
>> Level-1 <<	Estimation Settings	1	· Restricted maximum likelihood
Level-2	Hypothesis Testing		Adaptive Gaussian Quadrature Iteration Control
INTRCPT1 L	Output Settings	ring)	Do adaptive Gaussian iterations     Maximum number of iterations
SEX	Evelopatory Applysic (level 2)	-	Number of quadrature points
POPULAR	Exploratory Analysis (level 2)		C First derivative C Second derivative
	Exploratory Analysis (level 5)		LaPlace Iteration Control
			Do EM Laplace iterations Maximum number of iterations
			,
			🗖 Run as spatial dependence model 🛛 🗖 Diagonalize Tau
			Constraint of fixed effects Heterogeneous sigma*2 Plausible values Multiple imputation
			Level-1 Deletion Variables Weighting Latent Variable Regression
			Fix sigma*2 to specific value computed
			(Set to "computed" if you want sigma^2 random or if over-dispersion is desired) OK
			Mixed
I			

## Hox, Moerbeek, & Schoot, chapter 2: popularity data [ HLM7 MANUAL ]

Second, for the final model we will also need the variance-covariance matrix. To ask for this go to **Other Settings** > **Output Settings**. In the window that pops up, select **Print variance-covariance matrix**, and then press OK.

File Basic Settings Other Settings Run Analysis Help          Outcome       Level-1 <<         >> Level-1 <<       Level-2         INTRCPT1       Estimation Settings         EXTRAV       SEX         POPULAR       Exploratory Analysis (level 2)         Exploratory Analysis (level 3)         Ouput Settings - HLM2         # of OLS estimates shown 10         Iv Print variance-covariance matrices         Iv Reduced output         OK	🗮 WHLM: hlm2 MI	)M File: popularity.mdm	_	o x
Outcome       Level-1 <	File Basic Settings	Other Settings Run Analysis Help		
Level-2 INTRCPT1 EXTRAV SEX POPULAR Unput Settings - HLM2 # of OLS estimates shown 10 Print variance-covariance matrices Reduced output OK Mixed v	Outcome >> Level-1 <<	Iteration Settings Estimation Settings	bold italic: grand-mean centering)	^
Mixed v		Estimation Settings Hypothesis Testing Output Settings Exploratory Analysis (level 2) Exploratory Analysis (level 3) Duput Settings - HLM2 # of OLS estimates shown 10 Print variance-covariance matrices Reduced output	ring)	
				Mixed v

## **STEP 4: Building Models**

Once the data is loaded, and all options have been set, we can start building multilevel models. The first model we want to build is the intercept-only model, with error terms on both levels. Therefore we do not have to add any predictor variables yet. Your window should look like this:

WHLM: hlm2	MDM File: popularity.mdm —		×
File Basic Setting	gs Other Settings Run Analysis Help		
Outcome	LEVEL 1 MODEL (bold: group-mean centering; bold italic: grand-mean centering)		^
>> Level-1 <<	$POPULAR = \ell + r$		
Level-2			
INTRCPT1	LEVEL 2 MODEL (bold italic: grand-mean centering)		
SEX	$\beta_0 = \gamma_{00} + u_0$		
POPULAR			
		Mix	<ed td="" ⊻<=""></ed>

To calculate the model parameters, press **Run Analysis** from the menu bar, and in the window that pops up, press **Run the Model Shown.** You should see the terminal window for a few seconds, which fits the model. After the model has been fitted, a html file with the model output should be saved on the location that you specified during STEP 2.



The HTML file shows all kinds of output from the multilevel analysis. To verify the numbers from the second column Table 2.1 (the first column does not split the variance between levels and is thus not really part of a multilevel analysis) from Hox, Moerbeek, & van de Schoot, scroll down to the end of the text file. The first thing you want to check is usually the **Deviance**. If this seems OK, you can verify the parameter estimates. The fixed effects and variance components should be identical to the ones from Table 2.1. This baseline model without any independent variables can be used to check the intraclass correlation (ICC), and to check whether a multilevel analysis is warranted.

### **QUESTION 1: What is the ICC in this example?**

We continue by adding predictor variables. To add the level 1 predictors, first click on Level-1, then click the variable you want to add, and select Add Variable Uncentered. The book discusses the advantages of entering variables centered, but in this simple example we will stick to uncentered variables. Do this for EX-TRAV and SEX. In the book predictors on both levels are added at the same time. Here we will make the extra step by first only adding the first level variables and later also the second level variables.

The plot on the right shows how your model should look like and on the bottom we see the HTML output. Because we now add two variables, but no interactions yet, we are estimating 5 parameters instead of 3. The results of this output are not given in the book.

# Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. d.f.	p-value
For INTRCPT1, $\beta_0$					
INTRCPT2, y <sub>00</sub>	2.141383	0.116961	18.309	99	< 0.001
For EXTRAV slope	, β <sub>1</sub>				_
INTRCPT2, y10	0.441513	0.016150	27.337	1898	< 0.001
For SEX slope, $\beta_2$					
INTRCPT2, γ <sub>20</sub>	1.253137	0.037406	33.501	1898	<0.001

#### Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	d.f.	χ²	p-value
INTRCPT1, u <sub>0</sub>	0.78764	0.62037	99	2175.07480	< 0.001
level-1, r	0.76906	0.59146			

#### Statistics for the current model

Deviance = 4933.952263 Number of estimated parameters = 5

#### Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. d.f.	<i>p</i> -value
For INTRCPT1, $\beta_0$					
INTRCPT2, γ <sub>00</sub>	5.077859	0.086957	58.395	99	< 0.001

#### Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	d.f.	$\chi^2$	p-value
INTRCPT1, u <sub>0</sub>	0.83334	0.69446	99	1227.26511	< 0.001
level-1, r	1.10535	1.22179			

#### Statistics for the current model

Deviance = 6327.46775	52
Number of estimated pa	arameters = 3

🗮 WHLM: hlm2 MDM File: popularity.mdm 🛛 Command File: whlmtemp.hlm × File Basic Settings Other Settings Run Analysis Help Outcome LEVEL 1 MODEL (bold: group-mean centering; bold italic: grand-mean centering) >> Level-1 << POPULAR =  $f_0 + r$ Level-2 INTRCPT1 LEVEL 2 MODEL (bold italic: grand-mean centering) EXTPAV SEX Outcome variable POF add variable uncentered add variable group centered add variable grand centered Delete variable from model

#### Mixed V

🕎 WHLM: hlm2 MDM File: popularity.mdm Command File: whlmtemp.hlm × File Basic Settings Other Settings Run Analysis Help Outcome LEVEL 1 MODEL (bold: group-mean centering; bold italic: grand-mean centering) >> Level-1 << POPULAR =  $f_0 + f_1(EXTRAV) + f_2(SEX) + r$ Level-2 INTRCPT1 LEVEL 2 MODEL (bold italic: grand-mean centering) EXTRAV  $\mathcal{L}_0 = \gamma_{00} + u_0$ SEX  $\beta_1 = \gamma_{10} + u_1$  $\beta_2 = \gamma_{20} + u_2$ Mixed 🗸 Mixed Mode POPULAR =  $\gamma_{00} + \gamma_{10}$ \*EXTRAV +  $\gamma_{20}$ \*SEX +  $u_0$  + r

We now also (in addition to the level 1 variables that were both significant) add a predictor variable on the second level. Press Level-2, and make sure the  $\beta_0$  is selected from the Level 2 Model (the yellow bar). Then click TEXP and select Add Variable Uncentered, just like you did in level 1.

	🔣 WHLM: hlm2	MDM File: popularity.mdm Comm	nand File: whlmtemp.hlm	_		×	
	File Basic Setting	s Other Settings Run Analysis	Help				
•	Outcome Level-1		ean centering; bold italic: gran	d-mean ce	entering)	^	
	>> Level-2 << INTRCPT2 TEXP	LEVEL 2 MODEL (bold italic: gra	nd-mean centering)				
						_	
		$P_2 = \gamma_{20} + u_2$			Mixe	v he	
	🕎 WHLM: hlm2 l	MDM File: popularity.mdm Comm	nand File: whImtemp.hlm	_		X	

File Basic Settings Other Settings Run Analysis Help

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Outcome	I EVEL 1 MODEL (bold: group-mean centering: bold italic: grand-mean centering)	^
Level-1		
>> Level-2 <<	$POPULAR = \mu_0 + \mu_1(EXTRAV) + \mu_2(SEX) + r$	
INTRCPT2	LEVEL 2 MODEL (bold italic: grand-mean centering)	
TEXP	$\beta_0 = \gamma_{00} + \frac{\gamma_{01}(\text{TEXP})}{\gamma_{01}(\text{TEXP})} + u_0$	
	$\beta_1 = \gamma_{10} + u_1$	-
	$P_2 = \gamma_{20} + u_2$	
	Mixed	<b>v</b>

### Final estimation of fixed effects:

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We can see that both the level 1 and level 2 variables are significant. However, we have not added random slopes yet for any variables (as is done in table 2.1 in the book).

## Question 2: What is the explained variance at level 1 and at level 2?

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. d.f.	<i>p</i> -value
For INTRCPT1, $\beta_0$					
INTRCPT2, y <sub>00</sub>	0.809326	0.168827	4.794	98	< 0.001
TEXP, γ <sub>01</sub>	0.088409	0.008676	10.190	98	< 0.001
For EXTRAV slope	, β <sub>1</sub>				
INTRCPT2, y10	0.454484	0.016154	28.134	1898	< 0.001
For SEX slope, $\beta_2$					
INTRCPT2, γ <sub>20</sub>	1.254095	0.037265	33.653	1898	< 0.001

#### Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	d.f.	χ²	<i>p</i> -value
INTRCPT1, u <sub>0</sub>	0.53736	0.28876	98	1072.11886	< 0.001
level-1, r	0.76900	0.59136			

### Statistics for the current model

Deviance = 4862.295445 Number of estimated parameters = 6

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In the third column of Table 2.1, both predictor variables from level 1 (sex and extraversion) have random slopes. To accomplish this in HLM, activate the error terms for their slopes ( $\beta_1$  and  $\beta_2$ ) by clicking on  $u_1$  and  $u_2$ . This will make them turn black instead of grey.

This completes model M1. Press **Run Analysis** like you did before. Now you might encounter a **warning** in the DOS window about convergence. If this happens, type **yes** in the dos window, and press **Enter** to continue fitting the model.

Once done, again open the output file and inspect the parameter estimates like you did before. You might notice that they are slightly different from the ones in Hox, Moerbeek, & Schoot. The reason for this is that the error term for the slope of the variable SEX is very small, and therefore hard to estimate. In the next model this slope will be removed. This model corresponds to the third column of table 2.1 in Hox, Moerbeek, & Schoot. We therefore conclude that there is no slope variation of the SEX variable between classes and therefore the random slope estimation can be dropped from the next analyses.

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File Basic Setting	gs Other Settings Run Analysis Help	
Outcome	I EVEL 1 MODEL (bold: group-mean centering: bold italic: grand-mean centering)	^
Level-1		
>> Level-2 <<	$POPULAR = \mu_0 + \mu_1(EXTRAV) + \mu_2(SEX) + r$	
INTRCPT2	LEVEL 2 MODEL (bold italic: grand-mean centering)	
TEXP	$\beta_0 = \gamma_{00} + \gamma_{01}(\text{TEXP}) + u_0$	
	$\beta_1 = \gamma_{10} + u_1$	
	$\beta_2 = \gamma_{20} + u_2$	
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ł	'he	value	of	the	log-	likelihood	function	at	iteration	73	=	-2.405972E+003			
ī	he	value	of	the	log-	likelihood	function	at	iteration	74		-2.405969E+003			
i	he	value	of	the	log-	likelihood	function	at	iteration			-2.405966E+003			
ī	he	value	of	the	log-	likelihood	function	at	iteration	76		-2.405963E+003			
I	'he	value	of	the	log-	likelihood	function	at	iteration			-2.405961E+003			
ī	'he	value	of	the	log-	likelihood	function	at	iteration	78		-2.405958E+003			
ī	'he	value	of	the	log-	likelihood	function	at	iteration	79		-2.405956E+003			
I	'he	value	of	the	log-	likelihood	function	at	iteration	80		-2.405953E+003			
I	he	value	of	the	log-	likelihood	function	at	iteration	81		-2.405951E+003			
ī	he	value	of	the	log-	likelihood	function	at	iteration	82		-2.405948E+003			
ī	he	value	of	the	log-	likelihood	function	at	iteration	83		-2.405946E+003			
1	he	value	of	the	log-	likelihood	function	at	iteration	84		-2.405943E+003			
1	he	value	of	the	log-	likelihood	function	at	iteration	85		-2.405941E+003			
1	he	value	of	the	log-	likelihood	function	at	iteration	86		-2.405939E+003			
1	he	value	of	the	log-	likelihood	function	at	iteration	87		-2.405937E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	88		-2.405934E+003			
1	he	value	of	the	log-	likelihood	function	at	iteration	89		-2.405932E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	90		-2.405930E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	91		-2.405928E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	92		-2.405926E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	93		-2.405924E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	94		-2.405922E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	95		-2.405920E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	96		-2.405918E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	97		-2.405916E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	98		-2.405914E+003			
	he	value	of	the	log-	likelihood	function	at	iteration	99		-2.405912E+003			
	ne	maximu	um r	numbe	er of	iteration	s has beer	n r	eached, bu	t th	e	analysis has			
1	iot	conver	rgeo	d. Do	o you	want to c	ontinue u	nti.	1 converge	nce?					

### Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. d.f.	<i>p</i> -value
For INTRCPT1, $\beta_0$					
INTRCPT2, y <sub>00</sub>	0.760605	0.195930	3.882	98	< 0.001
ΤΕΧΡ, γ <sub>01</sub>	0.089399	0.008532	10.478	98	< 0.001
For EXTRAV slope	, β <sub>1</sub>				
INTRCPT2, γ <sub>10</sub>	0.452810	0.024509	18.475	99	< 0.001
For SEX slope, $\beta_2$					
INTRCPT2, y20	1.251146	0.037043	33.775	99	< 0.001

### Final estimation of variance components

Random Effect	Standard Deviation	Variance Component	d.f.	χ²	<i>p</i> -value
INTRCPT1, $u_0$	1.14871	1.31955	86	205.34339	< 0.001
EXTRAV slope, $u_l$	0.18468	0.03411	87	169.19730	< 0.001
SEX slope, $u_2$	0.05670	0.00321	87	80.58867	>0.500
level-1, r	0.74230	0.55101			

Note: The chi-square statistics reported above are based on only 88 of 100 units that had sufficient data for computation. Fixed effects and variance components are based on all the data.

### Statistics for the current model

Deviance = 4811.353882 Number of estimated parameters = 11

 $\sigma^2 = 0.55101$ 

Standard error of  $\sigma^2 = 0.01877$ 

τ			
INTRCPT1, $\beta_0$	1.31955	-0.18626	-0.02260
EXTRAV, $\beta_l$	-0.18626	0.03411	-0.00083
$SEX_{\beta_2}$	-0.02260	-0.00083	0.00321

### Standard errors of $\tau$

INTRCPT1, $\beta_0$	0.28836	0.04691	0.05269
EXTRAV, <i>β</i> 1	0.04691	0.00838	0.00899
$SEX_{\beta_2}$	0.05269	0.00899	0.01861

We continue by clicking on the error term for the parameter of SEX to deselect it (turning from black to grey again), like in the figure on the right.

The estimated variance components and the regression coefficients are now the same as table 2.2 and the 1st column (Model  $M_1$ ) of table 2.3 in the book.

To get the covariance between the class-level errors for the intercept and extraversion slope we have to look at the off diagonal elements of the variance-covariance output of HLM.

## **Question 3:**

- a. What is the intercept of the model?
- b. What is the fixed effect of sex?
- c. What is the effect of teacher experience?
- d. What is the mean effect of extraversion?
- e. What is the random effect of the slope of extraversion?

🔣 WHLM: hlm2	MDM File: popularity.mdm Command File: whImtemp.hlm $ \Box$	Х
File Basic Setting	gs Other Settings Run Analysis Help	
Outcome Level-1	LEVEL 1 MODEL (bold: group-mean centering; bold italic: grand-mean centering)	^
>> Level-2 <<	$POPULAR = \rho_0 + \rho_1(EXTRAV) + \rho_2(SEX) + r$	
INTRCPT2	LEVEL 2 MODEL (bold italic: grand-mean centering)	
12/1	$F_0 = \gamma_{00} + \gamma_{01}(IEXP) + u_0$	
	$\beta_1 = \gamma_{10} + u_1$	_
	$\rho_2 = \gamma_{20} + u_2$	
	Mixe	d∣∨

#### Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. <i>d.f.</i>	p-value
For INTRCPT1, $\beta_0$					
INTRCPT2, y <sub>00</sub>	0.738568	0.195209	3.783	98	< 0.001
ΤΕΧΡ, γ <sub>01</sub>	0.090813	0.008598	10.563	98	< 0.001
For EXTRAV slope,	e <sub>1</sub>				
INTRCPT2, y <sub>10</sub>	0.452641	0.024478	18.491	99	< 0.001
For SEX slope, $\beta_2$					
INTRCPT2, y <sub>20</sub>	1.252470	0.036554	34.263	1799	< 0.001

#### Final estimation of variance components

Random Effect	Standard Deviation	Co	Variance mponent	d.f.	$\chi^2$	<i>p</i> -value
INTRCPT1, u <sub>0</sub>	1.13200		1.28143	98	288.64116	< 0.001
EXTRAV slope, $u_l$	0.18417		0.03392	99	237.61747	< 0.001
level-1, r	0.74284		0.55181			

#### Statistics for the current model

Deviance = 4812.806967 Number of estimated parameters = 8

### $\sigma^2 = 0.55181$

Standard error of  $\sigma^2 = 0.01837$ 

τ INTRCPT1, $β_0$  1.28143 -0.18475 EXTRAV, $β_1$  -0.18475 0.03392

 Standard errors of τ

 INTRCPT1,β<sub>0</sub>
 0.28119
 0.04655

 EXTRAV,β<sub>1</sub>
 0.04655
 0.00833

In the next step to reproduce Model M<sub>2</sub> from Table 2.3, we add the crosslevel interaction between Extraversion and Teacher experience. This means we have to add TEXP as a predictor for the coefficient of EXTRAV. To do this in HLM select below **LEVEL 2 MODEL** the line with the coefficient for EXTRAV. This line should become yellow. Then click TEXP from the variable list on the left, and click **Add Variable Uncentered**. The model should then look like the figure on the right. Run the Analysis and view the output. The Deviance and model parameters are very similar to the ones from model M<sub>2</sub> in table 2.3. You will find the coefficient for the cross-level interaction at the table of fixed effects, below the predictors for EXTRAV. It is somewhere between -0.02 and -0.03, depending on the convergence and rounding settings of the software.

## Question 4: What is the explained slope variance of extraversion by using teacher experience as second level variable?

Question 5: What is the number of estimated parameters in this model?

#### 

Mixed ∨

#### Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard error	t-ratio	Approx. <i>d.f.</i>	<i>p</i> -value
For INTRCPT1, $\beta_0$					
INTRCPT2, y <sub>00</sub>	-1.207112	0.269006	-4.487	98	< 0.001
TEXP, γ <sub>01</sub>	0.226036	0.016620	13.600	98	< 0.001
For EXTRAV slope,	$\beta_1$				
INTRCPT2, $\gamma_{10}$	0.803142	0.039564	20.300	98	< 0.001
TEXP, γ <sub>11</sub>	-0.024699	0.002520	-9.803	98	< 0.001
For SEX slope, $\beta_2$					
INTRCPT2, y20	1.240624	0.036203	34.269	1799	< 0.001

#### Final estimation of variance components

Random Effect	Standard Deviation	Co	Variance mponent	d.f.	$\chi^2$	<i>p</i> -value
INTRCPT1, u <sub>0</sub>	0.67405		0.45434	98	172.85447	< 0.001
EXTRAV slope, $u_1$	0.06880		0.00473	98	123.39265	0.042
level-1, r	0.74335		0.55256			

#### Statistics for the current model

Deviance = 4747.624382

 $\sigma^2 = 0.55256$ 

Standard error of  $\sigma^2 = 0.01835$ 

5		
INTRCPT1, $\beta_0$	0.45434	-0.02910
EXTRAV, $\beta_1$	-0.02910	0.00473

 Standard errors of τ

 INTRCPT1, $β_0$  0.15903
 0.02353

 EXTRAV, $β_1$  0.02353
 0.00399

As explained in the book and shown in the results, both the intercept and the slope of the coefficient of extraversion on popularity is influenced by teacher experience. A male student (SEX=0) with a extraversion score of 0 in a class with a teacher with 0 years of experience has an expected popularity of -1.207 (these values are of course impossible, hence the importance of centering). A similar (male) student will improve its popularity with .80 points for every point more extraversion. When teacher experiences increases, the intercept also increases with .23 for every year of experience. So the same male student with no extraversion in a class with a teacher with 15 years of experience has an expected popularity score of -1.207+(15\*.226)= 2.183. The teacher experience also lessens the effect of extraversion on popularity. For a teacher with 15 years of experience the regression coefficient of extraversion on popularity is only 0.803-(15\*0.0247)=0.4325 (compared to .803 in a class with a teacher with 0 years of experience).

In HLM we can visualize these effects. By clicking **File> Graph Equations > Model graphs .** Then put Extraversion on the X-axis and select the **Entire range** as range of the x-axis. Use TEXP as a level-2 focus and select for the range of the "z"-axis 6 values of your choice (we picked 2 to 26 years of teacher experience).

	WHLM: hIm2 MDM File: popularity.mdm Command File:	whlm	itemp.hlm — 🗆 🗙
File	Basic Settings Other Settings Run Analysis Help		
	Create a new model using an existing MDM file Edit/Run old command(.hlm/.mlm) file Manually edit command(.hlm/.mlm) file Save Save As Save model as .emf Save mixed model as .emf Make new MDM file Make new MDM file Display MDM stats	>	d italic: grand-mean centering)  + r
	View Output		
	Graph Equations	>	Model graphs
	Graph Data	>	Level-1 equation graphing
	Preferences		Level-1 residual box-whisker
	Exit		Level-1 residual vs. predicted value Level-2 EB/OLS coefficient confidence intervals
	The second se		

 $\times$ 

#### Equation Graphing - Specification

Categories/transforms/interactions         1       2       3       4       5         Range/Titles/Color       Image: Choose up to 6       Image: Choose up to 6         Other settings       Image: Choose up to 6       Image: Choose up to 6         OK       Cancel       Image: Choose up to 6	Level-1 EXTRAV  Level-2 (not chosen) Level-3 Range of x-axis Entire range	Level-2 TEXP Level-2 TEXP Level-3 Range of z-axis Choose up to 6 values	- Choose up to 6 2.000000 7.000000 13.000000 18.000000 23.000000 26.000000
	Categories/transforms/interactions          1       2       3       4       5         Range/Titles/Color         Other settings	Z focus(2) Level-1 (not chosen) Level-2 (not chosen) Level-3 Range of z-axis	Choose up to 6

File Edit Graph Settings



Question 6: visualize the findings we wound earlier, that there is interecept variance of SEX but no slope variance.

## **STEP 5: Answers to question:**

Question 1: 0.69/(1.22+0.69)=.36

### Question 2:

- R2 at level 1: (1.222-0.591)/1.222= .52
- R2 at level 2: (0.694-0.289)/0.694= .58

#### Question 3:

- a. The intercept is 0.738
- b. The fixed effect of sex is 1.252
- c. The effect of teacher experience is 0.091
- d. The mean effect of extraversion is 0.453
- e. The random effect of the slope of extraversion is 0.034

Question 4: (0.03392-0.00473)/0.03392= .86

Question 5:9

Question 6: Two possibilities:

