

Introduction to Basic Dyadic Multilevel Models

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Dyadic Multilevel Models in HLM 6

- Basic unconditional dyad model (Model 1)
 - Provides estimates for dyad averages
 - Models within vs between dyad differences
 - Allows for estimation of ancillary statistics such as the Intraclass Correlation
- Two-intercept model for distinguishable dyads (Model 2a & b)
 - Provides separate estimates for husbands and wives
- Longitudinal dyadic model for distinguishable dyads (Model 3)
 - Estimates separate trajectories for husbands and wives



Examples: Family Transitions

- Data for all models is taken from Perry-Jenkins' Work & Family Transitions Project (Perry-Jenkins et al., 2007)
- 150 working-class, dual-earner heterosexual couples
- Interviewed at 5 times across the transition to parenthood and a sixth time when the child is 6 years old

Interview Schedule: WFTP 1

Birth of
Baby

Prenatal Interview	1-month Postnatal Interview	Return to Work Interview	6-Month Interview (mail)	One Year Follow-up Interview	Six Year Follow-up Interview
Well-Being • Mother • Father	Well-Being	Well-Being	Well-Being	Well-Being	Well-Being
Marriage	Marriage	Marriage	Marriage	Marriage	Marriage
Work • Mother • Father	Work	Work		Work	Work
Gender Ideol	Gender Ideol	Gender Ideol		Gender Ideol	Gender Ideol
Social Support	Social Support	Social Support		Social Support	Social Support
	Child Temp		Child Temp	Child Temp	Child MH & Development • Mother • Father • Teacher
					Parenting • Mother • Father

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Gender Ideol	Gender Ideol	Gender Ideol		Gender Ideol	Gender Ideol
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Marriage	Marriage	Marriage	Marriage	Marriage	Marriage
Work • Mother • Father	Work	Work		Work	Work
Gender Ideol	Gender Ideol	Gender Ideol		Gender Ideol	Gender Ideol
Social Support	Social Support	Social Support		Social Support	Social Support
	Child Temp		Child Temp	Child Temp	Child MB & Development • Mother • Father • Teacher
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Transition to Parenthood

- Time of renegotiating family roles
- Balancing the often conflicting demands of work and family life
- Can easily lead to “role overload”: Feeling overwhelmed by all of one’s responsibilities
 - Reilly (1982) Role Overload Scale
 - 13 items such as, “I just can’t find the energy in me to do all of the things expected of me.”
 - Responses range from 1 (strongly agree) to 5 (strongly disagree)



Research Questions for Model 1

- How overwhelmed do couples feel just before the birth of the first child?
- Do couples differ significantly in the amount of role overload they experience?
- How much of the variability in the experience of role overload is within couples vs. between couples?



Two Levels of MLM Model

□ Level 1: Within Couples

- Individual level data (responses that vary within couple)
- Models
 - Average overload for each couple
 - Within couple differences (variability around the average)

□ Level 2: Between Couples

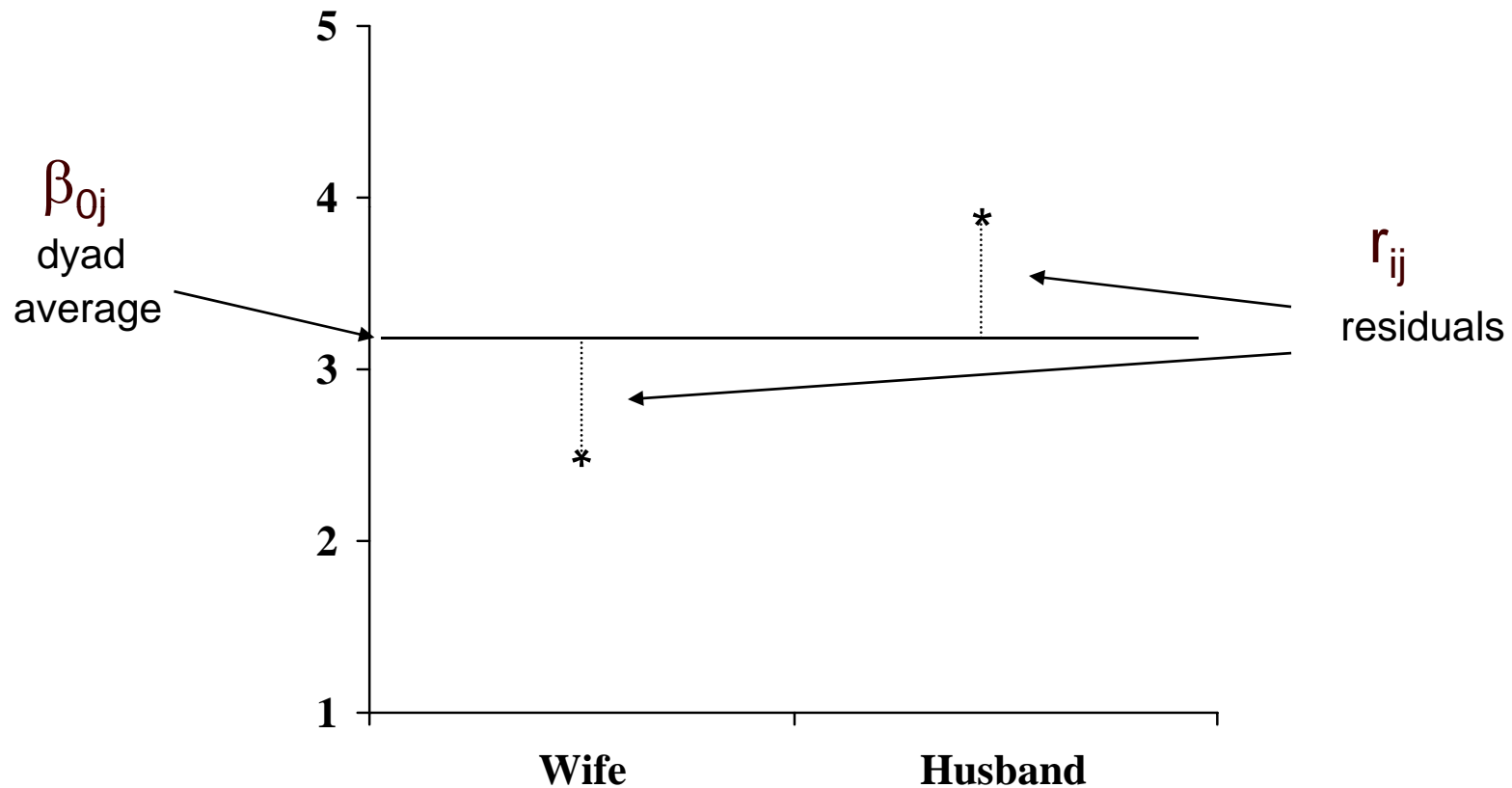
- Couple level variables
- Models
 - Average overload across all couples
 - Differences between couples (heterogeneity around average)

The Level-1 Model: Within Couples

$$Y_{ij} = \beta_{0j} + r_{ij}$$

- β_{0j} , models an average for each couple
- r_{ij} , residuals
 - Amount each spouse differs from the average
 - HLM estimates the variance of r_{ij}

Dyad Average & Residuals



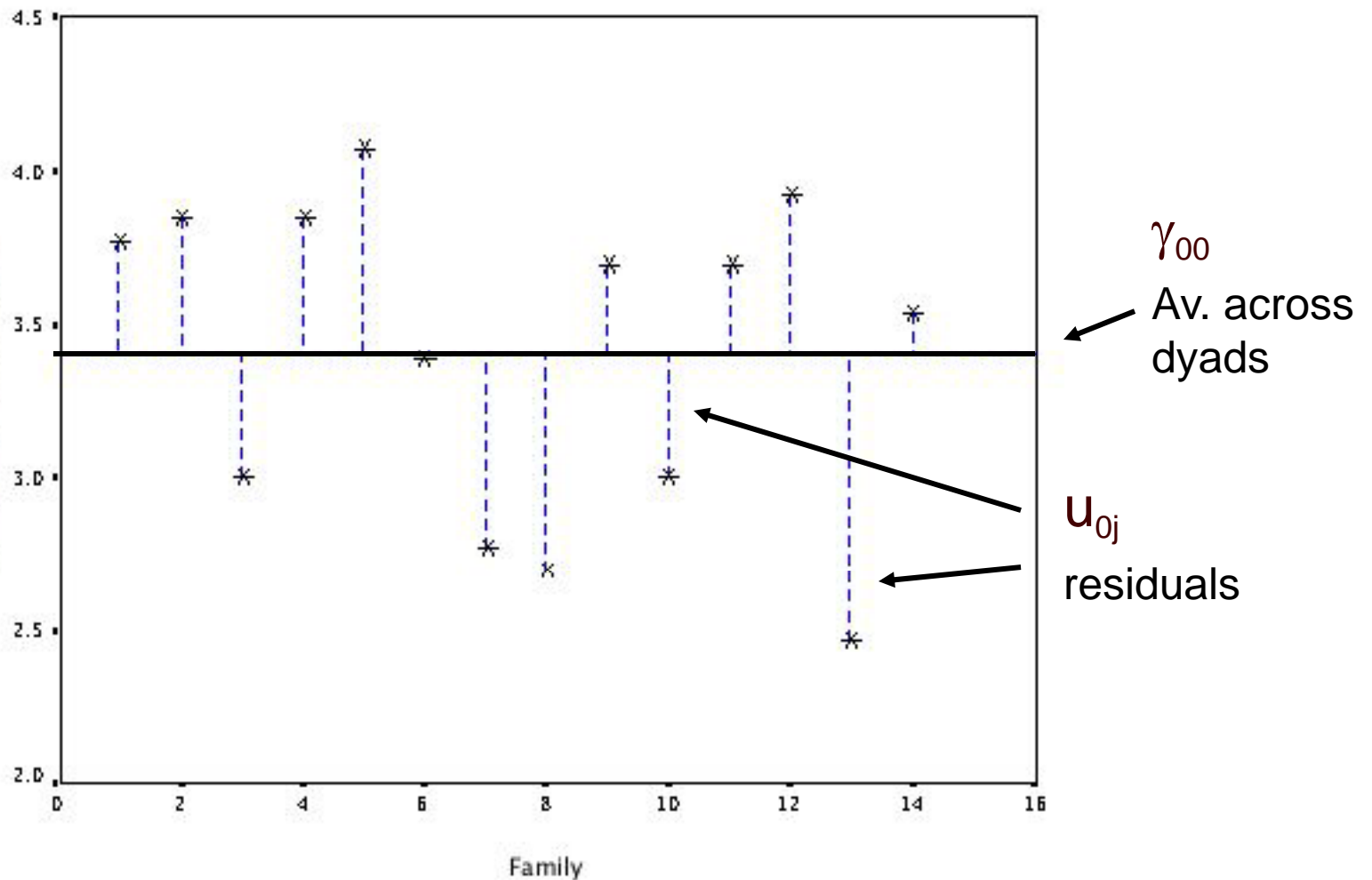
Level-2 Model: Between Couples

- The average for each couple, β_{0j} , becomes the outcome at Level-2

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

- γ_{00} estimates average overload across couples
- u_{0j} , residuals (how each couple's overload differs from the average couple)
 - HLM estimates the variance of u_{0j}

L2: Dyad Means and Residuals





Unconditional Dyad Model

$$\text{L1: } Y_{ij} = \beta_{0j} + r_{ij}$$

$$\text{L2: } \beta_{0j} = \gamma_{00} + u_{0j}$$

where i = individual responses within each couple 1 & 2
and j = couples 1, 2, 3...150



HLM Parameter Estimates

- Estimates average role overload scores across couples (fixed effects)
- Estimates variability in those scores (variance components)

Parameter Estimates: Fixed Effects

What is the average level of overload across couples?

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For INTRCPT1, B0 INTRCPT2, G00	3.161508	0.045467	69.534	150	0.000



Variance

- Goal of regression is to explain variance in outcomes (how much scores differ from each other)
- HLM breaks up that variance into two separate components
 - Variance WITHIN couples
 - How much spouses vary from each other
 - Variance BETWEEN couples
 - How much couples vary in role overload



Variance Components

- How much does overload vary within couples?
 - Variance of L1 residuals
 - $\text{Var} [r_{ij}] = \sigma^2$

- How much does overload vary across couples?
 - Variance of L2 residuals
 - $\text{Var} [u_{0j}] = \tau_{00}$
 - Significance test of H_0 : variance = 0

Parameter Estimates: Variance Components

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1,	U0	0.42846	0.18358	150	366.89226	0.000
level-1,	R	0.71544	0.51186			

Variance Components

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, level-1,	U0 R	0.42846 0.71544	0.18358 0.51186	150	366.89226	0.000

Variance WITHIN couples

How much do spouses vary in role overload?

(i.e., variance around couple mean)

Variance Components

Final estimation of variance components:

Random Effect		Standard Deviation	Variance Component	df	Chi-square	P-value
INTRCPT1, level-1,	U0	0.42846	0.18358	150	366.89226	0.000
	R	0.71544	0.51186			

Variance BETWEEN couples

How much do couples vary in role overload?



Intraclass Correlation Coefficient

- How much of the variance in role overload more is attributable to within couple characteristics?
 - Such as personality, gender, division of household tasks
 - Or attributable to between couple characteristics?
 - Such as family resources, geographic location
- Intraclass Correlation Coefficient
 - What proportion of the overall variance is between couples?

Intraclass Correlation Coefficient (ICC)

- Calculating the ICC

$$\text{ICC} = \text{between}/(\text{between} + \text{within})$$

$$\text{ICC} = \tau_{00}/(\tau_{00} + \sigma^2)$$

$$\text{ICC} = .184/ (.184 + .512) = .184/.696 = .264$$

- 26% of the variance is between couples
 - Fairly high dependency in outcomes (need HLM)
- The vast majority of the variance, 74%, is due to within couple differences



Two-intercept Model

- Theory and past research suggest important differences in the way husbands and wives experience the transition to parenthood
- Want to model husbands and wives overload separately



Questions for Model 2

- Model 2a (unconditional at L2)
 - What is the average level of wives' overload before the birth?
 - What is the average level of husbands' overload before the birth?

- Model 2b (add predictors at L2)
 - Is job satisfaction associated with lower overload for wives and husbands?

Level 1: Within Dyad

- At L1, create separate intercepts for husbands and wives

$$Y_{ij} = \beta_{1j}(\text{wife}) + \beta_{2j}(\text{husband}) + r_{ij}$$

- □ β_{1j} is the level of the wife's overload in couple j
- □ β_{2j} is the level of the husband's overload in couple j

Level 2: Between Dyads

- Intercepts become outcomes at Level 2

$$\begin{aligned} \text{L2: } \beta_{1j} &= \gamma_{10} + u_{1j} \\ \beta_{2j} &= \gamma_{20} + u_{2j} \end{aligned}$$

with

γ_{10} as the average level of overload across wives and

γ_{20} as the average level of overload across husbands

Model for Distinguishable Dyads

$$\text{L1: } Y_{ij} = \beta_{1j}(\text{wife}) + \beta_{2j}(\text{husband}) + r_{ij}$$

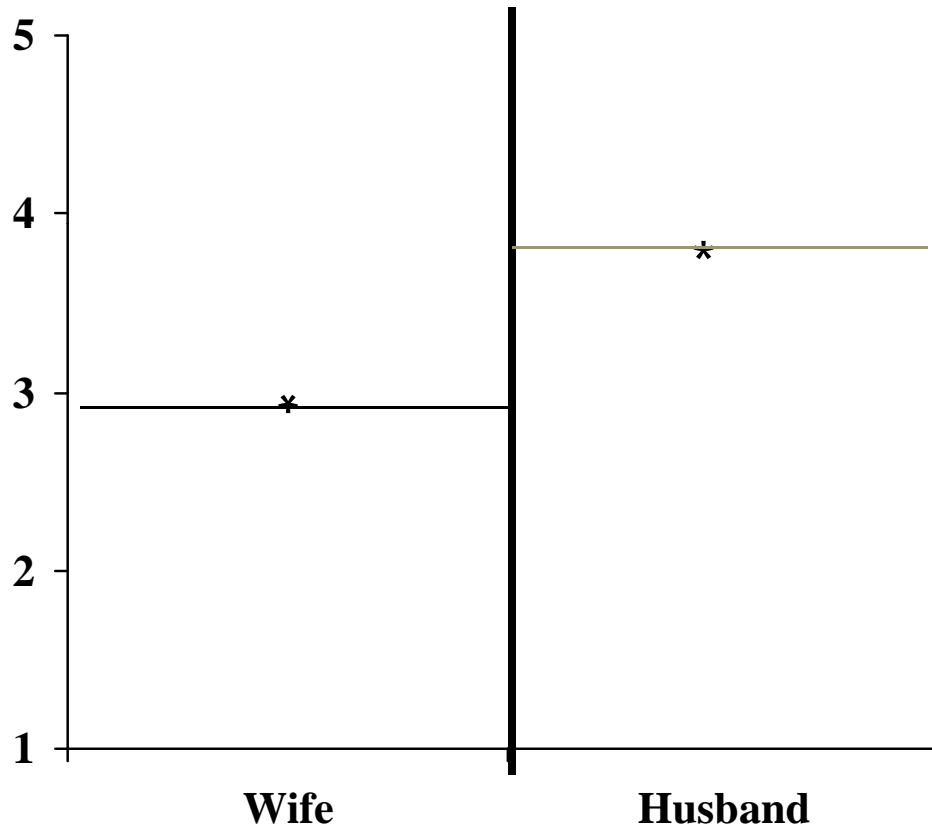
$$\text{L2: } \beta_{1j} = \gamma_{10} + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

where i = individual scores

and j = couples 1, 2, 3...150

L1: Estimated Overload for Couple





No Residuals

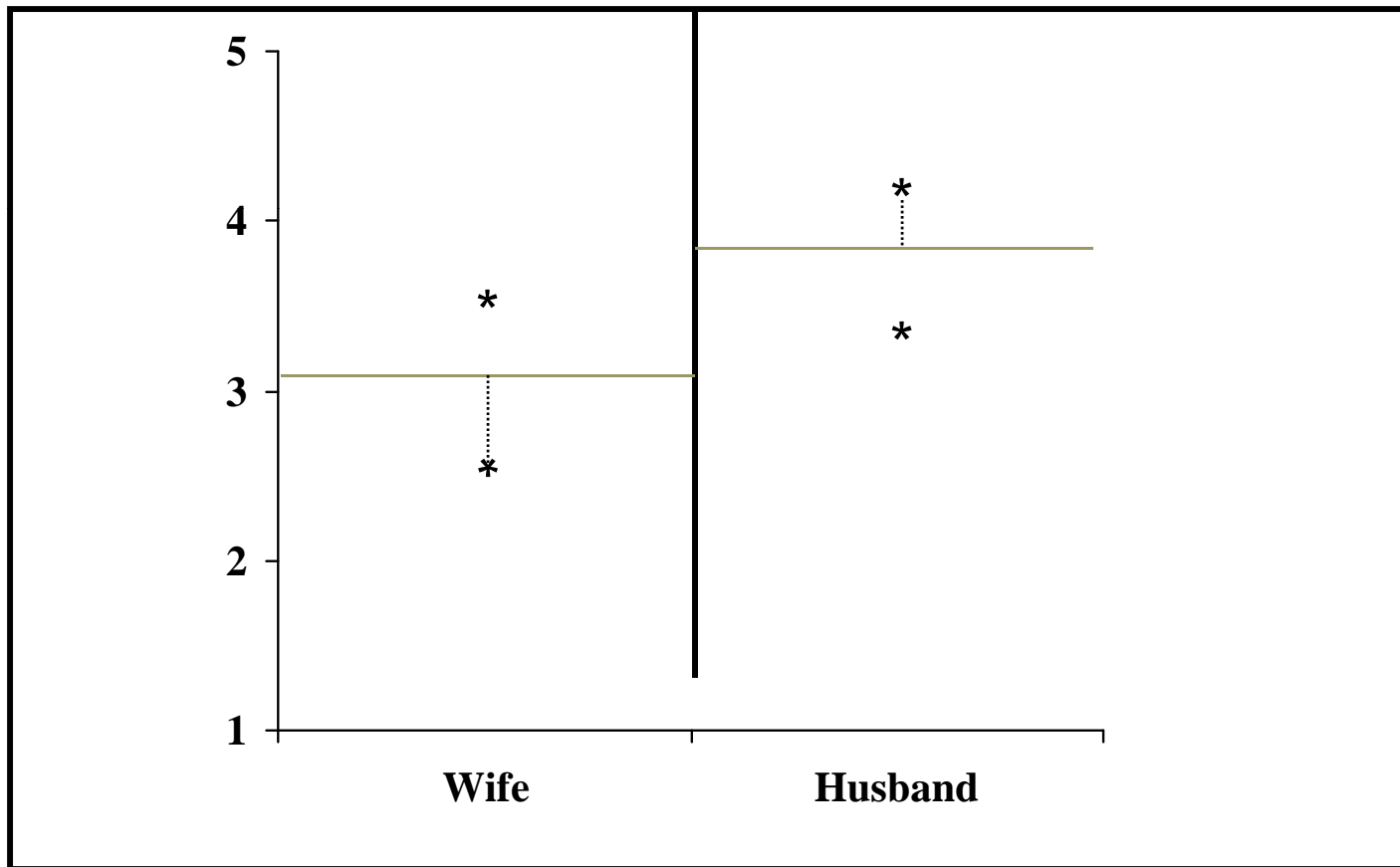
- Not enough information is provided to enable the estimation of residuals
 - Can't provide estimates of shared variance
 - Can't explain the variance by entering predictors



Solution: Parallel Scores

- Provide two estimates of the outcome for each dyad member (Raudenbush, Brennan & Barnett, 1995)
 - Split the initial scale into two parallel scales
 - A number of techniques for creating parallel scales
 - One way is to match items based on their standard deviations and then randomly assign one item from each pair to scale A and scale B

L1: Measurement Error





Alternate Solution

- Where parallel scales are not possible, you can provide your own estimate of measurement error (ME)
 - Similar to SEM approach to ME for single indicators of latent constructs
- ME is created outside of HLM and entered as a separate variable in the database
- HLM performs a weighted analyses whereby the outcome is weighted by the reliability ($1/ME$)

Calculating ME

- Get an estimate of the outcome scale's reliability for each partner
 - Usually Cronbach's alpha
- Determine the observed variance of the outcome for each partner
- $ME = (1 - \text{reliability}) * \left(\begin{array}{c} \text{observed variance} \\ \text{on outcome} \end{array} \right)$



Fitting the Model in HLM

- Preparing the data for the HLM program
 - L1 (within couple) data file
 - L2 (between couple) data file
- Linking HLM to your data
 - Creating the .mdm file
- Fitting the model
 - Settings
 - Creating the model



Data Structure

- Level 1: Within Couple
 - Outcomes
 - Two lines per dyad member (with parallel scores)
 - Dummy indicators for wife data and husband data
- Level 2: Between Couples
 - All predictors go in the Level-2 file
 - Only one score for “wife’s job satisfaction” per couple and one score for “husbands job satisfaction”

L1 Data Structure for Distinguishable Dyads

	family	member	parscore	overload	wife	husband
1	1	1	1	3.67	1	0
2	1	1	2	4.00	1	0
3	1	2	1	2.67	0	1
4	1	2	2	3.33	0	1
5	2	1	1	3.83	1	0
6	2	1	2	3.83	1	0
7	2	2	1	3.17	0	1
8	2	2	2	2.83	0	1

L2 Data Structure for Distinguishable Dyads

	family	w1jobsat	h1jobsat
1	1	3	3
2	2	4	4
3	3	3	3
4	4	3	3
5	5	2	2
6	6	3	4
7	7	3	3
8	8	4	3

Two-intercept Model in HLM 6

WHLM: hlm2 MDM File: distinguishable.mdm Command File: whlmtemp.hlm

File Basic Settings Other Settings Run Analysis Help

Outcome

Level-1

>> Level-2 <<

INTRCPT2
W1JOBSAT
H1JOBSAT

LEVEL 1 MODEL (bold: group-mean centering; bold italic: grand-mean centering)

$$\text{OVERLOAD} = \beta_1(\text{WIFE}) + \beta_2(\text{HUSBAND}) + r$$

LEVEL 2 MODEL (bold italic: grand-mean centering)

$$\beta_1 = \gamma_{10} + u_1$$

$$\beta_2 = \gamma_{20} + u_2$$

Fixed Effects

What is the average level of wives' overload?

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For WIFE slope, B1 INTRCPT2, G10	3.238962	0.067133	48.247	150	0.000
For HUSBAND slope, B2 INTRCPT2, G20	3.081674	0.061134	50.409	150	0.000

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Questions

- Is there significant variability around the average role overload for wives?
 - Do wives experience significantly different levels of role overload before the birth?

- Is there significant variability around the average role overload for husbands?
 - Do husbands experience significantly different levels of role overload before the birth?

Variance Components

- Is there significant variability in wives' overload?
- Is there significant variability in husbands' overload?

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
WIFE slope, U1	0.78234	0.61205	149	1495.51557	0.000
HUSBAND slope, U2	0.70152	0.49212	149	1228.02929	0.000
level-1, R	0.37007	0.13695			

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Interclass Correlation

- How correlated are husbands' and wives' overload before the birth?

```
Tau (as correlations)
  WIFE, B1  1.000  0.002
  HUSBAND, B2 0.002  1.000
```



Adding Predictors: Model 2b

- Is job satisfaction related to role overload for mothers and fathers before the birth?
- Hypothesis: Higher job satisfaction will be associated with lower role overload

Conditional Model

- Predictors are entered at L2


$$\text{L1: } Y_{ij} = \beta_{1j}(\text{wife}) + \beta_{2j}(\text{husband}) + r_{ij}$$

$$\text{L2: } \beta_{1j} = \gamma_{10} + \gamma_{11}(\text{w1jobsat}) + u_{1j}$$

$$\beta_{2j} = \gamma_{20} + \gamma_{21}(\text{h1jobsat}) + u_{2j}$$

where i = individual responses 1, 2, 3, 4
and j = couples 1, 2, 3...150

Conditional Model in HLM 6

 **WHLM: hlm2 MDM File: distinguishable.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	OVERLOAD = $\beta_1(\text{WIFE}) + \beta_2(\text{HUSBAND}) + r$
>> Level-2 <<	
INTRCPT2	LEVEL 2 MODEL (bold italic: grand-mean centering)
W1JOBSAT	$\beta_1 = \gamma_{10} + \gamma_{11}(\text{W1JOBSAT}) + u_1$
H1JOBSAT	
TOTINC	$\beta_2 = \gamma_{20} + \gamma_{21}(\text{H1JOBSAT}) + u_2$

Fixed Effects

- Is job satisfaction associated with lower role overload?

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For WIFE slope, B1					
INTRCPT2, G10	3.238962	0.063899	50.689	149	0.000
W1JOBSAT, G11	-0.329652	0.081611	-4.039	149	0.000
For HUSBAND slope, B2					
INTRCPT2, G20	3.083207	0.060025	51.366	149	0.000
H1JOBSAT, G21	-0.200332	0.083909	-2.387	149	0.018

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Residual Variance

- Is there still variance left to be explained?

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
WIFE slope, U1	0.74032	0.54807	148	1349.03536	0.000
HUSBAND slope, U2	0.68694	0.47189	148	1183.70876	0.000
level-1, R	0.37007	0.13695			



Dyadic Longitudinal Model

- Can be extended to examine change in time in dyads
 - Create separate trajectories for men and women
- Differences
 - New Level-1 model that incorporates time
 - New Level-1 database with measure for time



Dyadic Longitudinal Example

Model 3

- How does role overload change across the transition to parenthood for both men and women?

Level 1: Dyadic Longitudinal Model

- Introduce Time at Level-1 for both wives & husbands

$$Y_{ij} = \beta_{1j}(\text{Wife}) + \beta_{2j}(\text{WTime})_{ij} +$$

where i indexes the wives' timepoints and j indexes the dyad

$$\beta_{3j}(\text{Husband}) + \beta_{4j}(\text{HTime})_{ij} + r_{ij}$$

where i indexes the husbands' timepoints and j indexes the dyad

Time is measured in months and

Time = 0 at child's birth

Level 2: Average Level & Rates of Change

□ Wives level and change

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

Level of overload

$$\beta_{2j} = \gamma_{20} + u_{2j}$$

Linear change in overload

□ Husbands level and change

$$\beta_{3j} = \gamma_{30} + u_{3j}$$

Level of overload

$$\beta_{4j} = \gamma_{40} + u_{4j}$$

Linear change in overload



Data Structure

- Level-1: each line contains
 - Individual's score on the outcome
 - Time
 - Husband and Wife indicator variables

- Level 2
 - All predictors that differ across dyads (by individual) go in the Level-2 file
 - One line per couple

L1 Data Structure

	family	member	time	parscore	overload	wife	husband	wdobtime	hdobtime
1	1	1	1	1	3.67	1	0	-.72	.00
2	1	1	1	2	4.00	1	0	-.72	.00
3	1	1	2	1	3.67	1	0	.92	.00
4	1	1	2	2	3.17	1	0	.92	.00
5	1	1	3	1	4.00	1	0	4.49	.00
6	1	1	3	2	4.00	1	0	4.49	.00
7	1	1	4	1	4.00	1	0	6.23	.00
8	1	1	4	2	3.83	1	0	6.23	.00
9	1	1	5	1	4.33	1	0	14.59	.00
10	1	1	5	2	4.50	1	0	14.59	.00
11	1	2	1	1	2.67	0	1	.00	-.72
12	1	2	1	2	3.33	0	1	.00	-.72
13	1	2	2	1	2.17	0	1	.00	.92
14	1	2	2	2	3.50	0	1	.00	.92
15	1	2	3	1	4.00	0	1	.00	4.52
16	1	2	3	2	3.83	0	1	.00	4.52
17	1	2	4	1	3.50	0	1	.00	6.39
18	1	2	4	2	3.50	0	1	.00	6.39
19	1	2	5	1	3.67	0	1	.00	14.59
20	1	2	5	2	3.67	0	1	.00	14.59

L1 Data Structure

	family	member	time	parscore	overload	wife	husband	wdobtime	hdobtime
1	1	1	1	1	3.67	1	0	-.72	.00
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4	1	1	2	2	3.17	1	0	.92	.00
5	1	1	3	1	4.00	1	0	4.49	.00
6	1	1	3	2	4.00	1	0	4.49	.00
7	1	1	4	1	4.00	1	0	6.23	.00
8	1	1	4	2	3.83	1	0	6.23	.00
9	1	1	5	1	4.33	1	0	14.59	.00
10	1	1	5	2	4.50	1	0	14.59	.00
11	1	2	1	1	2.67	0	1	.00	-.72
12	1	2	1	2	3.33	0	1	.00	-.72
13	1	2	2	1	2.17	0	1	.00	.92
14	1	2	2	2	3.50	0	1	.00	.92
15	1	2	3	1	4.00	0	1	.00	4.52
16	1	2	3	2	3.83	0	1	.00	4.52
17	1	2	4	1	3.50	0	1	.00	6.39
18	1	2	4	2	3.50	0	1	.00	6.39
19	1	2	5	1	3.67	0	1	.00	14.59
20	1	2	5	2	3.67	0	1	.00	14.59

Longitudinal Model in HLM 6

The screenshot shows the HLM 6 software interface. The title bar reads "WHLM: hlm2 MDM File: distinguishable long jobsat.mdm Command File: whlmtem...". The menu bar includes "File", "Basic Settings", "Other Settings", "Run Analysis", and "Help".

The main window is divided into two sections: "Outcome" and "Level-1" / "Level-2".

Outcome

>> Level-1 <<

Level-2

INTRCPT1
OVERLOAD
WIFE
HUSBAND
WDOBTIME
HDOBTIME
HDOBMOSQ
HDOBMOCU
WDOBMOSQ
WDOBMOCU

LEVEL 1 MODEL (bold: group-mean centering; bold italic: grand-mean centering)

$$\text{OVERLOAD} = \beta_1(\text{WIFE}) + \beta_2(\text{HUSBAND}) + \beta_3(\text{WDOBTIME}) + \beta_4(\text{HDOBTIME}) + r$$

LEVEL 2 MODEL (bold italic: grand-mean centering)

$$\beta_1 = \gamma_{10} + u_1$$
$$\beta_2 = \gamma_{20} + u_2$$
$$\beta_3 = \gamma_{30} + u_3$$
$$\beta_4 = \gamma_{40} + u_4$$

Average Trajectories

Final estimation of fixed effects:

Fixed Effect	Coefficient	Standard Error	T-ratio	Approx. d.f.	P-value
For WIFE slope, B1 INTRCPT2, G10	3.336888	0.056379	59.186	150	0.000
For HUSBAND slope, B2 INTRCPT2, G20	3.075707	0.051800	59.377	150	0.000
For WDOBTIME slope, B3 INTRCPT2, G30	0.012920	0.004436	2.912	150	0.005
For HDOBTIME slope, B4 INTRCPT2, G40	0.000614	0.004077	0.151	150	0.881

Does mothers' overload change across the transition to parenthood?

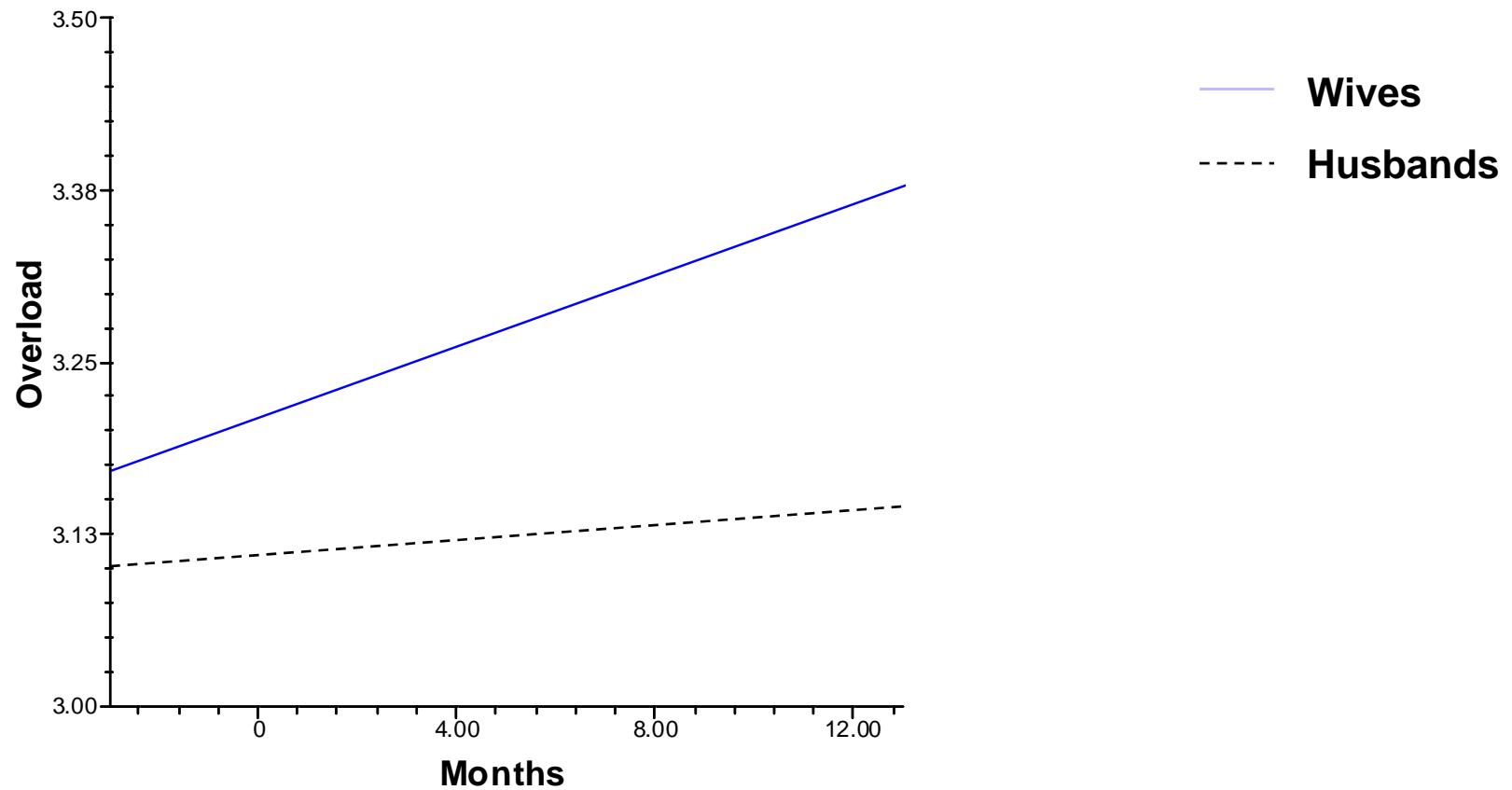
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For WDOBTIME slope, B3 INTRCPT2, G30	0.012920	0.004436	2.912	150	0.005
For HDOBTIME slope, B4 INTRCPT2, G40	0.000614	0.004077	0.151	150	0.881

Does husbands' overload change across the transition to parenthood?

Average Change in Overload



Variability in Trajectories

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
WIFE slope, U1	0.65093	0.42371	143	1296.30582	0.000
HUSBAND slope, U2	0.58800	0.34575	143	1113.16660	0.000
WDOBTIME slope, U3	0.03990	0.00159	143	338.97649	0.000
HDOBTIME slope, U4	0.03331	0.00111	143	301.70200	0.000
level-1, R	0.51108	0.26120			

Is there variability in wives trajectories?

In other words, do wives vary in their rate of change?

Variability in Trajectories

Final estimation of variance components:

Random Effect	Standard Deviation	Variance Component	df	Chi-square	P-value
WIFE slope, U1	0.65093	0.42371	143	1296.30582	0.000
HUSBAND slope, U2	0.58800	0.34575	143	1113.16660	0.000
WDOBTIME slope, U3	0.03990	0.00159	143	338.97649	0.000
HDOBTIME slope, U4	0.03331	0.00111	143	301.70200	0.000
level 1, R	0.51108	0.26120			

Is there variability in husbands' trajectories?

In other words, do husbands vary in their rate of change?



Extensions of the Dyadic Model

- Generating HLM estimates of L1 parameters
- Discrepancy (difference) scores
- Extension to triads
- Analyzing family groups with different numbers of members
- Indistinguishable dyads



Additional Materials

- A list of selected references on dyadic multilevel models, copies of the presentation slides, data used in the presentations, and step-by-step instructions on fitting the basic cross-sectional model in HLM 6 are all available on the web at

<http://www.umass.edu/family/ncfr.htm>