

The data below are from a sample of patients with insomnia problems in a double-blind clinical trial comparing an active hypnotic drug with a placebo. The response is the patient's reported time (in minutes) to fall asleep after going to bed. Patients responded before and following a 2-week treatment period. The two treatments, active drug and placebo, form a binary explanatory variable. The subjects were randomly allocated to the treatment groups. Here, each subject forms a cluster, with the observations in a cluster being the ordinal response at the two occasions of observation.

The response is 1, 2, 3, or 4, which denote the time to sleep was <20, 20–30, 30–60, and >60 minutes respectively.

```
data sleep;
input case treat occasion outcome;
datalines;
1      1      0      1
1      1      1      1
2      1      0      1
2      1      1      1
3      1      0      1
.....
236    0      0      4
236    0      1      4
237    0      0      4
237    0      1      4
238    0      0      4
238    0      1      4
239    0      0      4
239    0      1      4
;
```

We are going to fit this data with

$$\log \left\{ \frac{P(Y_{ij} \leq k | b_{i0})}{P(Y_{ij} > k | b_{i0})} \right\} = \beta_0 + \beta_1 G_i + \beta_2 t_{ij} + \beta_3 G_i t_{ij}$$

The effect of going from baseline to post treatment is  $e^{\beta_2}$  for the control group and  $e^{\beta_2 + \beta_3}$  for the treatment group.

```
proc glimmix method=quad(qpoints=50) data=sleep;
class case;
model outcome = treat occasion treat*occasion / link=cumlogit
dist=multinomial solution;
random int / subject=case;
run;
```

The SAS System
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The GLIMMIX Procedure

**Model Information**

**Data Set**

WORK.SLEEP

### Model Information

<b>Response Variable</b>	outcome
<b>Response Distribution</b>	Multinomial (ordered)
<b>Link Function</b>	Cumulative Logit
<b>Variance Function</b>	Default
<b>Variance Matrix Blocked By</b>	case
<b>Estimation Technique</b>	Maximum Likelihood
<b>Likelihood Approximation</b>	Gauss-Hermite Quadrature
<b>Degrees of Freedom Method</b>	Containment

### Class Level Information

#### Class Levels Values

case 239 1 2 3 4 5 6 7 8 9... 239

**Number of Observations Read** 478

**Number of Observations Used** 478

### Response Profile

<b>Ordered Value</b>	<b>outcome</b>	<b>Total Frequency</b>
1	1	97
2	2	118
3	3	129
4	4	134

The GLIMMIX procedure is modeling the probabilities of levels of outcome having lower Ordered Values in the Response Profile table.

### Dimensions

<b>G-side Cov. Parameters</b>	1
<b>Columns in X</b>	6
<b>Columns in Z per Subject</b>	1
<b>Subjects (Blocks in V)</b>	239

**Dimensions**

Max Obs per Subject	2
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**Optimization Information**

Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	7
Lower Boundaries	1
Upper Boundaries	0
Fixed Effects	Not Profiled
Starting From	GLM estimates
Quadrature Points	50

**Iteration History**

Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
0	0	4	1226.9387087	.	72.44447
1	0	2	1196.3631316	30.57557711	18.10421
2	0	3	1193.0623213	3.30081038	20.91976
3	0	2	1190.3894351	2.67288616	13.57284
4	0	3	1189.2483069	1.14112818	6.703743
5	0	2	1187.5023462	1.74596070	2.778815
6	0	2	1186.6273329	0.87501327	4.7954
7	0	2	1186.2377183	0.38961463	3.348319
8	0	2	1186.071747	0.16597136	2.1565
9	0	2	1185.9977503	0.07399664	1.405478
10	0	2	1185.9726747	0.02507558	1.036631
11	0	2	1185.94461	0.02806477	0.104798
12	0	3	1185.9442356	0.00037435	0.012845
13	0	3	1185.9442054	0.00003020	0.002786
14	0	3	1185.944205	0.00000045	0.000949

Convergence criterion (GCONV=1E-8) satisfied.

### Fit Statistics

<b>-2 Log Likelihood</b>	1185.94
<b>AIC (smaller is better)</b>	1199.94
<b>AICC (smaller is better)</b>	1200.18
<b>BIC (smaller is better)</b>	1224.28
<b>CAIC (smaller is better)</b>	1231.28
<b>HQIC (smaller is better)</b>	1209.75

### Fit Statistics for Conditional Distribution

<b>-2 log L(outcome   r. effects)</b>	789.00
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### Covariance Parameter Estimates

<b>Cov Parm</b>	<b>Subject</b>	<b>Estimate</b>	<b>Standard Error</b>
<b>Intercept</b>	<b>case</b>	3.6280	0.8815

### Solutions for Fixed Effects

<b>Effect</b>	<b>outcome</b>	<b>Estimate</b>	<b>Standard Error</b>	<b>DF</b>	<b>t Value</b>	<b>Pr &gt;  t </b>
<b>Intercept</b>	<b>1</b>	-3.4896	0.3588	237	-9.73	<.0001
<b>Intercept</b>	<b>2</b>	-1.4846	0.2903	237	-5.11	<.0001
<b>Intercept</b>	<b>3</b>	0.5613	0.2702	237	2.08	0.0388
<b>treat</b>		0.05786	0.3663	235	0.16	0.8746
<b>occasion</b>		1.6016	0.2834	235	5.65	<.0001
<b>treat*occasion</b>		1.0813	0.3805	235	2.84	0.0049

### Type III Tests of Fixed Effects

<b>Effect</b>	<b>Num DF</b>	<b>Den DF</b>	<b>F Value</b>	<b>Pr &gt; F</b>
<b>treat</b>	1	235	0.02	0.8746
<b>occasion</b>	1	235	31.95	<.0001
<b>treat*occasion</b>	1	235	8.08	0.0049

```

proc glimmix method=quad(qpoints=10) data=sleep;
class case outcome(ref="1");
model outcome = treat occasion treat*occasion / link=GLOGIT dist=multinomial
solution;
random int / subject=case group=outcome;
run;

```

## The SAS System

### The GLIMMIX Procedure

#### Model Information

<b>Data Set</b>	WORK.SLEEP
<b>Response Variable</b>	outcome
<b>Response Distribution</b>	Multinomial (nominal)
<b>Link Function</b>	Generalized Logit
<b>Variance Function</b>	Default
<b>Variance Matrix Blocked By</b>	case
<b>Estimation Technique</b>	Maximum Likelihood
<b>Likelihood Approximation</b>	Gauss-Hermite Quadrature
<b>Degrees of Freedom Method</b>	Containment

#### Class Level Information

Class	Levels	Values
case	239	1 2 3 4 5 6 ... 239
outcome	4	1 2 3 4

**Number of Observations Read** 478

**Number of Observations Used** 478

#### Response Profile

Ordered Value	outcome	Total Frequency
1	1	97
2	2	118
3	3	129
4	4	134

### Response Profile

Ordered outcome Value	Total Frequency
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In modeling category probabilities, outcome='1' serves as the reference category.

### Dimensions

G-side Cov. Parameters	3
Columns in X	12
Columns in Z per Subject	3
Subjects (Blocks in V)	239
Max Obs per Subject	2

### Optimization Information

Optimization Technique	Dual Quasi-Newton
Parameters in Optimization	15
Lower Boundaries	3
Upper Boundaries	0
Fixed Effects	Not Profiled
Starting From	GLM estimates
Quadrature Points	10

### Iteration History

Iteration	Restarts	Evaluations	Objective Function	Change	Max Gradient
0	0	4	1239.7426277	.	22.20949
1	0	2	1228.1019538	11.64067383	16.4115
2	0	3	1224.4588175	3.64313629	9.375126
23	0	3	1199.5074377	0.00001444	0.002029
24	0	3	1199.507437	0.00000075	0.001723

Convergence criterion (GCONV=1E-8) satisfied.

**Estimated G matrix is not positive definite.**

### Fit Statistics

<b>-2 Log Likelihood</b>	1199.51
<b>AIC (smaller is better)</b>	1227.51
<b>AICC (smaller is better)</b>	1228.41
<b>BIC (smaller is better)</b>	1276.18
<b>CAIC (smaller is better)</b>	1290.18
<b>HQIC (smaller is better)</b>	1247.12

### Fit Statistics for Conditional Distribution

<b>-2 log L(outcome   r. effects)</b>	826.62
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### Covariance Parameter Estimates

<b>Cov Parm</b>	<b>Subject</b>	<b>Group</b>	<b>Estimate</b>	<b>Standard Error</b>
<b>Intercept</b>	<b>case</b>	<b>outcome 2</b>	0	.
<b>Intercept</b>	<b>case</b>	<b>outcome 3</b>	0.7530	0.5949
<b>Intercept</b>	<b>case</b>	<b>outcome 4</b>	6.4050	2.6088

### Solutions for Fixed Effects

<b>Effect</b>	<b>outcome</b>	<b>Estimate</b>	<b>Standard Error</b>	<b>DF</b>	<b>t Value</b>	<b>Pr &gt;  t </b>
<b>Intercept</b>	<b>2</b>	0.3561	0.3484	478	1.02	0.3073
<b>Intercept</b>	<b>3</b>	0.8540	0.3439	478	2.48	0.0134
<b>Intercept</b>	<b>4</b>	1.0727	0.4371	478	2.45	0.0145
<b>treat</b>	<b>2</b>	0.1551	0.5047	0	0.31	.
<b>treat</b>	<b>3</b>	0.3272	0.4900	0	0.67	.
<b>treat</b>	<b>4</b>	-0.04118	0.6205	0	-0.07	.
<b>occasion</b>	<b>2</b>	-0.4227	0.4338	0	-0.97	.
<b>occasion</b>	<b>3</b>	-0.8486	0.4211	0	-2.02	.
<b>occasion</b>	<b>4</b>	-2.4529	0.5660	0	-4.33	.
<b>treat*occasion</b>	<b>2</b>	0.1143	0.6057	0	0.19	.
<b>treat*occasion</b>	<b>3</b>	-1.2945	0.6210	0	-2.08	.

### Solutions for Fixed Effects

Effect	outcome	Estimate	Standard Error	DF	t Value	Pr >  t
treat*occasion	4	-1.6081	0.7836	0	-2.05	.

### Type III Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
treat	3	0	0.23	.
occasion	3	0	6.62	.
treat*occasion	3	0	3.31	.