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

The effect of going from baseline to post treatment is for the control group and 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 |

The GLIMMIX Procedure

| **Model Information** | |
| --- | --- |
| **Data Set** | WORK.SLEEP |
| **Response Variable** | outcome |
| **Response Distribution** | Multinomial (ordered) |
| **Link Function** | Cumulative Logit |
| **Variance Function** | Default |
| **Variance Matrix Blocked By** | case |
| **Estimation Technique** | Maximum Likelihood |
| **Likelihood Approximation** | Gauss-Hermite Quadrature |
| **Degrees of Freedom Method** | 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** | | |
| --- | --- | --- |
| **Ordered Value** | **outcome** | **Total Frequency** |
| **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** | |
| --- | --- |
| **G-side Cov. Parameters** | 1 |
| **Columns in X** | 6 |
| **Columns in Z per Subject** | 1 |
| **Subjects (Blocks in V)** | 239 |
| **Max Obs per Subject** | 2 |

| **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** | |
| --- | --- |
| **-2 Log Likelihood** | 1185.94 |
| **AIC (smaller is better)** | 1199.94 |
| **AICC (smaller is better)** | 1200.18 |
| **BIC (smaller is better)** | 1224.28 |
| **CAIC (smaller is better)** | 1231.28 |
| **HQIC (smaller is better)** | 1209.75 |

| **Fit Statistics for Conditional Distribution** | |
| --- | --- |
| **-2 log L(outcome | r. effects)** | 789.00 |

| **Covariance Parameter Estimates** | | | |
| --- | --- | --- | --- |
| **Cov Parm** | **Subject** | **Estimate** | **Standard Error** |
| **Intercept** | **case** | 3.6280 | 0.8815 |

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

| **Type III Tests of Fixed Effects** | | | | |
| --- | --- | --- | --- | --- |
| **Effect** | **Num DF** | **Den DF** | **F Value** | **Pr > F** |
| **treat** | 1 | 235 | 0.02 | 0.8746 |
| **occasion** | 1 | 235 | 31.95 | <.0001 |
| **treat\*occasion** | 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** | |
| --- | --- |
| **Data Set** | WORK.SLEEP |
| **Response Variable** | outcome |
| **Response Distribution** | Multinomial (nominal) |
| **Link Function** | Generalized Logit |
| **Variance Function** | Default |
| **Variance Matrix Blocked By** | case |
| **Estimation Technique** | Maximum Likelihood |
| **Likelihood Approximation** | Gauss-Hermite Quadrature |
| **Degrees of Freedom Method** | 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 |
| **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** | |
| --- | --- |
| **-2 Log Likelihood** | 1199.51 |
| **AIC (smaller is better)** | 1227.51 |
| **AICC (smaller is better)** | 1228.41 |
| **BIC (smaller is better)** | 1276.18 |
| **CAIC (smaller is better)** | 1290.18 |
| **HQIC (smaller is better)** | 1247.12 |

| **Fit Statistics for Conditional Distribution** | |
| --- | --- |
| **-2 log L(outcome | r. effects)** | 826.62 |

| **Covariance Parameter Estimates** | | | | |
| --- | --- | --- | --- | --- |
| **Cov Parm** | **Subject** | **Group** | **Estimate** | **Standard Error** |
| **Intercept** | **case** | **outcome 2** | 0 | . |
| **Intercept** | **case** | **outcome 3** | 0.7530 | 0.5949 |
| **Intercept** | **case** | **outcome 4** | 6.4050 | 2.6088 |

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