

Knee Data - Sequential/Cumulative Random Effects Logit Models

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For the sequential and cumulative random effects logit models we use the knee data from "catdata". We load the data "kneesequential" and "kneecumulative" which are already transformed and ready for use in the sequential or cumulative model.

```
> library(catdata)
> data(kneesequential)
> data(kneecumulative)
```

The covariate "Age" is centered around 30 years and a quadratic effect of "Age" is created for both data sets.

```
> kneesequential$Age <- kneesequential$Age - 30
> kneesequential$Age2 <- kneesequential$Age^2
> kneecumulative$Age <- kneecumulative$Age - 30
> kneecumulative$Age2 <- kneecumulative$Age^2
```

For the sequential random effects logit model with Gauss-Hermite-Quadrature the function "glmer" from "lme4" is used.

```
> library(lme4)
```

Now the sequential model with 25 quadrature points (option "nAGQ=25") and a random intercept is fitted.

```
> seqGH <- glmer(y ~ -1 + Icept1 + Icept2 + Icept3 + Icept4 + Th + Age + Age2 + (1 | Person),
+               family = binomial(link = logit), data = kneesequential, nAGQ = 25)
> summary(seqGH)
```

Generalized linear mixed model fit by maximum likelihood (Adaptive Gauss-Hermite Quadrature, nAGQ = 25) [glmerMod]

Family: binomial (logit)

Formula: y ~ -1 + Icept1 + Icept2 + Icept3 + Icept4 + Th + Age + Age2 + (1 | Person)

Data: kneesequential

AIC	BIC	logLik	deviance	df.resid
778	818	-381	762	1010

Scaled residuals:

Min	1Q	Median	3Q	Max
-2.843	-0.188	-0.024	0.115	7.153

Random effects:

Groups Name	Variance	Std.Dev.
Person (Intercept)	36.9	6.08

Number of obs: 1018, groups: Person, 127

Fixed effects:

	Estimate	Std. Error	z value	Pr(> z)
Icept1	-7.26241	1.24049	-5.85	4.8e-09 ***
Icept2	-4.45158	1.14265	-3.90	9.8e-05 ***
Icept3	-0.47229	1.08840	-0.43	0.6643
Icept4	7.16899	1.36775	5.24	1.6e-07 ***
Th	2.29676	1.17221	1.96	0.0501 .
Age	0.03489	0.06362	0.55	0.5834
Age2	0.02062	0.00748	2.76	0.0058 **

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Correlation of Fixed Effects:

	Icept1	Icept2	Icept3	Icept4	Th	Age
Icept2	0.926					
Icept3	0.841	0.913				
Icept4	0.355	0.462	0.584			
Th	-0.538	-0.554	-0.529	-0.272		
Age	0.118	0.134	0.151	0.169	0.127	
Age2	-0.638	-0.633	-0.606	-0.319	0.021	-0.283

The sequential model with Penalized Quasi-Likelihood is fitted with the function "glmmPQL" from the "MASS" library.

```
> library(MASS)
```

Here the sequential model with Penalized Quasi-Likelihood is fitted.

```
> seqPQL<-glmmPQL(y ~-1+Icept1+Icept2+Icept3+Icept4+Th+Age+Age2,
+ random=list(Person=~1), family=binomial(link=logit), data=kneesequential, niter=30)
> summary(seqPQL)
```

Linear mixed-effects model fit by maximum likelihood

Data:	kneesequential
AIC BIC logLik	
NA NA NA	

Random effects:

Formula:	~1 Person
(Intercept) Residual	
StdDev:	5.43 0.631

```

Variance function:
  Structure: fixed weights
  Formula: ~invwt
Fixed effects: y ~ -1 + Icept1 + Icept2 + Icept3 + Icept4 + Th + Age + Age2
      Value Std.Error   DF t-value p-value
Icept1 -7.10      0.964 888   -7.36  0.0000
Icept2 -4.03      0.937 888   -4.30  0.0000
Icept3 -0.18      0.928 888   -0.19  0.8485
Icept4  6.75      1.018 888    6.63  0.0000
Th       2.11      1.006 124    2.10  0.0377
Age      0.03      0.055 124    0.48  0.6346
Age2     0.02      0.006 124    2.77  0.0064
Correlation:
      Icept1 Icept2 Icept3 Icept4 Th      Age
Icept2  0.948
Icept3  0.913  0.954
Icept4  0.745  0.775  0.806
Th      -0.528 -0.540 -0.530 -0.437
Age      0.166  0.168  0.172  0.171  0.118
Age2    -0.613 -0.613 -0.609 -0.528 -0.020 -0.330

Standardized Within-Group Residuals:
      Min      Q1      Med      Q3      Max
-5.2851 -0.3074 -0.0354  0.2488 11.1251

Number of Observations: 1018
Number of Groups: 127

```

The cumulative models will be fitted with "clmm" from the package "ordinal".

```
> library(ordinal)
```

For the sequential random effects logit model with Gauss-Hermite Quadrature the number of quadrature points is defined by the option "nAGQ=25". Now the model is fitted again with a random intercept as the only random effect.

```

> cumGH<-clmm2(as.factor(y)~1+Th+Age+Age2, random = as.factor(Person), data =
+ kneecumulative, link = "logistic",nAGQ=25,start=c(-5,-3,3,5,rep(0.001,4)),Hess=TRUE)
> summary(cumGH)

```

Cumulative Link Mixed Model fitted with the adaptive Gauss-Hermite quadrature approximation with 25 quadrature points

Call:

```

clmm2(location = as.factor(y) ~ 1 + Th + Age + Age2, random = as.factor(Person),
      data = kneecumulative, start = c(-5, -3, 3, 5, rep(0.001,
      4)), Hess = TRUE, link = "logistic", nAGQ = 25)

```

Random effects:

```

      Var Std.Dev
as.factor(Person) 39.1    6.25

```

Location coefficients:

	Estimate	Std. Error	z value	Pr(> z)
Th	-2.380	1.205	-1.975	0.048
Age	-0.034	0.066	-0.516	0.606
Age2	-0.021	0.008	-2.774	0.006

No scale coefficients

Threshold coefficients:

	Estimate	Std. Error	z value
1 2	-7.461	1.256	-5.942
2 3	-4.498	1.168	-3.850
3 4	-0.396	1.118	-0.354
4 5	7.363	1.390	5.296

log-likelihood: -380.42

AIC: 776.84

Condition number of Hessian: 227257.12

For Laplace–Approximation the option "nAGQ" can be dropped.

```
> cumLP<-clmm2(as.factor(y)~1+Th+Age+Age2, random = as.factor(Person), data =  
+ kneecumulative, link = "logistic",start=c(-5,-3,3,5,rep(0.001,4)), Hess = TRUE)  
> summary(cumLP)
```

Cumulative Link Mixed Model fitted with the Laplace approximation

Call:

```
clmm2(location = as.factor(y) ~ 1 + Th + Age + Age2, random = as.factor(Person),  
data = kneecumulative, start = c(-5, -3, 3, 5, rep(0.001,  
4)), Hess = TRUE, link = "logistic")
```

Random effects:

	Var	Std.Dev
as.factor(Person)	40.6	6.37

Location coefficients:

	Estimate	Std. Error	z value	Pr(> z)
Th	-2.667	1.263	-2.111	0.035
Age	-0.038	0.068	-0.558	0.577
Age2	-0.025	0.008	-3.285	0.001

No scale coefficients

Threshold coefficients:

	Estimate	Std. Error	z value
1 2	-8.024	1.340	-5.987
2 3	-5.073	1.241	-4.087
3 4	-0.949	1.173	-0.809
4 5	6.900	1.204	5.733

log-likelihood: -382.90
AIC: 781.80
Condition number of Hessian: 260184.54