

Today...

- adding covariates, using matrix notation
- including factors as covariates (including time)
- including time/covariate interactions
- writing random effects similarly

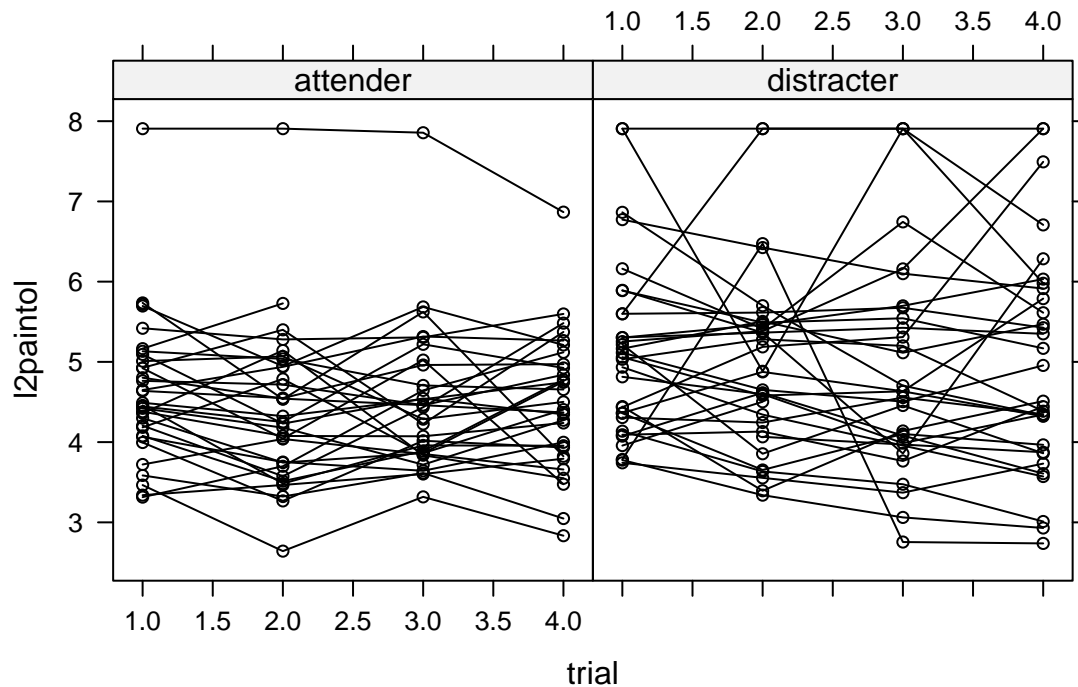
The pediatric pain data

```

> pp <- read.delim("http://rem.ph.ucla.edu/rob/mld/data/tabdelimiteddata/pain.txt")
> pp$id <- factor(pp$id)
> pp$trialF <- factor(pp$trial)
> pp <- subset(pp, !is.na(l2paintol))

> mtheme <- standard.theme("pdf", col = FALSE)
> mtheme$superpose.symbol$pch <- 1
> mtheme$superpose.line$lty <- 1
> p1 <- xyplot(l2paintol ~ trial | cs, group = id, data = pp, type = c("p",
+   "l"))
> plot(update(p1, par.settings = mtheme))

```



```

> print(subset(pp, id == 1), digits = 2)

```

id	ses	cs	treatment	sex	age	trial	paintol	l2paintol	trialF	
1	1	74	attender	attend	female	10	1	21	4.4	1
2	1	74	attender	attend	female	10	2	35	5.1	2
3	1	74	attender	attend	female	10	3	14	3.8	3
4	1	74	attender	attend	female	10	4	12	3.5	4

Writing trial as a continuous covariate

```
> m1 <- gls(l2paintol ~ trial, correlation = corCompSymm(form = ~1 |
+   id), data = pp)
> print(summary(m1))
```

...

Correlation Structure: Compound symmetry

Formula: ~1 | id

Parameter estimate(s):

Rho

0.709507

Coefficients:

	Value	Std.Error	t-value	p-value
(Intercept)	4.851909	0.1491448	32.53153	0.0000
trial	-0.035968	0.0342969	-1.04871	0.2954

...

Writing trial as a categorical covariate

```
> m2 <- gls(l2paintol ~ trialF, correlation = corCompSymm(form = ~1 |
+   id), data = pp)
> summary(m2)
```

...

Correlation Structure: Compound symmetry

Formula: ~1 | id

Parameter estimate(s):

Rho

0.709043

Coefficients:

	Value	Std.Error	t-value	p-value
(Intercept)	4.873252	0.1390196	35.05442	0.0000
trialF2	-0.171854	0.1070196	-1.60582	0.1096
trialF3	-0.146066	0.1097488	-1.33091	0.1845
trialF4	-0.128272	0.1082590	-1.18486	0.2372

...

Adding an additive covariate

```
> m3 <- gls(l2paintol ~ cs + trial, correlation = corCompSymm(form = ~1 |
+   id), data = pp)
> summary(m3)
```

...

Correlation Structure: Compound symmetry

Formula: ~1 | id

Parameter estimate(s):

Rho

0.6991802

Coefficients:

	Value	Std.Error	t-value	p-value
(Intercept)	4.624141	0.18982807	24.359626	0.0000
csdistracter	0.457070	0.24093314	1.897083	0.0590
trial	-0.036504	0.03431347	-1.063827	0.2885

...

Adding a continuous covariate with interaction with time

```
> m4 <- gls(l2paintol ~ cs * trial, correlation = corCompSymm(form = ~1 |
+   id), data = pp)
> summary(m4)
```

...

Correlation Structure: Compound symmetry

Formula: ~1 | id

Parameter estimate(s):

Rho

0.6987603

Coefficients:

	Value	Std.Error	t-value	p-value
(Intercept)	4.577443	0.20770723	22.037956	0.0000
csdistracter	0.551001	0.29430377	1.872217	0.0624
trial	-0.017288	0.04872473	-0.354812	0.7230
csdistracter:trial	-0.038253	0.06874132	-0.556472	0.5784

...

Adding a categorical covariate with interaction with time

```
> m5 <- gls(l2paintol ~ cs * trialF, correlation = corCompSymm(form = ~1 |
+   id), data = pp)
> summary(m5)
```

...

Correlation Structure: Compound symmetry

Formula: ~1 | id

Parameter estimate(s):

Rho

0.6965347

Coefficients:

	Value	Std.Error	t-value	p-value
(Intercept)	4.636986	0.1930756	24.016435	0.0000
csdistracter	0.474004	0.2739912	1.729996	0.0849
trialF2	-0.219556	0.1524610	-1.440078	0.1512
trialF3	-0.102597	0.1559828	-0.657748	0.5113
trialF4	-0.093787	0.1542512	-0.608012	0.5438
csdistracter:trialF2	0.089871	0.2153705	0.417284	0.6768
csdistracter:trialF3	-0.089458	0.2208438	-0.405076	0.6858
csdistracter:trialF4	-0.071977	0.2178577	-0.330387	0.7414

...

Random Intercept

```
> m6 <- lme(l2paintol ~ trial, random = ~1 | id, data = pp)
> summary(m6)
```

```
...
```

```
Random effects:
```

```
Formula: ~1 | id
```

```
(Intercept) Residual
```

```
StdDev:    0.934123 0.597715
```

```
Fixed effects: l2paintol ~ trial
```

```
Value Std.Error DF t-value p-value
```

```
(Intercept) 4.851909 0.14914476 180 32.53154 0.0000
```

```
trial -0.035968 0.03429691 180 -1.04871 0.2957
```

```
...
```

How is this the same as the gls model using AR(1)?

Random Intercept and Slope

```
> m6 <- lme(l2paintol ~ trial, random = ~trial | id, data = pp)
> summary(m6)

...
Random effects:
Formula: ~trial | id
Structure: General positive-definite, Log-Cholesky parametrization
           StdDev   Corr
(Intercept) 0.9565892 (Intr)
trial        0.1880152 -0.275
Residual     0.5466477

Fixed effects: l2paintol ~ trial
           Value Std.Error DF t-value p-value
(Intercept)  4.851700 0.14682309 180 33.04453  0.0000
trial        -0.035517 0.03951166 180 -0.89889  0.3699
...

```