

## Multivariate Models for Longitudinal Differences Scores

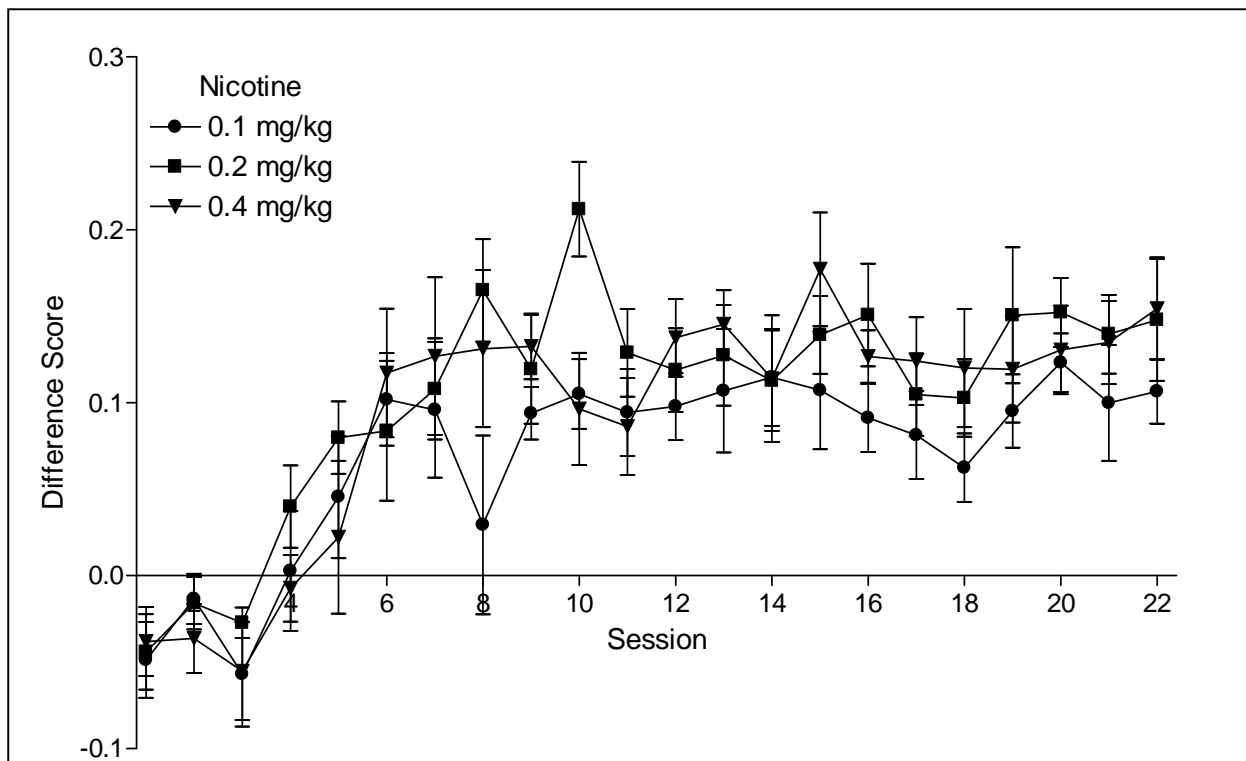
### SAS Data Manipulation:

```

* Importing data from excel;
PROC IMPORT DATAFILE = "F:\Example Data\Rick Difference Scores\Difference Scores.xls"
  OUT=DiffScore DBMS=EXCEL REPLACE; SHEET="Sheet1"; GETNAMES=YES; RUN;

* Stacking data using ARRAY statements;
* ARRAY = list of variables -- repeat for each one in list;
DATA Stacked; SET DiffScore;
  ARRAY difscore(22) one--twentytwo;
  ARRAY nicscore(22) nic1--nic22;
  ARRAY salscore(22) sal1--sal22;
  * Repeat from 1 to 22;
  DO i=1 TO 22;
    time=(i); timel=(i)-1; timell=(i)-11;
    diff=difscore(i); nic=nicscore(i); sal=salscore(i);
    OUTPUT; END;      * OUTPUT writes line of data, END do loop;
  DROP i one--sal22; * Remove unnecessary variables;
  LABEL   timel=      "Time (0=timel)"
         timell=     "Time (0=timell)"
         diff=       "diff: Difference Score"
         nic=        "nic: Nicotine (Treatment) Score"
         sal=        "sal: Saline (Control) Score"; RUN;

```



### 1a) Original Model: Univariate Repeated Measures ANOVA on 22 Difference Scores over Time

```

TITLE1 "Univariate (CS) Repeated Measures ANOVA of Difference Scores";
PROC MIXED DATA=Stacked COVTEST NOCLPRINT NOITPRINT IC METHOD=REML;
  CLASS rat time group;
  MODEL diff = timell|timell|group / SOLUTION DDFM=Satterthwaite;
  REPEATED time / R RCORR TYPE=CS SUBJECT=rat; run;

```

```

Dimensions
Covariance Parameters      2 #variance parameters
Columns in X               12
Columns in Z Per Subject   0
Subjects                   28 #rats
Max Obs Per Subject        22 #occasions

```

```

Covariance Parameter Estimates
              Standard      Z
Cov Parm    Subject  Estimate  Error  Value    Pr Z
CS           Rat     12.2687   4.3199  2.84     0.0045 → ICC = .16
Residual                    65.8208   3.8585  17.06    <.0001

```

```

Information Criteria
Neg2LogLike  Parms    AIC    AICC    HQIC    BIC    CAIC
      4385.2      2    4389.2  4389.3  4390.1  4391.9  4393.9

```

```

Solution for Fixed Effects
              Standard
Effect       Group  Estimate  Error    DF    t Value  Pr > |t|
Intercept                    12.5087   1.5409  38.6    8.12    <.0001
time11                    0.8862   0.09789  582    9.05    <.0001
time11*time11             -0.08853  0.01704  582   -5.20    <.0001
Group                0.1    -3.0026   2.0674  38.6    -1.45    0.1545
Group                0.2     1.1778   2.0674  38.6     0.57    0.5722
Group                0.4         0         .         .         .         .
time11*Group         0.1    -0.2245   0.1313  582    -1.71    0.0879
time11*Group         0.2    -0.1110   0.1313  582    -0.85    0.3984
time11*Group         0.4         0         .         .         .         .
time11*time11*Group   0.1     0.01809  0.02286  582     0.79    0.4292
time11*time11*Group   0.2    -0.00116  0.02286  582    -0.05    0.9595
time11*time11*Group   0.4         0         .         .         .         .

```

```

Type 3 Tests of Fixed Effects
              Num    Den
Effect       DF    DF    F Value  Pr > F
time11              1    582    216.61  <.0001
time11*time11      1    582     81.92  <.0001
Group              2    38.6     2.43  0.1018
time11*Group       2    582     1.47  0.2310
time11*time11*Group 2    582     0.49  0.6148

```

**Repeated Measures ANOVA assumes compound symmetry, or that all variances are equal, and all covariances are equal. Let's see how plausible this assumption is when analyzing difference scores.**

### 1b) Alternative Model: Multivariate Repeated Measures ANOVA on 22 Difference Scores over Time

```

TITLE1 "Repeated Measures ANOVA of Difference Scores";
PROC MIXED DATA=Stacked COVTEST NOCLPRINT NOITPRINT IC METHOD=REML;
  CLASS rat time group;
  MODEL diff = time11|time11|group / SOLUTION DDFM=Satterthwaite;
  REPEATED time / R RCORR TYPE=UN SUBJECT=rat; run;

```

```

Dimensions
Covariance Parameters      253 uh-oh...
Columns in X               12
Columns in Z               0
Subjects                   28
Max Obs Per Subject        22

```

**Estimated R Matrix for Rat 4643 (truncated to save space)**

Row	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10
1	50.6484	-2.6286	23.9842	7.2632	-25.8866	-25.2120	-34.2468	-19.2795	-35.2882	-39.3483
2	-2.6286	27.2690	22.7249	-5.2882	-14.3012	-30.5797	-29.6504	-6.4147	-10.2327	-31.3275
3	23.9842	22.7249	82.1743	31.6494	-19.2908	-41.4100	-62.0528	14.9226	-37.1728	-63.0418
4	7.2632	-5.2882	31.6494	67.3995	-20.0117	-2.7806	-25.0091	9.4439	-14.3104	2.1397
5	-25.8866	-14.3012	-19.2908	-20.0117	101.65	25.6514	28.9618	-19.3801	25.0158	47.2026
6	-25.2120	-30.5797	-41.4100	-2.7806	25.6514	142.98	96.1246	20.0728	40.6579	80.7067
7	-34.2468	-29.6504	-62.0528	-25.0091	28.9618	96.1246	158.42	-9.6038	63.4528	91.6666
8	-19.2795	-6.4147	14.9226	9.4439	-19.3801	20.0728	-9.6038	208.88	30.4385	38.8520
9	-35.2882	-10.2327	-37.1728	-14.3104	25.0158	40.6579	63.4528	30.4385	78.4232	47.9712
10	-39.3483	-31.3275	-63.0418	2.1397	47.2026	80.7067	91.6666	38.8520	47.9712	145.18

**Estimated R Correlation Matrix for Rat 4643 (truncated to save space)**

Row	Col1	Col2	Col3	Col4	Col5	Col6	Col7	Col8	Col9	Col10
1	1.0000	-0.07073	0.3718	0.1243	-0.3608	-0.2963	-0.3823	-0.1874	-0.5599	-0.4589
2	-0.07073	1.0000	0.4801	-0.1234	-0.2716	-0.4897	-0.4511	-0.08500	-0.2213	-0.4979
3	0.3718	0.4801	1.0000	0.4253	-0.2111	-0.3820	-0.5439	0.1139	-0.4631	-0.5772
4	0.1243	-0.1234	0.4253	1.0000	-0.2418	-0.02833	-0.2420	0.07959	-0.1968	0.02163
5	-0.3608	-0.2716	-0.2111	-0.2418	1.0000	0.2128	0.2282	-0.1330	0.2802	0.3886
6	-0.2963	-0.4897	-0.3820	-0.02833	0.2128	1.0000	0.6387	0.1162	0.3840	0.5602
7	-0.3823	-0.4511	-0.5439	-0.2420	0.2282	0.6387	1.0000	-0.05280	0.5693	0.6044
8	-0.1874	-0.08500	0.1139	0.07959	-0.1330	0.1162	-0.05280	1.0000	0.2378	0.2231
9	-0.5599	-0.2213	-0.4631	-0.1968	0.2802	0.3840	0.5693	0.2378	1.0000	0.4496
10	-0.4589	-0.4979	-0.5772	0.02163	0.3886	0.5602	0.6044	0.2231	0.4496	1.0000

**Information Criteria**

Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
3743.4	253	4249.4	4613.5	4352.5	4586.5	4839.5

**Solution for Fixed Effects**

Effect	Group	Estimate	Standard Error	DF	t Value	Pr >  t
Intercept		7.9610	0.5747	25	13.85	<.0001
time11		0.4976	0.06088	25	8.17	<.0001
time11*time11		-0.05069	0.005941	25	-8.53	<.0001
Group	0.1	-3.1415	0.7711	25	-4.07	0.0004
Group	0.2	-0.7993	0.7711	25	-1.04	0.3099
Group	0.4	0	.	.	.	.
time11*Group	0.1	-0.2863	0.08169	25	-3.50	0.0017
time11*Group	0.2	-0.3304	0.08169	25	-4.04	0.0004
time11*Group	0.4	0	.	.	.	.
time11*time11*Group	0.1	0.01561	0.007971	25	1.96	0.0614
time11*time11*Group	0.2	-0.01131	0.007971	25	-1.42	0.1684
time11*time11*Group	0.4	0	.	.	.	.

**Type 3 Tests of Fixed Effects**

Effect	Num DF	Den DF	F Value	Pr > F
time11	1	25	79.66	<.0001
time11*time11	1	25	237.91	<.0001
Group	2	25	9.39	0.0009 (used to be 0.0108)
time11*Group	2	25	9.32	0.0009 (used to be 0.2310)
time11*time11*Group	2	25	6.46	0.0055 (used to be 0.6148)

**Now what?? Which is the 'right' model, and which set of fixed effects should we believe?**

## New Strategy: Model-Based Difference Scores within a Multivariate Longitudinal Model

### SAS Data Manipulation:

```
* Double-stacking for multivariate models;
DATA BivStacked; SET Stacked;
  y=nic; dv="Nic"; dvnic=1; dvsal=0; OUTPUT;
  y=sal; dv="Sal"; dvnic=0; dvsal=1; OUTPUT; run;
```

Preliminary univariate analyses on each outcome revealed that a fixed quadratic, random linear fit best for nicotine, whereas a random linear fit best for saline. In order to eventually test differences in the quadratic effect, however, we'll keep the fixed quadratic for saline.

### 2a) Direct Effects Model: Whether each effect is significant per outcome:

```
TITLE1 "Direct Effects (Method #1): Significance Per Outcome";
PROC MIXED DATA=BivStacked COVTEST NOCLPRINT NOITPRINT IC NAMELEN=100 METHOD=REML;
  CLASS rat group time dv;
  MODEL y = dvnic dvnic*group dvnic*time11 dvnic*time11*group
    dvnic*time11*time11 dvnic*time11*time11*group
    dvsal dvsal*group dvsal*time11 dvsal*time11*group
    dvsal*time11*time11 dvsal*time11*time11*group
    / NOINT SOLUTION DDFM=Satterthwaite;
  RANDOM dvnic dvsal dvnic*time11 dvsal*time11 / G GCORR SUBJECT=rat TYPE=UN;
  REPEATED dv / R RCORR SUBJECT=time*rat TYPE=UN;
  * Getting missing group contrasts for each DV and each growth effect;
  ESTIMATE "Nic Intercept: g=.1 v g=.2" dvnic*group -1 1 0;
  ESTIMATE "Nic Linear: g=.1 v g=.2" dvnic*time11*group -1 1 0;
  ESTIMATE "Nic Quadratic: g=.1 v g=.2" dvnic*time11*time11*group -1 1 0;
  ESTIMATE "Sal Intercept: g=.1 v g=.2" dvsal*group -1 1 0;
  ESTIMATE "Sal Linear: g=.1 v g=.2" dvsal*time11*group -1 1 0;
  ESTIMATE "Sal Quadratic: g=.1 v g=.2" dvsal*time11*time11*group -1 1 0; run;
```

Dimensions	
Covariance Parameters	18
Columns in X	24
Columns in Z Per Subject	5
Subjects	28
Max Obs Per Subject	44 = 2 DVs * 22 sessions

Estimated R Matrix for Rat*time 4643 1			Estimated R Correlation Matrix for Rat*time 4643 1		
Row	Col1	Col2	Row	Col1	Col2
1	44.7127	3.7316	1	1.0000	0.1241
2	<b>3.7316</b>	24.6166	2	<b>0.1125</b>	1.0000

Estimated G Matrix						
Row	Effect	Rat	Col1	Col2	Col3	Col4
1	dvnic	4643	24.3324	9.7679	0.5569	-1.0500
2	dvsal	4643	9.7679	6.5504	0.005899	-0.5255
3	dvnic*time11	4643	<b>0.5569</b>	0.005899	0.04308	-0.00209
4	dvsal*time11	4643	-1.0500	-0.5255	<b>-0.00209</b>	0.05671

Estimated G Correlation Matrix						
Row	Effect	Rat	Col1	Col2	Col3	Col4
1	dvnic	4643	1.0000	0.7737	0.5439	-0.8939
2	dvsal	4643	<b>0.7737</b>	1.0000	0.01111	-0.8623
3	dvnic*time11	4643	0.5439	0.01111	1.0000	-0.04235
4	dvsal*time11	4643	-0.8939	-0.8623	<b>-0.04235</b>	1.0000

Covariance Parameter Estimates (truncated to save space)					
Cov Parm	Subject	Estimate	Standard Error	Z	Pr >  Z
UN(2,1)	Rat	9.7679	3.4719	2.81	0.0049
UN(4,3)	Rat	-0.00209	0.01786	-0.12	0.9067
UN(2,1)	Rat*time	3.7316	1.4146	2.64	0.0083

Information Criteria						
Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC
7959.8	13	7985.8	7986.1	7991.1	8003.1	8016.1

Solution for Fixed Effects

Effect	Group	Estimate	Standard Error	DF	t Value	Pr >  t	
dvnic		20.1456	1.9007	30	10.60	<.0001	nic time11 Y for g=.4
dvnic*Group	0.1	-3.2210	2.5501	30	-1.26	0.2163	nic time11 g=.4 v g=.1
dvnic*Group	0.2	0.04085	2.5501	30	0.02	0.9873	nic time11 g=.4 v g=.2
dvnic*Group	0.4	0	.	.	.	.	
dvnic*time11		0.5450	0.1091	25.8	5.00	<.0001	nic linear for g=.4
dvnic*time11*Group	0.1	-0.2680	0.1463	25.8	-1.83	0.0786	nic linear g=.4 v g=.1
dvnic*time11*Group	0.2	-0.1743	0.1463	25.8	-1.19	0.2443	nic linear g=.4 v g=.2
dvnic*time11*Group	0.4	0	.	.	.	.	
dvnic*time11*time11		-0.07674	0.01404	557	-5.46	<.0001	nic quad for g=.4
dvnic*time11*time11*Group	0.1	0.01259	0.01884	557	0.67	0.5044	nic quad g=.4 v g=.1
dvnic*time11*time11*Group	0.2	0.006194	0.01884	557	0.33	0.7425	nic quad g=.4 v g=.2
dvnic*time11*time11*Group	0.4	0	.	.	.	.	
dvsal		7.6369	1.0646	34.8	7.17	<.0001	sal time11 Y for g=.4
dvsal*Group	0.1	-0.2184	1.4283	34.8	-0.15	0.8793	sal time11 g=.4 v g=.1
dvsal*Group	0.2	-1.1370	1.4283	34.8	-0.80	0.4314	sal time11 g=.4 v g=.2
dvsal*Group	0.4	0	.	.	.	.	
time11*dvsal		-0.3412	0.1033	25.5	-3.30	0.0028	sal linear for g=.4
time11*dvsal*Group	0.1	-0.04349	0.1386	25.5	-0.31	0.7562	sal linear g=.4 v g=.1
time11*dvsal*Group	0.2	-0.06333	0.1386	25.5	-0.46	0.6516	sal linear g=.4 v g=.2
time11*dvsal*Group	0.4	0	.	.	.	.	
time11*time11*dvsal		0.01179	0.01042	557	1.13	0.2582	sal quad time for g=.4
time11*time11*dvsal*Group	0.1	-0.00550	0.01398	557	-0.39	0.6942	sal quad g=.4 v g=.1
time11*time11*dvsal*Group	0.2	0.007357	0.01398	557	0.53	0.5990	sal quad g=.4 v g=.2
time11*time11*dvsal*Group	0.4	0	.	.	.	.	

Estimates

Label	Estimate	Standard Error	DF	t Value	Pr >  t
Nic Intercept: g=.1 v g=.2	3.2619	2.4043	30	1.36	0.1850
Nic Linear: g=.1 v g=.2	0.09368	0.1379	25.8	0.68	0.5031
Nic Quadratic: g=.1 v g=.2	-0.00639	0.01776	557	-0.36	0.7191
Sal Intercept: g=.1 v g=.2	-0.9185	1.3466	34.8	-0.68	0.4997
Sal Linear: g=.1 v g=.2	-0.01984	0.1307	25.5	-0.15	0.8805
Sal Quadratic: g=.1 v g=.2	0.01286	0.01318	557	0.98	0.3298

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F	
dvnic	1	30	349.01	<.0001	nic across-group intercept = 0?
dvnic*Group	2	30	1.17	0.3240	nic group diff in intercept at time 11?
dvnic*time11	1	25.8	46.00	<.0001	nic across-group linear = 0?
dvnic*time11*Group	2	25.8	1.70	0.2026	nic group diff in linear at time 11?
dvnic*time11*time11	1	557	87.18	<.0001	nic across-group quadratic = 0?
dvnic*time11*time11*Group	2	557	0.22	0.7991	nic group diff in quadratic?
dvsal	1	34.8	157.69	<.0001	sal across-group intercept = 0?
dvsal*Group	2	34.8	0.38	0.6884	sal group diff in intercept at time 11?
time11*dvsal	1	25.5	46.04	<.0001	sal across-group linear = 0?
time11*dvsal*Group	2	25.5	0.11	0.8989	sal group diff in linear at time 11?
time11*time11*dvsal	1	557	4.91	0.0271	sal across-group quadratic = 0?
time11*time11*dvsal*Group	2	557	0.48	0.6200	sal group diff in quadratic?

Although the previous model tells us whether there are group differences in the growth curves for each condition (nicotine vs. saline) separately, it does not tell us whether there are group differences in the *difference* across outcomes over time, which is what they are really interested in. The easiest way to test this is to re-estimate the model using the “differences in effects (method 2)” specification.

**2b) Differences in Effects Model: Whether the difference between outcomes over time varies by group:**

```
TITLE1 "Differences in Effects (Method #2): Significance of Differences";
PROC MIXED DATA=BivStacked COVTEST NOCLPRINT NOITPRINT IC NAMELEN=100 METHOD=REML;
  CLASS rat group time dv;
  MODEL y = group dvsal dvnic*group time11 time11*group dvsal*time11 dvnic*time11*group
    time11*time11 time11*time11*group dvsal*time11*time11 dvnic*time11*time11*group
    / SOLUTION DDFM=Satterthwaite;
  RANDOM dvnic dvsal dvnic*time11 dvsal*time11 / G GCORR SUBJECT=rat TYPE=UN;
  REPEATED dv / R RCORR SUBJECT=time(rat) TYPE=UN;
  * Group differences in DIFFERENCE SCORES at time=11;
  LSMEANS group / AT (dvnic dvsal time11) = (0 1 0) DIFF=ALL;
  * Group differences in DIFFERENCE SCORES at time=1;
  LSMEANS group / AT (dvnic dvsal time11) = (0 1 -11) DIFF=ALL;
  * Group differences in DIFFERENCE SCORES at time=22;
  LSMEANS group / AT (dvnic dvsal time11) = (0 1 11) DIFF=ALL;
run;
```

		Information Criteria						
Neg2LogLike	Parms	AIC	AICC	HQIC	BIC	CAIC		
7959.8	13	7985.8	7986.1	7991.1	8003.1	8016.1		
Solution for Fixed Effects								
Effect	Group	Estimate	Standard Error	DF	t Value	Pr >  t		
Intercept		20.1456	1.9007	30	10.60	<.0001	nic @time11 for g=.4	
Group	0.1	-3.2210	2.5501	30	-1.26	0.2163	nic @time11 g=.4 v.1	
Group	0.2	0.04085	2.5501	30	0.02	0.9873	nic @time11 g=.4 v.2	
Group	0.4	0	.	.	.	.		
dvsal		-12.5087	1.4862	38.7	-8.42	<.0001	Ydiff@time11 for g=.4	
dvsal*Group	0.1	3.0026	1.9939	38.7	1.51	0.1402	Ydiff@time11 g=.4 v.1	
dvsal*Group	0.2	-1.1778	1.9939	38.7	-0.59	0.5582	Ydiff@time11 g=.4 v.2	
dvsal*Group	0.4	0	.	.	.	.		
time11		0.5450	0.1091	25.8	5.00	<.0001	nic linear for g=.4	
time11*Group	0.1	-0.2680	0.1463	25.8	-1.83	0.0786	nic linear g=.4 v.1	
time11*Group	0.2	-0.1743	0.1463	25.8	-1.19	0.2443	nic linear g=.4 v.2	
time11*Group	0.4	0	.	.	.	.		
dvsal*time11		-0.8862	0.1483	25.6	-5.97	<.0001	Ydiff lin for g=.4	
dvsal*time11*Group	0.1	0.2245	0.1990	25.6	1.13	0.2697	Ydiff lin g=.4 v.1	
dvsal*time11*Group	0.2	0.1110	0.1990	25.6	0.56	0.5819	Ydiff lin g=.4 v.1	
dvsal*time11*Group	0.4	0	.	.	.	.		
time11*time11		-0.07674	0.01404	557	-5.46	<.0001	nic quad for g=.4	
time11*time11*Group	0.1	0.01259	0.01884	557	0.67	0.5044	nic quad g=.4 v.1	
time11*time11*Group	0.2	0.006194	0.01884	557	0.33	0.7425	nic quad g=.4 v.1	
time11*time11*Group	0.4	0	.	.	.	.		
dvsal*time11*time11		0.08853	0.01652	557	5.36	<.0001	Ydiff quad for g=.4	
dvsal*time11*time11*Group	0.1	-0.01809	0.02216	557	-0.82	0.4148	Ydiff quad g=.4 v.1	
dvsal*time11*time11*Group	0.2	0.001163	0.02216	557	0.05	0.9582	Ydiff quad g=.4 v.2	
dvsal*time11*time11*Group	0.4	0	.	.	.	.		

Requested mean nicotine vs. saline difference scores by group at time 11, time 1, and time 22:

Least Squares Means									
Effect	Group	dvsal	time11	dvnic	Estimate	Standard Error	DF	t Value	Pr >  t
Group	0.1	1.00	0.00	0.00	7.4185	0.9522	34.8	7.79	<.0001
Group	0.2	1.00	0.00	0.00	6.5000	0.9522	34.8	6.83	<.0001
Group	0.4	1.00	0.00	0.00	7.6369	1.0646	34.8	7.17	<.0001
Group	0.1	1.00	-11.00	0.00	12.4111	1.9267	38.8	6.44	<.0001
Group	0.2	1.00	-11.00	0.00	13.2666	1.9267	38.8	6.89	<.0001
Group	0.4	1.00	-11.00	0.00	12.8167	2.1541	38.8	5.95	<.0001
Group	0.1	1.00	11.00	0.00	3.9489	1.0144	71.1	3.89	0.0002
Group	0.2	1.00	11.00	0.00	4.3678	1.0144	71.1	4.31	<.0001
Group	0.4	1.00	11.00	0.00	5.3113	1.1342	71.1	4.68	<.0001

Requested tests of differences between groups in those difference scores at time 11, time 1, and time 22:

Differences of Least Squares Means										
Effect	Group	Group	dvsal	time11	dvnic	Estimate	Standard Error	DF	t Value	Pr >  t
Group	0.1	0.2	1.00	0.00	0.00	0.9185	1.3466	34.8	0.68	0.4997
Group	0.1	0.4	1.00	0.00	0.00	-0.2184	1.4283	34.8	-0.15	0.8793
Group	0.2	0.4	1.00	0.00	0.00	-1.1370	1.4283	34.8	-0.80	0.4314
Group	0.1	0.2	1.00	-11.00	0.00	-0.8554	2.7248	38.8	-0.31	0.7552
Group	0.1	0.4	1.00	-11.00	0.00	-0.4056	2.8901	38.8	-0.14	0.8891
Group	0.2	0.4	1.00	-11.00	0.00	0.4499	2.8901	38.8	0.16	0.8771
Group	0.1	0.2	1.00	11.00	0.00	-0.4189	1.4346	71.1	-0.29	0.7712
Group	0.1	0.4	1.00	11.00	0.00	-1.3623	1.5216	71.1	-0.90	0.3736
Group	0.2	0.4	1.00	11.00	0.00	-0.9435	1.5216	71.1	-0.62	0.5372

Omnibus tests of group differences for nicotine and difference scores from saline:

Type 3 Tests of Fixed Effects					
Effect	Num DF	Den DF	F Value	Pr > F	
Group	2	30	1.17	0.3240	nic group diff in intercept at time 11?
dvsal	1	38.7	221.95	<.0001	Ydiff across-group intercept at time 11 = 0?
<b>dvsal*Group</b>	<b>2</b>	<b>38.7</b>	<b>2.61</b>	<b>0.0866</b>	<b>Ydiff group diff in intercept at time 11?</b>
time11	1	25.8	46.00	<.0001	nic across-group linear at time 11 = 0?
time11*Group	2	25.8	1.70	0.2026	nic group diff in linear at time 11?
dvsal*time11	1	25.6	94.33	<.0001	Ydiff across-group linear at time 11 = 0?
<b>dvsal*time11*Group</b>	<b>2</b>	<b>25.6</b>	<b>0.64</b>	<b>0.5356</b>	<b>Ydiff group diff in linear at time 11?</b>
time11*time11	1	557	87.18	<.0001	nic across-group quadratic = 0?
time11*time11*Group	2	557	0.22	0.7991	nic group diff in quadratic?
dvsal*time11*time11	1	557	87.15	<.0001	Ydiff across-group quadratic = 0?
<b>dvsal*time11*time11*Group</b>	<b>2</b>	<b>557</b>	<b>0.52</b>	<b>0.5960</b>	<b>Ydiff group diff in quadratic?</b>

These results strongly suggest the initial conclusion was indeed valid: the dosage groups do not appear to differ in the rates of learning (as indicated by a positive difference score for nicotine relative to saline).