Repeated Measures ANOVA

One Factor, Correlated Measures:

- Same reasoning of Correlated Measures t-test
  - More Power (and more efficient)
    - Pulls out relatively small differences among treatments
      - Relative to Big differences among subjects
        - Removes Differences among subjects from error term

Subjects vs. Treatments

	Levels of independent variable, X		
Subjects	X_1	X_2	X_3
S_1	57	60	64
S_2	71	72	74
S_3	75	76	78
S_4	93	92	96
$\overline{X}$	74	75	78

↑ Large Differences (Error) ↓

← Small Differences (Effect) →

Partitioning The Variance

$SS_{Total} = SS_{Subjects} + SS_{Treatment} + SS_{Error}$

SS_{Error} Is the Variability which a single subject would have
If you repeatedly measured him without changing treatment

Partitioning The Variance

Common Response to Tx Unique Response to Tx

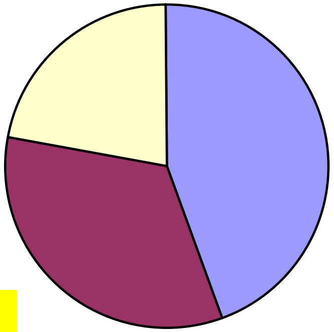
$$SS_{Total} = SS_{Subjects} + SS_{Treatment} + SS_{Error}$$

SS_{Error} Is the Variability which a single subject would have
If you repeatedly measured him without changing treatment

The Structure of the ANOVA

Partitioning the Total Sum of Squared Deviations
From the Grand Mean

Spontaneous Variability of Subject
Change is not the same for each Subject



E.G., Strategies

Subjects

D.V.: Test Score

If you test your subjects repeatedly:
Counter Balance for (e.g.) practice effects/fatigue

POC: Piece of Cake

	1st choice	Control	Notes
S1	57	60	64
S2	71	72	74
S3	75	76	78
S4	93	92	96

Step 1: Find The Total SS

	Raw Data	Cell Deviations	Square Deviations
S1T1	57	-18.7	348.4
S2T1	71	-4.7	21.8
S3T1	75	-0.7	0.4
S4T1	93	17.3	300.4
S1T2	60	-15.7	245.4
S2T2	72	-3.7	13.4
S3T2	76	0.3	0.1
S4T2	92	16.3	266.8
S1T3	64	-11.7	136.1
S2T3	74	-1.7	2.8
S3T3	78	2.3	5.4
S4T3	96	20.3	413.4
Grand Mean=	**75.67**	**SS-Total=**	**1754.7**

Step 2: Compute Between Subjects SS

Subject				
Means	**Deviation**	**Sq Dev**	**Sq Dev*3**	
60.3	-15.3	235.1	705.33	
72.3	-3.3	11.1	33.33	
76.3	0.7	0.4	1.33	
93.7	18.0	324	972	
		SS-Sub=	**1712**	"/3
		MS-Sub=	**570.7**	

Step 3: Compute Treatment SS

Treatment Means		74	75	78			
	Deviation	-1.7	-0.7	2.3			
	Sq Dev	2.8	0.4	5.4			
	Sq dev*4	11.1	1.8	21.8	**SS-Treat=**	**34.7**	"/2
					MS-Treat=	**17.3**	

Step 4: Compute SS Error

SS-Total	"-	SS-Sub-	SS-Treat	"=	SS-Error
1754.7		1712	34.7		8.0
					"/(4-1)(3-1)
				MS-Error=	1.333

This is the Same as the Interaction Term in a 2-Way ANOVA

IV_1: Treatment

IV_2: Subject

Interaction: Subject x Treatment

Step 5: Determine Degrees of Freedom

In general:

$$df_{\text{tot}} = N_{\text{tot}} - 1$$
$$df_{\text{subjects}} = N_s - 1$$
$$df_{\text{treat}} = N_t - 1$$
$$df_{\text{error}} = (N_s - 1)(N_t - 1)$$

For the strategy study:

$$df_{\text{tot}} = 12 - 1 = 11$$
$$df_{\text{subjects}} = 4 - 1 = 3$$
$$df_{\text{strategies}} = 3 - 1 = 2$$
$$df_{\text{error}} = (3)(2) = 6$$

Just like Interaction df

Step 6: Calculate MS & F

F = MS-Treat /	MS-Error	
" 17.3 /	1.333 =	13.003

TABLE 12.4 ANOVA summary table for the exam strategy study

Source	*SS*	*df*	*MS*	*F*
Subjects	1712.000	3		
Strategies	34.667	2	17.333	13.00
Error	8.000	6	1.333	
Total	1754.667	11		

$F_{.05}(2, 6) = 5.14$ $F_{.01}(2, 6) = 10.92$

If ANOVA is Significant

Use Tukey Test to compare treatments

$$\mathrm{HSD} = \frac{\bar{X}_1 - \bar{X}_2}{s_{\bar{X}}}$$

$$s_{\bar{X}} = \sqrt{\frac{MS_{\mathrm{error}}}{N_t}}$$

N_t is Number of Subjects in your Experiment

Caution

- Caryover effects
  - Counter-balance
  - Vs. Trend Analysis

- Populations Normally Distributed