Beyond the ANOVA: Alternative techniques for statistical analyses of neuropsychological data.

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online reprint: http://schatz.sju.edu/nan/

Background

Alt: “How to become a stats geek without trying”

Why this talk at NAN?

Resources:
Texts: Stevens, Tabachnick & Fidel
Web calculators: http://calculators.stat.ucla.edu/
Web sites: www2.chass.ncsu.edu/garson/pa765/statnote.htm
What is "variance"? N=1?

What is "variance"? N=20?

What is "variance"? N=100?

The developer of Swampy Acres Retirement Home is attempting to sell lots in a "Southern Paradise" to northern buyers. The "marks" express concern that flooding might occur. The developer reassures them by explaining that the average elevation of the lots is 78.5 feet and that the water has never exceeded 25 feet.

Would you buy a "used Retirement Home" from this data?
What is “variance”? N=100?

Would you buy a “used Retirement Home” from this data?

What is “variance”? N=100? normally distributed?

Multicollinearity

Inter-relationship between variables
AKA: Shared variance

Which variable contributes the MOST variance?
Which variables then contribute the most UNIQUE variance that is not shared with the first?
Multicollinearity

Why use a covariate?
Non-Equivalent Groups Design

To ANCOVA or not to ANCOVA…

What are the “rules” or “assumptions for ANCOVA?

1. DV is linear and normally distributed
2. There is a homogeneity of regression slopes (slope of regression line is same in each group)
3. There is a theoretical and statistical correlation between the DV and proposed CV
To ANCOVA or not to ANCOVA...

What are the "rules" or "assumptions for ANCOVA?"

1. DV is linear and normally distributed - easy!
   - Know your data
   - Frequency distributions, graphs

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To ANCOVA or not to ANCOVA...

What are the "rules" or "assumptions for ANCOVA?"

1. DV is linear and normally distributed
   - IV: Concussion Group
     - None, 1+, 2+ Recent
   - DV: Attention Subscale (RBANS)
   - CV: GPA?


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To ANCOVA or not to ANCOVA...

1. DV is linear and normally distributed - yes!

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To ANCOVA or not to ANCOVA…

What are the "rules" or "assumptions for ANCOVA?"

2. There is a homogeneity of regression slopes
(slope of regression line is same in each group)

- Simple, but little known method: SPSS syntax
  MANOVA DV by IV (X,X) WITH CV
  /PRINT=SIGNIF(BRIEF)
  /ANALYSIS = DV
  /METHOD = SEQUENTIAL
  /DESIGN CV IV CV by IV.
To ANCOVA or not to ANCOVA...

What are the "rules" or "assumptions for ANCOVA?"

3. There is a theoretical and statistical correlation between the DV and proposed CV - not so easy!
   - Statistical - Pearson's r - simple
   - Theoretical - based on literature, knowledge - not so simple

<table>
<thead>
<tr>
<th>Correlations</th>
<th>grade point average</th>
<th>attentionAL level</th>
</tr>
</thead>
<tbody>
<tr>
<td>grade point average</td>
<td>1.00</td>
<td>0.231</td>
</tr>
<tr>
<td>N</td>
<td>254</td>
<td>230</td>
</tr>
<tr>
<td>attentionAL level</td>
<td>0.231</td>
<td>1.00</td>
</tr>
<tr>
<td>N</td>
<td>233</td>
<td>238</td>
</tr>
</tbody>
</table>

(All correlations are significant at the 0.05 level (2-tailed).

To ANCOVA or not to ANCOVA...

3. There is a theoretical and statistical correlation between the DV and proposed CV - not so easy!
   - Statistical - Pearson's r - simple

"No means of achieving the superficially appealing goal of 'correcting' or 'controlling for' real group differences on a potential covariate"

To ANCOVA or not to ANCOVA...

3. There is a theoretical and statistical correlation between the DV and proposed CV - not so easy!
   • Makes no sense to ask how students with low GPA in school would score on attention test if they had high GPA...
   • Not all students have a high GPA...
   • GPA and concussion are intimately related

To ANCOVA or not to ANCOVA...

3. There is a theoretical and statistical correlation between the DV and proposed CV - not so easy!
   • Removal of variance in attention associated with GPA may remove considerable variance in attention associate with concussion

Beyond (M)ANOVA...

Between Groups Differences (MANOVA)
IV: Concussion (Yes/No)
DV: ImpACT Subscales, Symptom
MANOVA: [F(25,514)=4.4; p<.001]

Beyond (M)ANOVA…

Can you predict Group membership with p<.001?

Discriminant Analysis

- Characterizes the relationship between a set of IVs with a categorical DV with relatively few categories
- Creates a linear combination of the IVs that best characterizes the differences among the groups
  - Predictive discriminant analysis focus on creating a rule to predict group membership
  - Descriptive DA studies the relationship between the DV and the IVs.

Discriminant Analysis

Characterizes the relationship between a set of IVs with a categorical DV with relatively few categories

- Creates a linear combination of the IVs that best characterizes the differences among the groups
  - Predictive DA - focus on creating a rule to predict group membership
  - Descriptive DA - studies the relationship between the DV and the IVs.
Discriminant Analysis

Flip the MANOVA upside-down: Between Groups Differences (MANOVA)

- IV: Concussion (Yes/No)
- DV: ImPACT Subscales, Symptom

Predict Group Membership (DA)

- DV = “Predictant” = Concussion (yes/no)
- IVs = Predictors = ImPACT Subscales, Symptom

1. We have a between group difference
2. The DA returns 1 “function” - it is significant (Chi-Square) - predicts a specific amount of variance (Eigen, Canonical Correlation)

<table>
<thead>
<tr>
<th>Function</th>
<th>Wilks' Lambda</th>
<th>$\lambda$</th>
<th>$\eta^2$</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.05</td>
</tr>
</tbody>
</table>

Discriminant function: Significance, Percentage of variance, Canonical correlations.

<table>
<thead>
<tr>
<th>Discriminant function</th>
<th>Significance</th>
<th>Percentage of variance</th>
<th>Canonical correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

3. Classification Table reveals “success” in discriminating between groups

<table>
<thead>
<tr>
<th>Actual</th>
<th>Predicted group membership</th>
<th>Consonu</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive (5)</td>
<td>59</td>
<td>13</td>
<td>72</td>
</tr>
<tr>
<td>None</td>
<td>7</td>
<td>89</td>
<td>96</td>
</tr>
<tr>
<td>Consenstu (2)</td>
<td>81.9</td>
<td>81.3</td>
<td>80.0</td>
</tr>
<tr>
<td>Not consenstu</td>
<td>104.6</td>
<td>104.1</td>
<td>100.0</td>
</tr>
</tbody>
</table>

Note: 85.9% of original grouped cases correctly classified.

4. Standardized canonical discriminant function coefficients - like beta weights in a regression - rank importance of each variable

<table>
<thead>
<tr>
<th>Factor</th>
<th>Standardized coefficient</th>
<th>Correlations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Visual Memory composite</td>
<td>-0.45</td>
<td>-0.19</td>
</tr>
<tr>
<td>Processing Speed composite</td>
<td>0.48</td>
<td>-0.78</td>
</tr>
<tr>
<td>Impulse Control composite</td>
<td>-0.24</td>
<td>0.46</td>
</tr>
<tr>
<td>Post-Concussion Symptom Scale</td>
<td>-0.25</td>
<td>0.89</td>
</tr>
</tbody>
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Discriminant Analysis

Standardized canonical discriminant function coefficients and pooled within-groups correlations for Post-Concussion Symptom Scale, and the ImpACT Impulse Control, Processing Speed, and Visual Memory composite scores.

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<th>Standardized Coefficients</th>
<th>Correlations</th>
</tr>
</thead>
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<tr>
<td>Visual Memory composite</td>
<td>0.47</td>
<td>0.29</td>
</tr>
<tr>
<td>Processing Speed composite</td>
<td>0.48</td>
<td>0.78</td>
</tr>
<tr>
<td>Impulse Control composite</td>
<td>-0.11</td>
<td>-0.56</td>
</tr>
<tr>
<td>Post-Concussion Symptom Scale</td>
<td>-0.25</td>
<td>-0.16</td>
</tr>
</tbody>
</table>

5. Correlation coefficients - how much each variable correlates with the function.

6. Calculating sensitivity

<table>
<thead>
<tr>
<th></th>
<th>Concussed</th>
<th>Control</th>
</tr>
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<tbody>
<tr>
<td>Concussed</td>
<td>81.9%</td>
<td>18.1%</td>
</tr>
<tr>
<td>Not Conc</td>
<td>10.6%</td>
<td>89.4%</td>
</tr>
</tbody>
</table>

Correct "positive" hits = 81.9%
(e.g., the probability that a test result will be positive when a concussion is present)

7. Calculating specificity

<table>
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<tr>
<th></th>
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</tr>
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Correct "negative" hits = 89.4%
(e.g., the probability that a test result will be negative when a concussion is not present)
Discriminant Analysis

8. Calculating positive likelihood ratio

<table>
<thead>
<tr>
<th>Predicted-&gt;</th>
<th>Concussed</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concussed</td>
<td>81.9%</td>
<td>18.1%</td>
</tr>
<tr>
<td>Not Conc</td>
<td>10.6%</td>
<td>89.4%</td>
</tr>
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</table>

prob of an indv with the condition having a pos test = 81.9 / 7.73:1
prob of an indv w/out the condition having a pos test = 10.6
(ratio between the probability of a positive test result given the presence of a concussion and the probability of a positive test result given the absence of a concussion)

Beyond ANOVA

Dependent ANOVA analyses:
- Change from Time 1 to Time 2
- IV=Baseline versus Post-concussion
- DV=ImPACT

Wilke’s Lambda revealed a multi-rate within-subjects effect (time) on ImPACT performance [F(2,70)=1670; p=.000; ES=.98], with significant declines noted from baseline-to-3 days (eta squared=.56).
Beyond ANOVA - Reliable Change?

Is change from Time 1 to Time 2 a reliable change?
- Reliable Change Index (RCI) is computed for each case:
  - Time 2 - Time 1 / SE
  - Report total percentage of cases with "reliable change"
  - Report RCI intervals for that measure

Table 1: Formulas for calculating the reliable change index.

<table>
<thead>
<tr>
<th>Standard error of measurement (s.e.m.)</th>
<th>Standard deviation of the comparison sample standard error (s.e.)</th>
<th>Standard error of the difference (s.e.d.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>s.e.m. = s.d. / \sqrt{2}</td>
<td>s.d. = standard deviation of the comparison sample</td>
<td>s.e.d. = \sqrt{\text{s.e.m.}^2 + \text{s.e.}^2}</td>
</tr>
<tr>
<td>Reliable change index (RCI)</td>
<td>RCI = \frac{s.e.d.}{X2 - X1}</td>
<td>X2 = post-treatment score; X1 = pre-treatment baseline score</td>
</tr>
</tbody>
</table>

(Note: adapted from 

Beyond ANOVA - Reliable Change?

<table>
<thead>
<tr>
<th>Using Excel</th>
<th>Mean 1</th>
<th>Mean 2</th>
<th>R^2</th>
<th>Test 1</th>
<th>Test 2</th>
<th>SE</th>
<th>t</th>
<th>p</th>
<th>SE</th>
<th>w</th>
<th>ROI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base-30day</td>
<td>0.46</td>
<td>0.49</td>
<td>0.34</td>
<td>0.45</td>
<td>0.57</td>
<td>1.36</td>
<td>0.51</td>
<td>0.55</td>
<td>1.13</td>
<td>0.63</td>
<td>0.87</td>
</tr>
</tbody>
</table>
Beyond ANOVA - Reliable Change?

Baseline to Time 1:
58% showed "reliable change" in at least one composite score
27% showed "reliable change" in two or more composite score

Required "Change Intervals":
Reaction Time: 0.17
Verbal Memory: 19%
Visual Memory: 29%
Processing Spd: 19.2
Symptom Score: 15

Covassin, Schnitt, Swainik, (in review), Neurosurgery

National Academy of Neuropsychology, San Antonio, TX, October 2006