1. What is a composite variable?
2. Using Composites for nonlinear variables
3. Composites v. Latents - when and why?
4. Comparison in context
5. Treatment as a Composite variable
Composite Variables Reflect Joint Effects

- Coefficients can be statistically estimated.
- Fixing error to 0 aids in identification (otherwise it’s a latent composite)
- Specifying a scale is often helpful.

Coefficients Can be Fixed

- Relative Density
- Relative Abundance
- Relative Frequency

Easy way to incorporate concepts into models, particularly if exogenous variables have effects beyond the composite variable.

Composites and Nonlinearities

Indicates one variable derived from another

Composites and Categorical Variables

Categories coded as 0 or 1
To SEM and Beyond!
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Mediation in Analysis of Post-Fire Recovery of Plant Communities in California Shrublands*

*Five year study of wildfires in Southern California in 1993. 90 plots (20 x 50m), (data from Jon Keeley et al.)

Analysis focus: understand post-fire recovery of plant species richness

measured vegetation recovery:
- plant cover
- species richness

Examination of woody remains allowed for estimate of age of stand that burned as well as severity of the fires.

Linear or Nonlinear?

linear<-lm( rich ~ cover, data=keeley)
nonlinear<-lm( rich ~ cover+I(cover^2), data=keeley)
aictab( list( linear, nonlinear), c("linear", "squared"))
Model selection based on AICc:

<p>| | | | |</p>
<table>
<thead>
<tr>
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</thead>
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<tr>
<td>K</td>
<td>AICc</td>
<td>Delta_AICc</td>
<td>AICcWt</td>
</tr>
<tr>
<td>squared</td>
<td>4</td>
<td>735.92</td>
<td>0.00</td>
</tr>
<tr>
<td>linear</td>
<td>3</td>
<td>739.08</td>
<td>3.15</td>
</tr>
</tbody>
</table>

Linear or Nonlinear?

**A Simple Nonlinear Model**

```r
#Create a new nonlinear variable in the data
keeley <- within(keeley, coverSQ <- cover^2)

#Now, for a model
noCompModel <- 'rich ~ cover + coverSQ'

noCompFit <- sem(noCompModel, data=keeley)
```

```r
> summary(noCompFit)

Regression:

|                          | Estimate | Std.err | Z-value | P(>|z|) |
|--------------------------|----------|---------|---------|---------|
| rich ~ cover             | 57.999   | 18.613  | 3.116   | 0.002   |
| rich ~ coverSQ           | -28.577  | 12.176  | -2.347  | 0.019   |
```

**A Simple Composite Model**

```r
#Create a new nonlinear variable in the data
keeley <- within(keeley, coverSQ <- cover^2)

#Now, for a model
noCompModel <- 'rich ~ cover + coverSQ'

noCompFit <- sem(noCompModel, data=keeley)

compModel <- 'coverEffect <- 58*cover + coverSQ
rich ~ coverEffect'

compFit <- sem(compModel, data=keeley)
```
A Simple Composite Model

```
+-----------------+-------+---+---+---+
| cover           | 58.0  | 1 |
| coversq         | -28.6 |   |
+-----------------+-------+---+---+---+
```

Composites:
- coverEffect

Regressions:
- rich ~ coverEffect

Variances:
- rich

Estimate Std.err Z-value P(>|z|)
- coverEffect <- cover
coversq 58.000 3.996 -7.152 0.000
- regression rich - coverEffect
- variance rich 189.597 28.263

R² = 0.16

Note About the Latent Nature of Composite

- Response variables act like latent variable indicators
- Therefore, responses must share some variance.
- Rules that applied to identifiably of latent variables also apply to composites.
- One composite per response if composite error = 0. If composite has multiple responses, error variance should be free.

Exercise: A Nonlinear Relationship Between abiotic and firesev

1. Fit this model – start with a regression
2. Compare the effect of fixing the abiotic loading on abiotic effect to the coefficient from the regression to fixing the abioticEffect on firesev to 1.
For some reason, this model fails

```
keeley$abioticSQ <- keeley$abiotic^2
abioticCompModelBad <-'
  abioticEffect <- 0.4 * abiotic + abioticSQ
  firesev ~ abioticEffect'
abioticCompFitBad <- sem(abioticCompModelBad, data=keeley)
```

This model does not: try multiple methods with composites!

```
keeley$abioticSQ <- keeley$abiotic^2
abioticCompModel <-'
  abioticEffect <- abiotic + abioticSQ
  firesev ~ 1*abioticEffect'
abioticCompFit <- sem(abioticCompModel, data=keeley)
```

Endogenous Composite Variables

```
endoCompModel <-'
  coverEffect <- 1*cover + coverSQ
  cover ~ coverSQ
  age ~ coverSQ
  cover ~ age
  rich ~ age + coverEffect'
endoCompFit <- sem(endoCompModel, data=keeley, fixed.x=F)
```

### Estimate Std.err Z-value P(>|z|)

| Composites:       | Estimate | Std.err | Z-value | P(>|z|) |
|-------------------|----------|---------|---------|---------|
| coverEffect ~     | -0.497   | 0.078   | -6.378  | 0.000   |
| cover ~ coverSQ   | 1.000    |         |         |         |
| age ~ coverSQ     | -0.002   | 0.001   | -3.129  | 0.002   |

### Regression:

|          | Estimate | Std.err | Z-value | P(>|z|) |
|----------|----------|---------|---------|---------|
| rich ~   | -0.201   | 0.121   | -1.667  | 0.095   |
| age ~    | -0.082   | 0.001   | -3.129  | 0.002   |
| coverEffect | 48.705   | 19.246  | 2.531   | 0.011   |
To SEM and Beyond!
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Consider This Model...

What is the direction of causality?
Are the indicators in a block interchangeable?

Do indicators covary because of joint causes?

Do indicators have a consistent set of causal influences?

Latents and Composites Together: L-C Block for Measurement Error
Latents and Composites Together: L-C Block

Questions to Ask of Your Latent/Composite Variables
1. What is the direction of causality?
2. Are the indicators in a block interchangeable?
3. Do indicators covary because of joint causes?
4. Do indicators have a consistent set of causal influences?

To SEM and Beyond!
1. What is a composite variable?
2. Using Composites for nonlinear variables
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Example: Tree Recolonization and Composite Variables

What is the Contribution of Local versus Regional Factors to Recolonization

Adding Variables to the Metamodel

Latent or Composites?

Generality v. Specificity
3/26/13

**Generality vs. Specificity**

Grace and Bollen 2008

\[ \chi^2 = 45.20 \text{ DF}=10 \text{ P}<0.00005 \]

\[ \chi^2 = 6.88 \text{ DF}=3 \text{ P}=0.075 \]

How Confident are We in Composite Loadings and their Conclusions?

Specific model without composites provides similar answers.

Testing our Confidence in Composites

The general composite construct is not obscuring more specific relationships in the data.

To SEM and Beyond!

1. What is a composite variable?
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1. *Rhodymenia* is not good food.
   - Urchins eat more, but produce less gonad
2. Performance is similar with *Macrocystis* or Mixture diet

---

**A Composite Treatment Model**

```r
urchinCompositeModel<-'Treatment <- MAPY + .002*R

Feeding.rate.dry ~ Treatment
GONAD_INDEX ~ Treatment + Feeding.rate.dry
```

---

**MAPY Has No Effect**

```
lavaan (0.5-12) converged normally after 71 iterations

Number of observations Used Total
20 21

Estimator ML
Minimum Function Test Statistic 1.993
Degrees of freedom 1
P-value (Chi-square) 0.158
```
Exercise: Fit this Model

```r
> urchinCompositeFit2<-sem(urchinCompositeModel2, data=urchinData)
```

Error in solve.default(E) :
  system is computationally singular: reciprocal condition number = 2.09555e-16

[lavaan message:] could not compute standard errors!
You can still request a summary of the fit to inspect the current estimates of the parameters.

Transform Scales to Fit

```r
urchinData$TEST_CHANGE_10<-urchinData$TEST_CHANGE/10
```

Exercise: Fit this Model

```r
> head(urchinData[,c(5,17)])
```

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Feeding.rate.dry</td>
<td>TEST_CHANGE</td>
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<td>7.68</td>
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<tr>
<td></td>
<td></td>
<td>4.94</td>
</tr>
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Fit Model

```r
Estimate Std.err Z-value  P(>|z|)
Regressions:
Feeding.rate.dry ~ Treatment 0.888 0.319 2.875 0.005
TEST_CHANGE_10 ~ Treatment -104.771 32.011 -3.273 0.001
Feeding.rate.dry ~ Treatment -104.771 32.011 -3.273 0.001
```

```
Feeding.rate.dry ~ 23.670 16.784 1.410 0.158
```

A Composite Conclusion

- Composite variables are useful as variables to gather information about multiple aspects of a single effect.
- Excellent for representing nonlinearities.
- Often what ecologists think of in terms of aggregate variables.
- Provide method of incorporating complex treatment effects.