



Higher Education Research Institute at UCLA

Building Useful Factors and Scales to Aid in the Assessment of Learning Gains and Other Student Outcomes

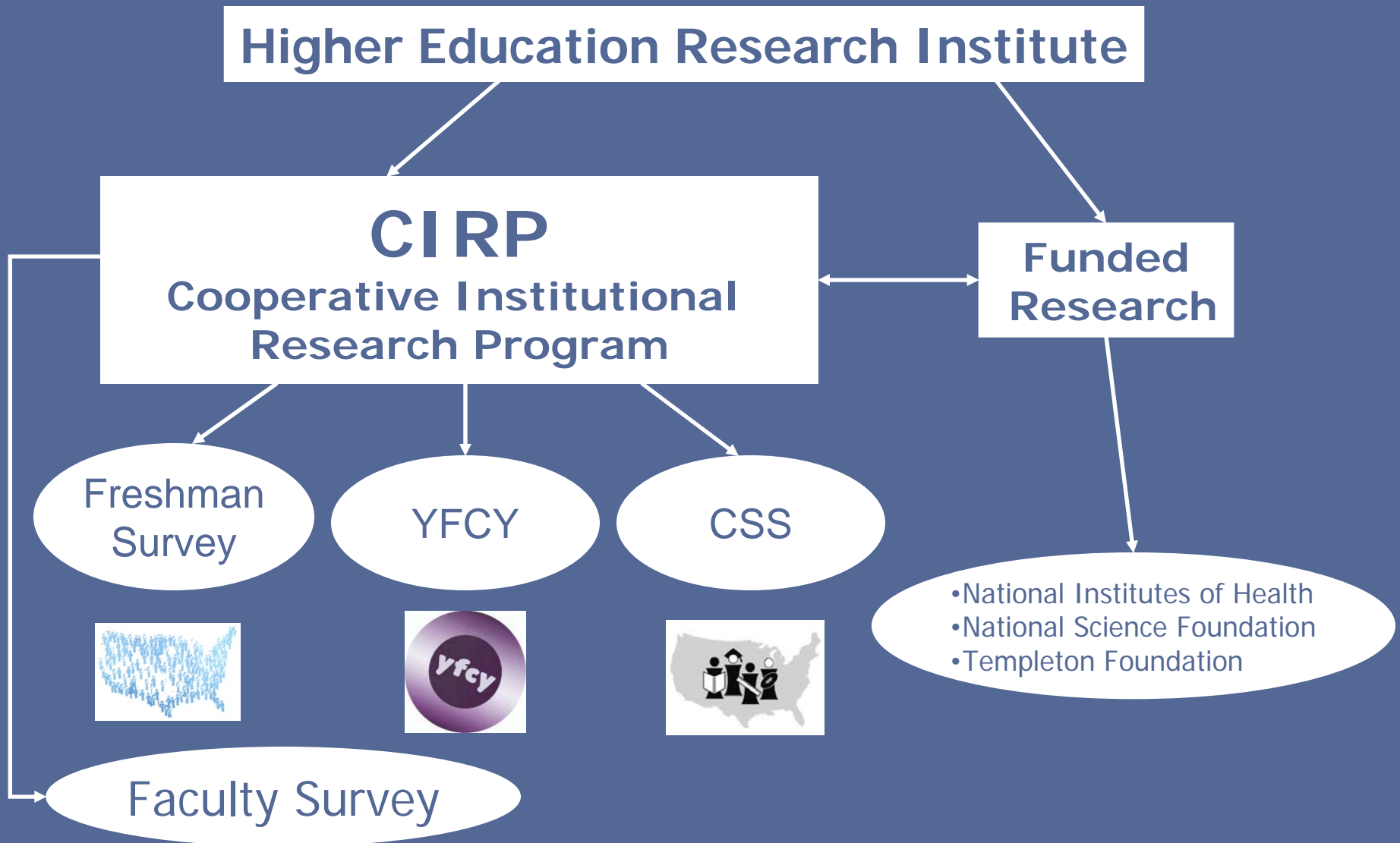
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This presentation

- General factor analysis overview
- Example of creating and refining a factor
- Use of factor score in comparing institutions
- Use of factor score in examining student experiences and outcomes
- Future directions for research at CIRP



What is Factor Analysis?

- Mathematical procedure to analyze interrelationships (correlations) among a set of variables
- Can explain the interrelationships in terms of a reduced number of variables – factors
 - **Factors:** hypothetical (latent) variables that influence scores on one or more observed variables
 - Factors represent the “reason” why variables are highly correlated



Two Kinds of Factor Analysis

- **Exploratory Factor Analysis (EFA)**
 - Explore the underlying structure of a set of observed variables without imposing a preconceived structure on the outcome
- **Confirmatory Factor Analysis (CFA)**
 - Allows the researcher to test whether a hypothesized relationship between observed variables and their underlying latent construct(s) exists. The relationship is postulated a priori and then tested statistically.
- Both analyses tell us whether the responses to a set of survey questions are organized into clusters, but have different functions



Exploratory Factor Analysis Example: Cross-Racial Interactions (YFCY)

13. To what extent have you experienced the following with students from a racial/ethnic group other than your own?
(Mark one for each item)

	Very Often	Often	Sometimes	Seldom	Never
Dined or shared a meal	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Had meaningful and honest discussions about race/ethnic relations outside of class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Had guarded, cautious interactions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Shared personal feelings and problems	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Had tense, somewhat hostile interactions	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Had intellectual discussions outside of class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Felt insulted or threatened because of race/ethnicity	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Studied or prepared for class	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Socialized or partied	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
Attended events sponsored by other racial/ethnic groups	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



Correlation Matrix

	1	2	3	4	5	6	7	8	9	10
1 Dined or shared a meal	1									
2 Discussed race/ethnic relations outside class	0.61	1								
3 Had guarded, cautious interactions	0.25	0.40	1							
4 Shared personal feelings and problems	0.65	0.63	0.29	1						
5 Had tense, somewhat hostile interactions	0.18	0.31	0.59	0.26	1					
6 Had intellectual discussions outside of class	0.63	0.66	0.27	0.72	0.25	1				
7 Felt insulted or threatened because of race/ethnicity	0.12	0.25	0.50	0.16	0.62	0.16	1			
8 Studied or prepared for class	0.56	0.52	0.28	0.61	0.27	0.65	0.17	1		
9 Socialized or partied	0.60	0.49	0.19	0.60	0.18	0.57	0.11	0.55	1	
10 Attended events by other racial/ethnic groups	0.45	0.50	0.28	0.46	0.26	0.47	0.26	0.47	0.48	1



Exploratory Factor Analysis

- Three stages:
 - (1) choose an **extraction** method
 - (2) decide the **number** of factors
 - (3) choose a **rotation** method



Extraction

- Two common extraction techniques:
 - **Component** (In SPSS: Principal Components Analysis, **PCA**)
 - A data reduction method
 - Utilizes all of the variance in a set of variables
 - Most common
 - “True” **Factor** analysis (In SPSS: Principal Axis Factoring, **PAF**)
 - Also a data reduction method, but assumes that the variables co-vary in some way
 - Uses only the shared variance (correlations) of a set of variables to compute the factor solution
- Some researchers prefer one method, some prefer the other.
 - Many researchers believe that Principal Components Analysis is not appropriate for exploratory factor analysis

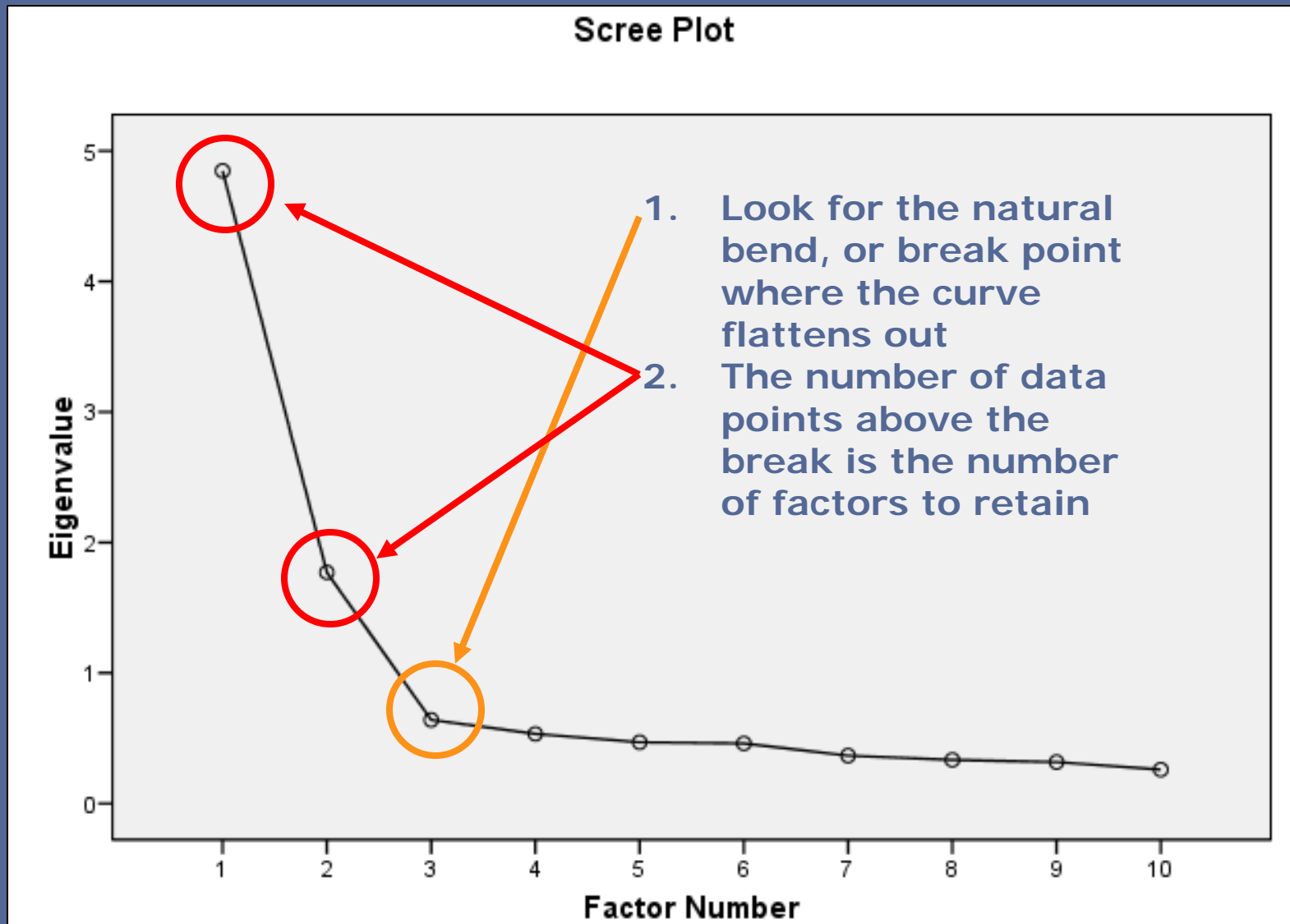


Number of Factors: How to decide?

- Choose a set of variables
- Run a factor analysis using extraction method chosen
 - Here: Principal Axis Factoring
- Examine Scree Plot
 - Plots Eigenvalues of all possible factors



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Rotation

- Rotation simplifies and clarifies the underlying data structure
- Two common rotation methods:
 - **Varimax** – orthogonal rotation that assumes **uncorrelated** factors
 - Produces cleaner and more easily interpreted results
 - May not be appropriate for “messy” data of the real world
 - **Promax** – Oblique rotation method that allows factors to **correlate**
 - Produces slightly more complex output to interpret
 - May more accurately resemble the “real world”
- If factors are truly uncorrelated, both rotations will produce nearly identical results



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Output from both rotational methods

PAF, Varimax

Rotated Factor Matrix^a

	Factor	
	1	2
Had intellectual discussions outside of class	.825	.141
Shared personal feelings and problems	.816	.151
Dined or shared a meal	.783	.086
Socialized or partied	.724	.066
Studied or prepared for class	.723	.170
Had meaningful and honest discussions about race/ethnic relations outside of class	.716	.283
Attended events sponsored by other racial/ethnic groups	.564	.245
Had tense, somewhat hostile interactions	.151	.822
Felt insulted or threatened because of race/ethnicity	.076	.731
Had guarded, cautious interactions	.231	.673

Extraction Method: Principal Axis Factoring.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

PAF, Promax

Pattern Matrix^a

	Factor	
	1	2
Had intellectual discussions outside of class	.848	-.030
Shared personal feelings and problems	.837	-.018
Dined or shared a meal	.815	-.079
Socialized or partied	.757	-.087
Studied or prepared for class	.734	.023
Had meaningful and honest discussions about race/ethnic relations outside of class	.702	.145
Attended events sponsored by other racial/ethnic groups	.548	.138
Had tense, somewhat hostile interactions	-.014	.841
Felt insulted or threatened because of race/ethnicity	-.075	.761
Had guarded, cautious interactions	.103	.665

Extraction Method: Principal Axis Factoring.
Rotation Method: Promax with Kaiser Normalization.

a. Rotation converged in 3 iterations.



Evaluating the fit of items in a factor

- Cronbach's Alpha
- Commonalities

Reliability Statistics

Cronbach's Alpha	N of Items
.901	7

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Dined or shared a meal	17.64	37.177	.735	.884
Had meaningful and honest discussions about race/ethnic relations outside of class	18.30	37.476	.711	.886
Shared personal feelings and problems	18.04	36.518	.775	.879
Had intellectual discussions outside of class	18.05	36.493	.783	.878
Studied or prepared for class	18.04	36.900	.701	.888
Socialized or partied	17.83	37.885	.684	.889
Attended events sponsored by other racial/ethnic groups	18.67	39.581	.574	.901

Communalities

	Initial	Extraction
Dined or shared a meal	.562	.621
Had meaningful and honest discussions about race/ethnic relations outside of class	.569	.593
Had guarded, cautious interactions	.427	.506
Shared personal feelings and problems	.630	.689
Had tense, somewhat hostile interactions	.504	.699
Had intellectual discussions outside of class	.647	.700
Felt insulted or threatened because of race/ethnicity	.421	.541
Studied or prepared for class	.514	.552
Socialized or partied	.492	.529
Attended events sponsored by other racial/ethnic groups	.366	.378

Extraction Method: Principal Axis Factoring.



Creating Factor Scores

- **Factor score** – score that theoretically would have been obtained for a person had we been able to measure the latent factor directly
- **Coarse Factor Scores** – unweighted composites (averages or sums) of the items having salient factor loadings
- **Refined Factor Scores** – use information from the correlation matrix or factor coefficients to weight the combination of items
 - Ex. Thurstone's least squares regression approach (in SPSS, "Regression,")
- Generally, researchers agree that refined scores have less bias than coarse scores
 - However, weights are sample-dependent
 - Refined scores are best option if one wants to employ a weighting scheme that uses all of the items (not just the items that load on one factor)

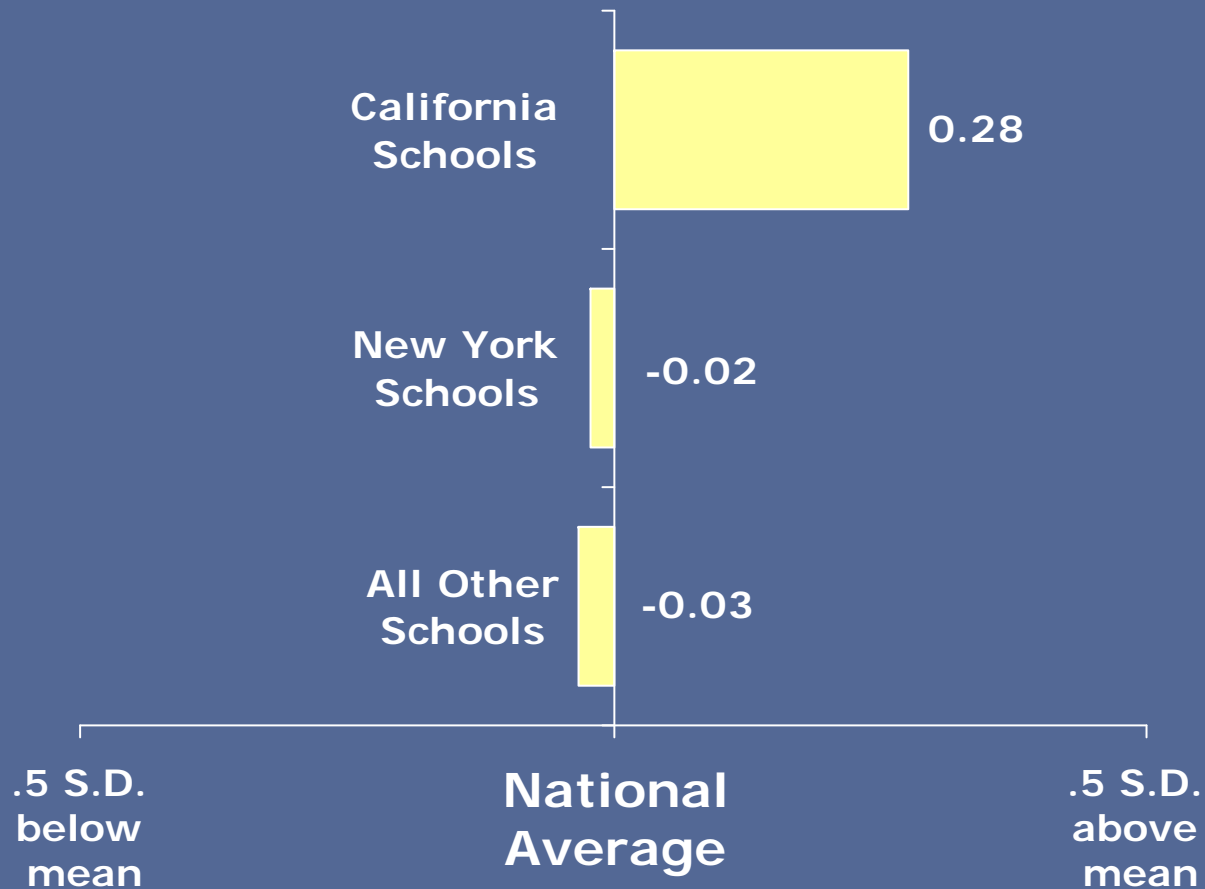


Using Factor Scores For Institutional Assessment

- Computed Regression Estimates from SPSS for Positive Racial/Ethnic Relations Factor
 - Mean = 0, Standard Deviation ≈ 1
- Can compare any institution or group of institutions on their scores
- Examples to follow that use the 2008 Your First College Year (YFCY) data
 - 501 institutions; 41,118 students
 - California: 33 institutions; 4,273 students
 - New York: 57 institutions; 3,325 students

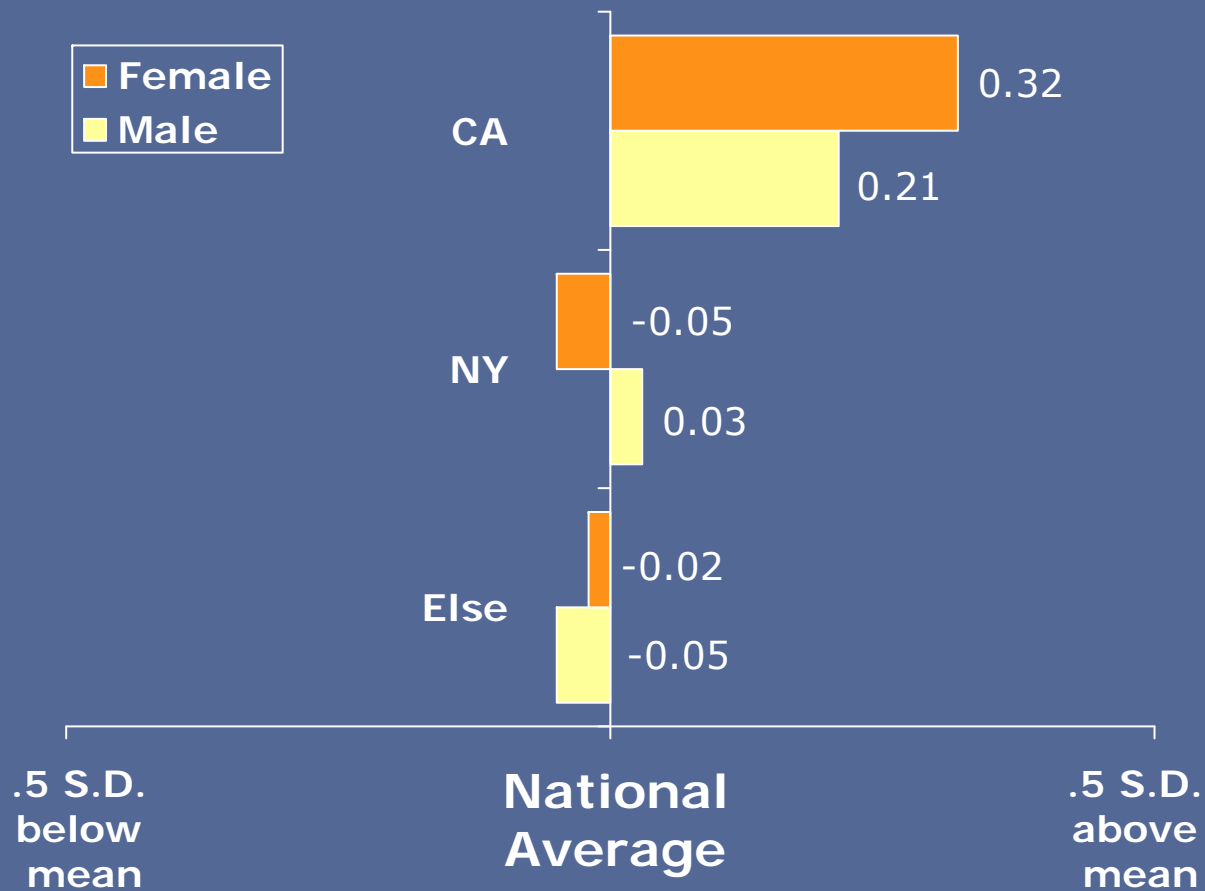


Comparing Levels of Positive Racial/Ethnic Interaction: By State





Comparing Levels of Positive Racial/Ethnic Interaction: By State & Gender





What leads to positive racial/ethnic interaction?

- Use the factor score as the dependent variable in a regression

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.185	.036		-33.209	.000
	That your courses inspired you to think in new ways	.207	.008	.138	27.489	.000
	Performed volunteer work	.127	.008	.089	16.930	.000
	Participated in student government	.168	.017	.050	9.938	.000
	Joined a social fraternity or sorority	-.039	.015	-.013	-2.565	.010
	Participated in student clubs/groups	.212	.010	.108	20.508	.000
	Enrolled in a formal program where a group of students take two or more courses together (e.g., FIG, learning cluster, learning community, linked courses)	.067	.014	.024	4.933	.000
	Your sex (Male)	-.038	.010	-.019	-3.834	.000

a. Dependent Variable: Positive Racial/Ethnic Relations



Does positive racial/ethnic interaction lead to positive student outcomes?

- Use the factor score as an independent variable in a regression

Coefficients^a

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.780	.024		117.390	.000
	HPW past year: Studying/homework	.051	.002	.104	20.813	.000
	HPW past year: Talking with professors outside of class	.040	.004	.055	11.021	.000
	The Faculty here are interested in students' academic problems (Agreement)	.170	.005	.158	31.132	.000
	Easy to understand what your professors expect of you academically?	.043	.006	.043	7.628	.000
	Easy to develop effective study skills?	.053	.005	.060	10.983	.000
	Positive Racial/Ethnic Relations	.053	.004	.074	15.005	.000

a. Dependent Variable: Critical thinking skills



Additional Considerations

- Reliability – results stable over time?
- Validity – measure what we think it does?
- Same factor structure for different groups?
- What to do when combining items with different scales?
 - Standardize items?
 - Item Response Theory (IRT) – a more methodologically sophisticated way to construct scales representing latent traits



Current projects at CIRP

- Methodological examination of factor score computation
- Methodological investigation into IRT
 - Advantages and disadvantages over “classic” factor analysis for the creation of scales from college student surveys
- Creation of database of factors that have been used in published research
 - Easy to apply at your institution



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