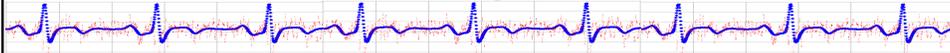


Empirical Research Methods in Information Science

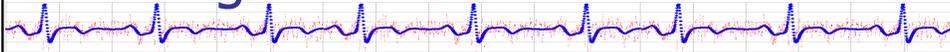
IS 4800 / CS 6350



Lecture 23
Regression
Factor Analysis
Final Exam Prep #1

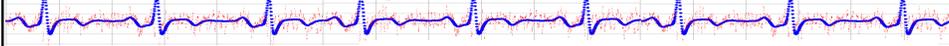
1

Regression

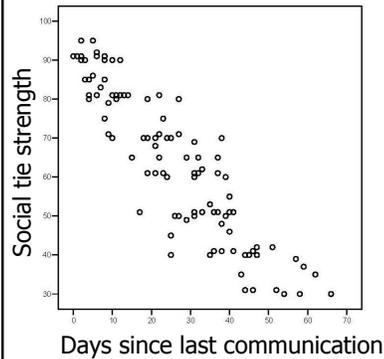


2

Bivariate ("Simple") Linear Regression



- Use a best fit line to relate two interval or ratio variables.
 - Predict longevity from BMI
 - Predict hours of computer game use from user age
 - Predict strength of social tie from days since last communication

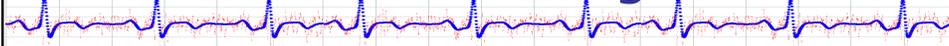


$$Y = a + bX$$

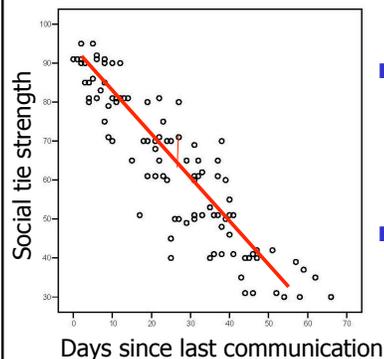
- How is this different from hypothesis testing?

3

Bivariate Linear Regression

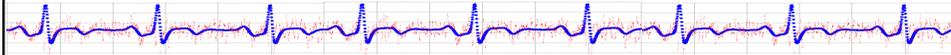


- How good is the model?
- Measure how far off it is for each data point = error
- To accrue positive AND negative errors, square and sum
- Find a model that minimizes this



4

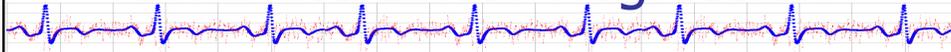
R² – Metric for fit



- SS_R = Model sum of squares = residuals from observations to your model
- SS_T = Total sum of squares = residuals from observations to mean (simplest model)
- $SS_M = SS_T - SS_R$
- $R^2 = SS_M / SS_T$
- = %improvement in $SS_T =$ %variance accounted for by model
- $\text{Sqrt}(R^2) =$ Pearson r

5

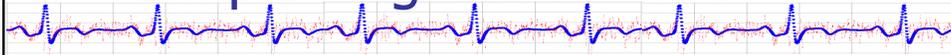
Bivariate Linear Regression



- $Y = f(X)$ and $X = f(Y)$ can give different results, unless...
- You start with Z_x and Z_y (Z-transformed scores for each variable)
- Then $a = 0$, $b = \beta =$ Pearson r
- Hypothesis test: is β significantly different from zero?

6

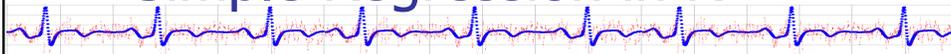
Simple Regression in R



Height	Weight
60	138.7647
61	140.0441
62	124.3235
63	161.6029
64	164.8824
65	136.1618
66	152.4412
67	143.7206

7

Simple Regression in R



```
> m <- lm(Weight ~ Height, data=d) #lm = 'linear model'
> summary(m)
```

Call:

```
lm(formula = Weight ~ Height, data = d)
```

Residuals:

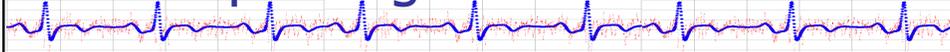
```
      Min       1Q   Median       3Q      Max
-25.5238 -2.7381  0.0476   4.9762  16.4762
```

Coefficients:

```
              Estimate Std. Error t value Pr(>|t|)
(Intercept) -11.1905     30.5831  -0.366   0.718
Height       2.4937      0.4353   5.729 1.6e-05 ***
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Simple Regression in R



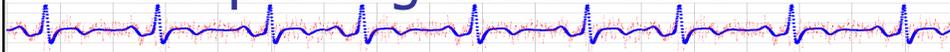
Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	-11.1905	30.5831	-0.366	0.718
Height	2.4937	0.4353	5.729	1.6e-05 ***

- Intercept: When Height = 0, Weight is -11.2 lbs (!)
- Slope: For every inch of Height, Weight increases 2.5 lbs.
 - P-value = probability of observing this data if Height coefficient (model contribution) were actually zero and Weight were modeled by mean+/-SD, indicating, Height does contribute significantly to the model.

9

Simple Regression in R



Residual standard error: 12.08 on 19 degrees of freedom
Multiple R-squared: 0.6334, Adjusted R-squared: 0.6141
F-statistic: 32.82 on 1 and 19 DF, p-value: 1.603e-05

- $R^2 = .63$, so 63% of variance in Weight is explained by our linear model as a function of Height
- F-statistic: the linear model predicts Weight significantly better compared to a model comprised just of mean Weight
 - Ratio of variance from differences between mean and model / variance from differences between model and data

10

Experiment



Part 1. Model Time as
linear function of expertise
or seniority.

11

Multiple Regression

- Say you want to predict

social tie strength = $f(\text{time-since-last-comm}, \text{educational-difference})$

- Multiple regression provides a β coefficient for each predictor
- R = multiple correlation coefficient
- R^2 is the % of the variation in the criterion variable accounted for by the overall model

12

Assumptions in Linear Regression

- Same as for correlation
 - Not a curvilinear relationship
 - Measures are not restricted in range
 - No significant outliers
 - For accuracy of hypothesis test:
 - Underlying populations are normal

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Experiment

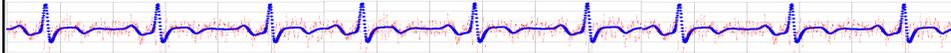


Part 2. Model Time as
linear function of expertise
and seniority.

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Example paper:

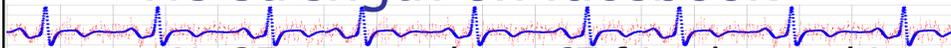
Predicting Tie Strength with Social Media



Eric Gilbert and Karrie Karahalios
CHI'09

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Tie strength on facebook



- N=35, ea rated avg 67 friends, resulting in 2,184 data points

facebook John Doe Friends Applications Inbox Home Settings

John Doe
Wall Info Photos

How strong is your relationship with this person?
barely know them ————— we are very close

How would you feel asking this friend to loan you \$100 or more?
would never ask ————— very comfortable

How helpful would this person be if you were looking for a job?
no help at all ————— very helpful

How upset would you be if this person unfriended you?
not upset at all ————— very upset

If you left Facebook for another social site, how important would it be to bring this friend along?
would not matter ————— must bring them

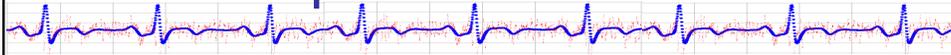
Write Post Photo Record Video Share Link Give Gift

Mutual Friends

Write something...

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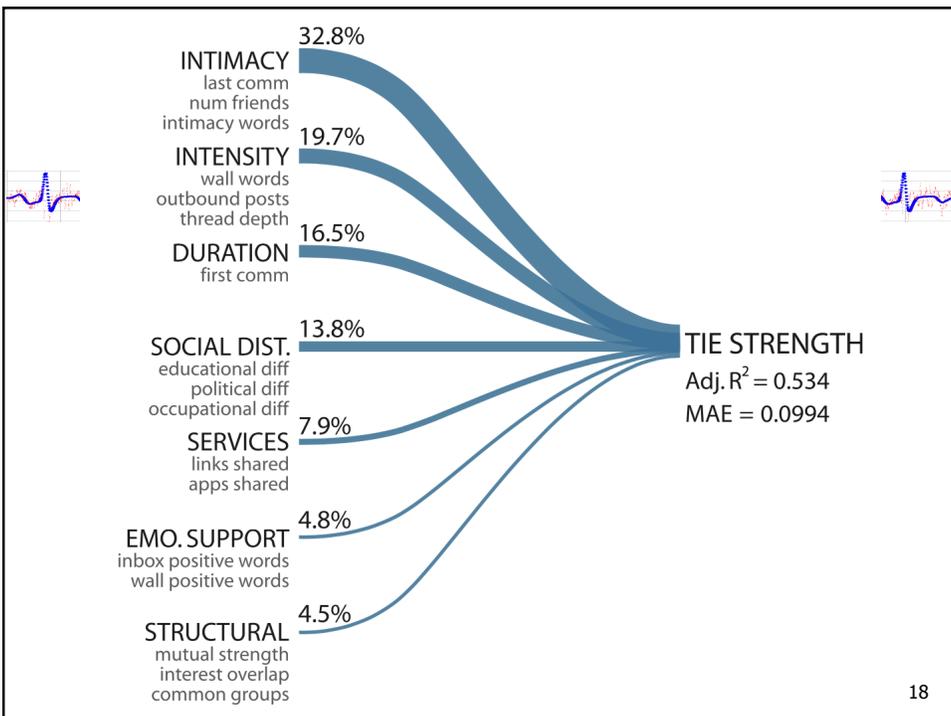
For ea friend collected fb data to compute 74 features



Intimacy Variables

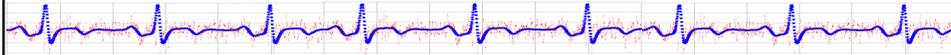
Participant's number of friends		729
Friend's number of friends		2050
Days since last communication		1115
Wall intimacy words		148
Inbox intimacy words		137
Appearances together in photo		73
Participant's appearances in photo		897
Distance between hometowns (mi)		8182
Friend's relationship status	 6% engaged 32% married 30% single 30% in relationship	

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18

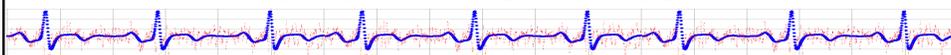
TF-IDF



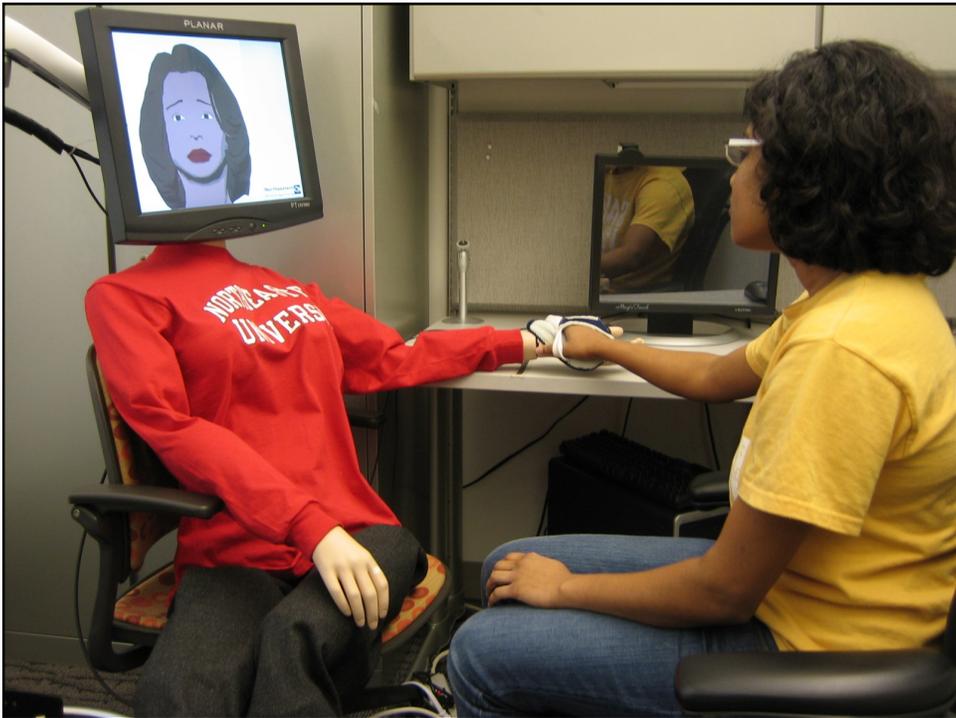
- term frequency–inverse document frequency
- how important a word is to a document in a collection or corpus
- increases proportionally to the number of times a word appears in the document (% of words in a doc that are the target word)
- offset by the frequency of the word in the corpus (log of num documents / num documents having the target word)

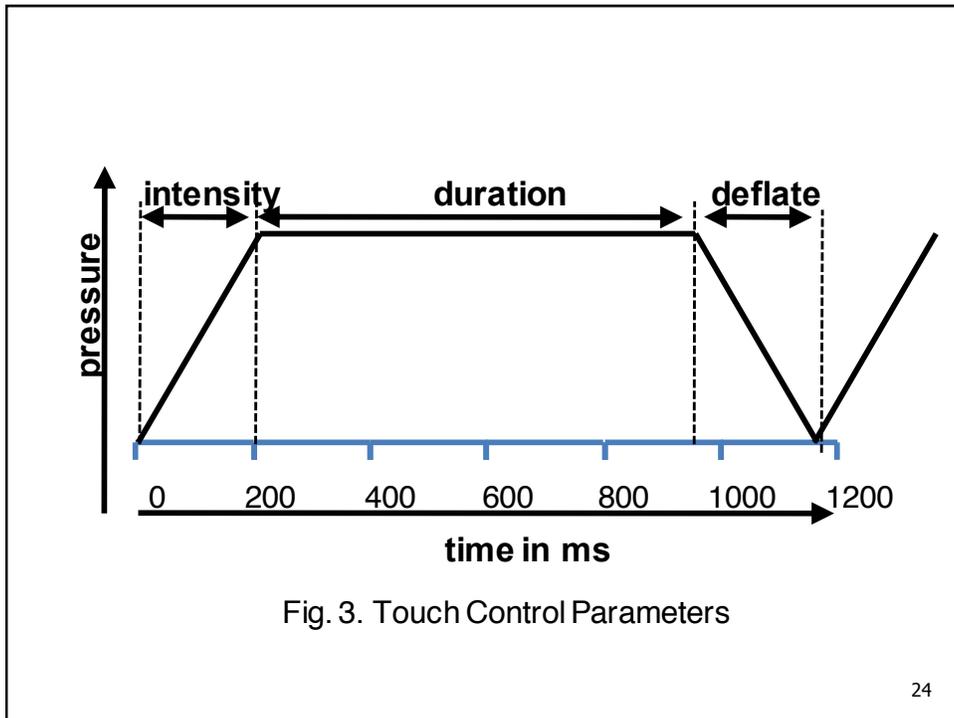
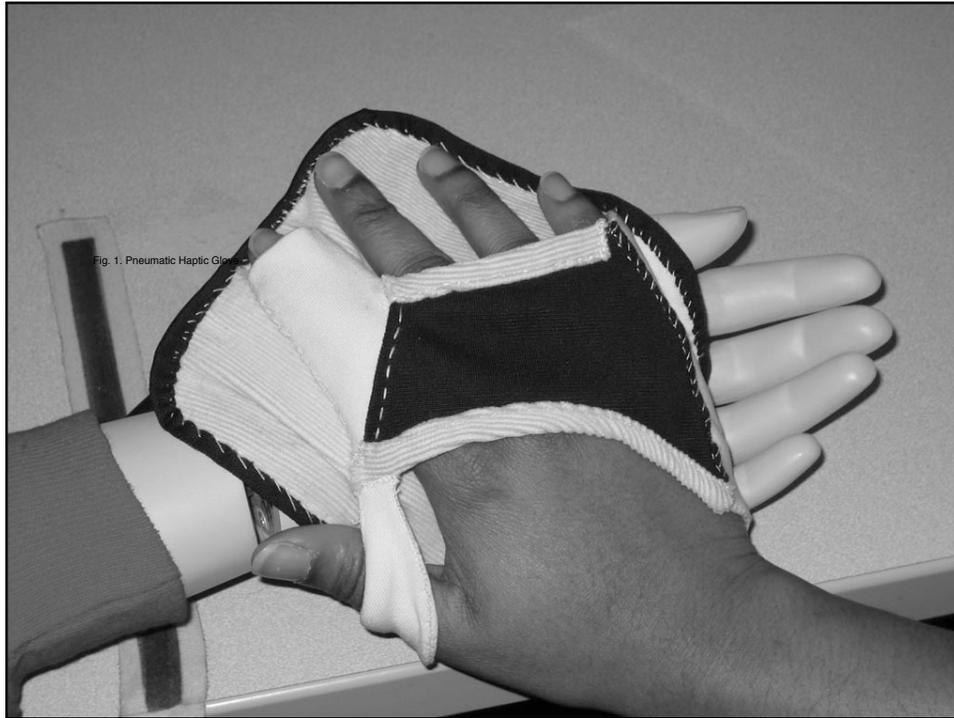
19

The TouchBot Studies



20





TouchBot Study 1

- Do people associate squeeze patterns with affective communication?

25

Herstenstein, M., Keltner, D., App, B., Bulleit, B., & Jaskolka, A. (2006). Touch Communicates Distinct Emotions. *Emotion*, 6(3), 528-533.



26

Herstenstein, M., Keltner, D., App, B., Bulleit, B., & Jaskolka, A. (2006). Touch Communicates Distinct Emotions. *Emotion, 6(3), 528-533.*

Percentage of Most Frequent Types of Touch Used in Study 1 and Percentage of Decoding Accuracy of Most Frequently Chosen Emotion for Studies 1 and 2

Emotion and tactile behavior	Most frequent types of touch in Study 1 (%)	Decoding accuracy (%)	
		Study 1 (United States)	Study 2 (Spain)
Ekman's emotions			
Anger		Anger, 57**	Anger, 59**
Hitting	23		
Squeezing	20		
Trembling	11		
Fear		Fear, 51**	Fear, 48**
Trembling	50		
Squeezing	27		
Shaking	6		

27

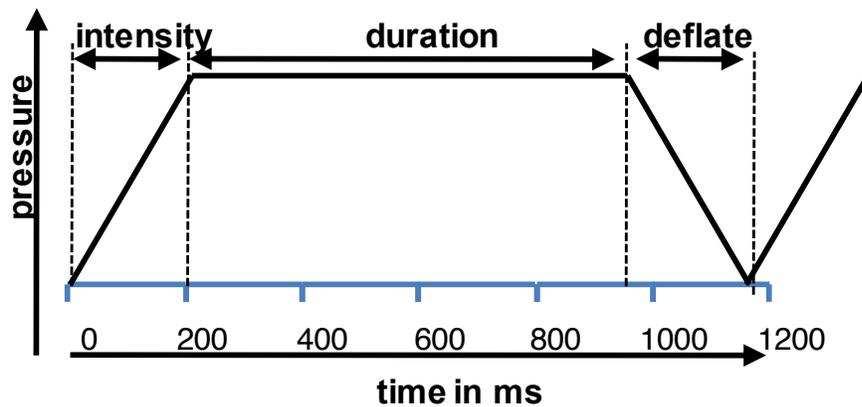


Fig. 3. Touch Control Parameters

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Experiment

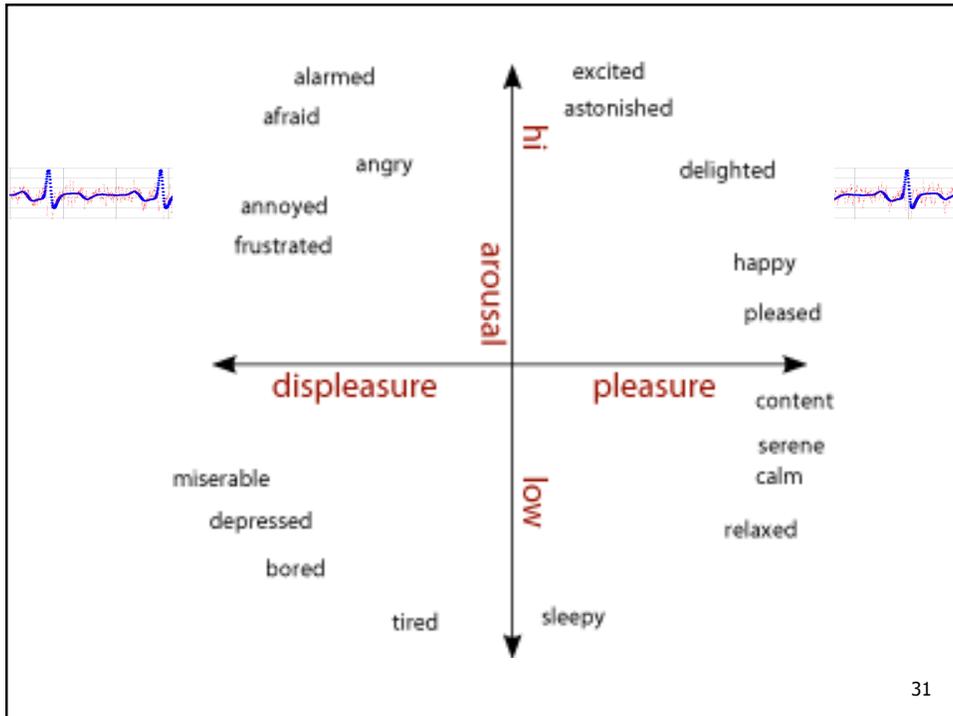
- Three different levels of intensity, duration, and number of pulses to create 27 unique touch gestures
 - 17 were presented to subjects
- Intensity: of the gesture (maximum pressure of the bladder), we adjusted how long the air bladder within the glove was allowed to inflate with the vent valve closed, ranging from 100 milliseconds inflation for low intensity, 150 milliseconds inflation for medium intensity, and 200 milliseconds inflation for high intensity.
- Duration: we varied how long the glove would stay inflated before opening the vent valve, ranging from 400 milliseconds for short duration, 500 milliseconds for medium duration, and 750 milliseconds for long duration.
- Deflation was always achieved by venting for 250 milliseconds prior to the start of the next gesture.
- Number of pulses: specified the number of complete inflation, hold, and deflation cycles, ranging from one to three

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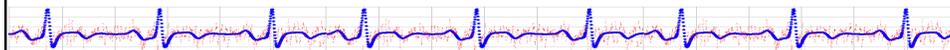
Please indicate the emotion you feel most closely matches what the agent was trying to communicate.

Emotion	
• anger	• disgust
• fear	• happiness
• sadness	• surprise
• sympathy	• embarrassment
• love	• envy
• pride	• gratitude
• pay attention	• none of these

30

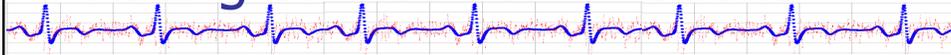


Test-retest reliability



- Participants chose the same emotion label on 5.8% of the repeated items. This is not significantly different from chance ($\chi^2(1)=0.148$, $p=0.70$).
- The within-subjects correlation of perceived arousal and valence on repeated items was assessed. There was a significant correlation between repeated ratings of arousal ($r=0.37$, $p=0.01$), and a near-significant correlation between repeated ratings of valence ($r=0.26$, $p=0.09$).

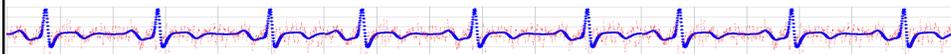
Rating of Discrete Emotions



- There was no significant association between the touch stimulus and the discrete emotion label a participant identified ($\chi^2(264)=269, p=0.40$).

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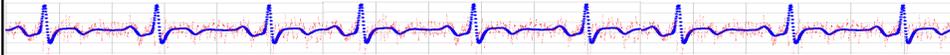
Arousal Results



- Intensity & Pulses: Participants reported significantly greater perceived arousal for stimuli with higher levels of intensity (... $p<0.001$) and with more pulses (... $p<0.001$).
- Duration: There was no significant effect of pulse duration on arousal (... $p=0.23$)

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Valence

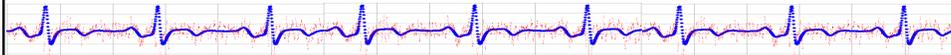


- Pulses: Participants reported significantly more positively valenced affect with more pulses (... $p=0.006$)
- Duration: Participants reported significantly more negatively valenced affect with longer squeeze durations (... $p=0.04$).
- Intensity: There was no significant effect of intensity on valence (... $p=0.68$), and there were no significant interaction effects

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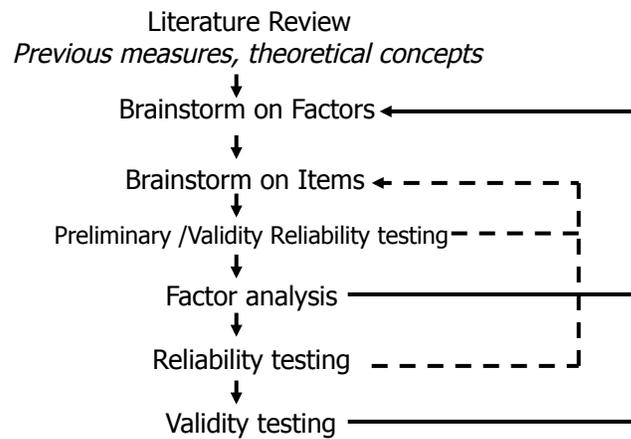
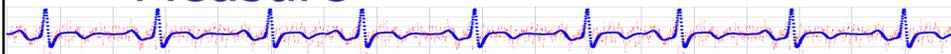


Factor Analysis



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Designing a Composite Measure



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Factor analysis

- Invented nearly 100 years ago by Charles Spearman
- Hypothesized that all human mental ability could be explained by one underlying "factor" of general intelligence that he called g .



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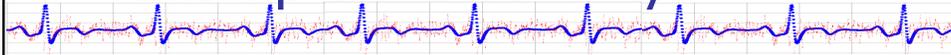
Exploratory Factor Analysis

- You often want to measure things that cannot be directly measured (“latent variables” or “factors”*)
 - IQ
 - Personality
 - Attitude towards iPhones

**A different meaning of factor than IV*

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Example: Personality

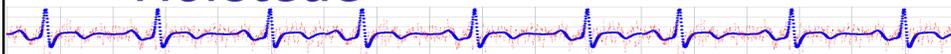


- The “big 5” traits
 - Openness
 - Conscientiousness
 - Extraversion
 - Agreeableness
 - Neuroticism

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Example: Cultural Traits

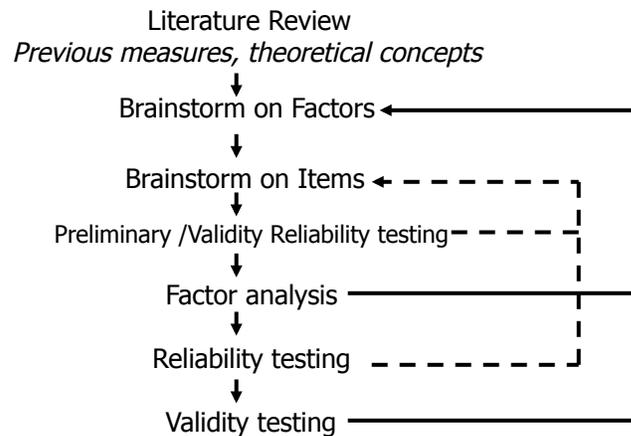
Hofstede



- Power distance
 - extent to which the less powerful members accept and expect that power is distributed unequally.
- Individualism (IDV) vs. collectivism
- Uncertainty avoidance
- Masculinity
- Long-term orientation

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Designing a Composite Measure



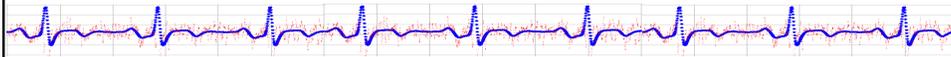
45

Exploratory Factor Analysis

- Lets you discover what the meaningful factors are
- "By reducing a dataset from a group of interrelated variables into a smaller set of factors, factor analysis achieves parsimony by explaining the maximum amount of variance using the smallest number of explanatory constructs." *Field*

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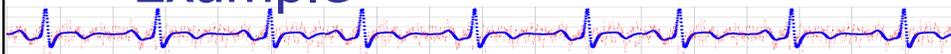
Example: Popularity



- Measure:
 - Social Skills
 - Selfish – how selfish they are
 - Interest – how interesting others find them
 - Talk1 – time spent talking about other
 - Talk2 – time spent talking about self
 - Liar – propensity to lie
- Put each on a scale
- Give to 1,000 people

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Example



- Then compute correlation matrix:

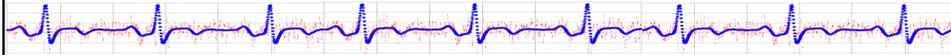
	Talk 1	Social Skills	Interest	Talk 2	Selfish	Liar
Talk 1	1.000					
Social Skills	.772	1.000				
Interest	.646	.879	1.000			
Talk 2	.074	-.120	.054	1.000		
Selfish	-.131	.031	-.101	.441	1.000	
Liar	.068	.012	.110	.361	.277	1.000

Factor 1 is indicated by a blue circle around the top-left 3x3 submatrix (Talk 1, Social Skills, Interest).

Factor 2 is indicated by a blue circle around the bottom-right 3x3 submatrix (Talk 2, Selfish, Liar).

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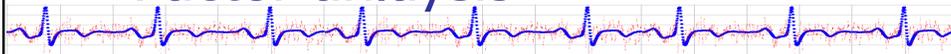
So?



- Popularity can be explained by two factors – social skills & selfishness
- Instead of 6 questions/items, there are really only two underlying dimensions

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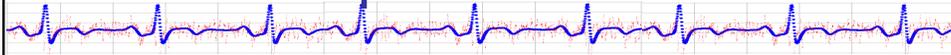
Factor analysis



- Many specific analysis methods.
- Two general kinds
 - Exploratory factor analysis attempts to discover the nature of the constructs influencing a set of responses.
 - Typically proceed by first finding the subset of measures that, together, explain the most variance in the measures.
 - Then, the subset of remaining measures that explain the most variance are identified.
 - Etc. until all measures are incorporated.
 - Confirmatory factor analysis tests whether a specified set of constructs is influencing responses in a predicted way.

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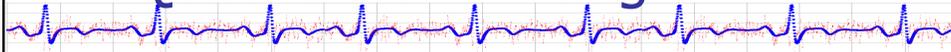
Factor Analysis Data Requirements



- Measures: interval or ratio
- Power: 200-300 or more samples
- Bivariate normal distribution for each pair of variables
- Observations should be independent

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Use of Factor Analysis in Questionnaire Design



- In early stages, to determine what the underlying factors of a concept are.
 - Have Ss complete surveys with all possible related items
- In later stages, to confirm
 - Number and nature of assumed factors
 - Appropriateness of questionnaire items to reliably assess factors

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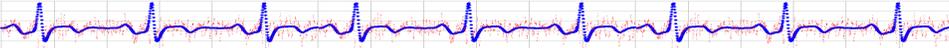
Buys & Brown Example



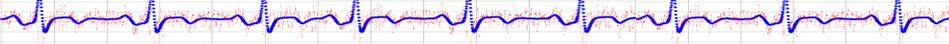
CS1	Satisfied with the customer support	0.08	0.02	0.76	0.27	0.20
CS2	Satisfied with the after-sales service	0.18	0.16	0.80	0.29	0.12
CS3	Problems and requests understood	0.19	0.19	0.80	0.10	0.23
CS4	Responds to requests fast enough	0.18	0.21	0.69	0.05	0.32
SE1	Security of transaction data and privacy	0.10	0.91	0.21	0.08	0.05
SE2	Feel safe in transactions with web site	0.17	0.92	0.10	0.17	0.09
SE3	Web site is secure	0.14	0.91	0.14	0.10	0.12
EOU1	Web site is user friendly	0.26	0.15	0.37	0.14	0.81
EOU2	Output format is easy to read	0.21	0.09	0.18	0.20	0.84
EOU3	Web site is easy to use	0.26	0.06	0.28	0.16	0.83
DPS3	Provides high quality products or services	0.68	0.25	0.35	0.22	0.19
DPS4	Provides innovative products or services	0.73	0.19	0.33	0.14	0.11
TP1	Satisfied with payment system	0.18	0.15	0.26	0.80	0.25
TP2	Satisfied with transaction procedures	0.37	0.20	0.20	0.77	0.18
TP3	Clear transaction and price information	0.27	0.08	0.19	0.82	0.10
IC1	Information exactly fits needs	0.74	0.11	0.13	0.38	0.13
IC2	Accurate information	0.81	0.06	0.10	0.16	0.12
IC3	Information that can be trusted	0.77	0.07	0.14	0.10	0.28
IC4	Up-to-date information	0.84	0.08	-0.01	0.15	0.14

Table 4: Factor Analysis

Buys & Brown Correlation Test of Factors

- 
- Section 4.3 "Correlations"
 - Shows factors are related (all measure dimensions of "satisfaction")
 - But – not too related (they are distinct factors)
 - *Why is this construct validity?*

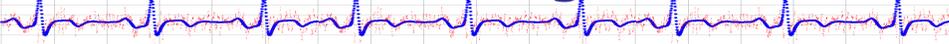
Customer Satisfaction with Internet Banking Web Sites



- Research procedure
 1. Administer 19-item questionnaire to 168 participants
 2. Confirm factors previously identified
 - Dropped some items
 - Reinterpret factors (4 old, 1 new)
 3. Assess internal consistency
 - Alpha per factor
 4. "Validation" by correlation
 - Factors related, but not too related
 5. Additional validation by correlating measure with other measures

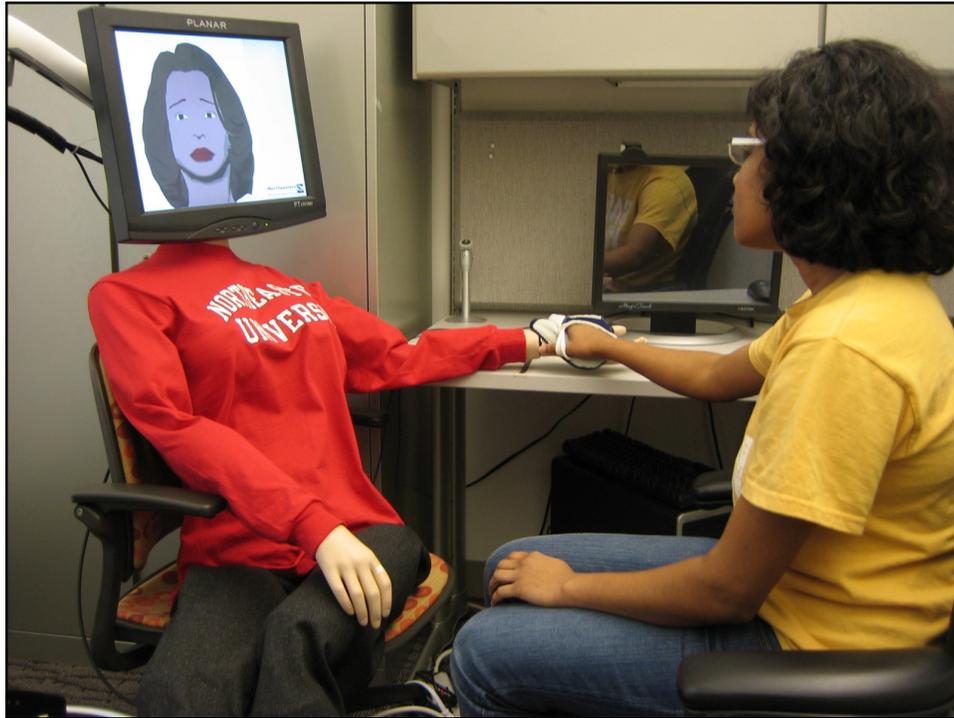
55

Customer Satisfaction with Internet Banking Web Sites

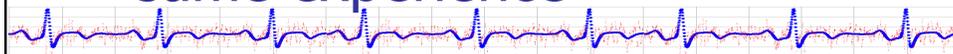


- How could they have better validated their instrument?

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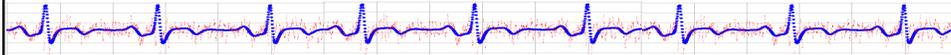
Everyone did not have the same experience



- "I saw it as an expression of sympathy or empathy"
- "I guess if it was like a real situation, I would interpret it as caring, and you know, really being in to the conversation, and not like talking to me, but talking with me."
- "I'm more uncomfortable on the whole touching while having a conversation thing."
- "I think it's a little different for guys and girls. Being a guy, I definitely find it a bit weird. You know, if a doctor reached out and squeezed my hand as he gave me bad news, I'd you know...I would find that more strange than anything else"

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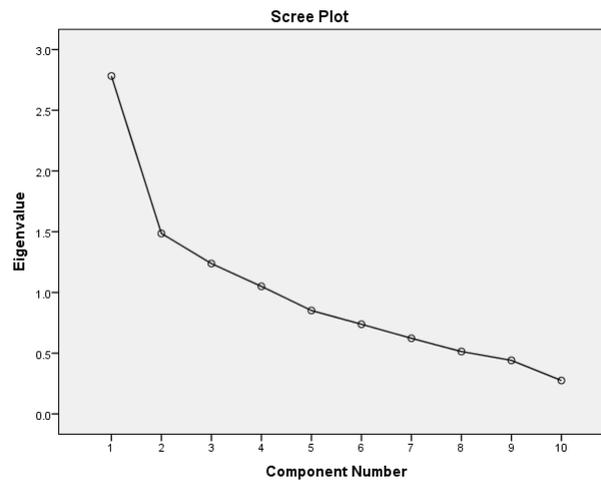
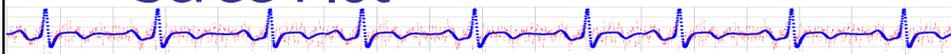
Touch Receptivity Scale



- Started with 18 items
- Gave to 33 people
- Did factor analysis.
- Conducted test-retest validation

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Scree Plot

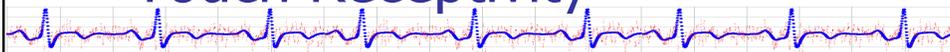


60

Touch Receptivity Scale

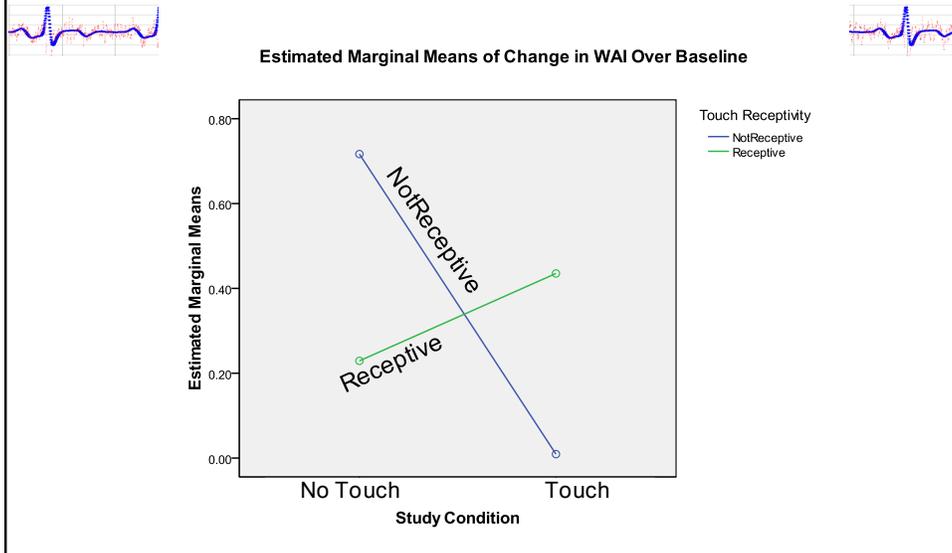
- **In the following, “casual touch” refers to your being touched on the hand, arm or shoulder when interacting with a professional such as a doctor or nurse.**
- 1. *I feel uncomfortable when someone casually touches me.
- 2. I go out of my way to interact with people who casually touch a lot.
- 3. When someone is comforting me, it helps if they casually touch me.
- 4. I like people who casually touch a lot.
- 5. I would be comfortable if a health professional were to casually touch me during a consultation.
- 6. I like people who shake hands with me.
- 7. *During a medical checkup, I feel uncomfortable when the doctor or nurse touches me.
- 8. If I were in pain, comforting touch from someone would make me feel better.
- 9. *I find it uncomfortable if someone touches my arm during a conversation.
- 10. I am likely to touch someone on their arm during a conversation.

Touch Receptivity



- Test-retest reliability was shown to be adequate ($r=0.68$, $p<.05$) when administered twice to a group of nine subjects over a one week interval.
- Internal consistency was shown to be adequate with $\alpha=0.87$ when given to a second group of 33 subjects.
- Convergent construct validity was demonstrated through correlation with a validated measure of extroversion, $r=0.6$, $p<.001$, when administered concurrently to the same group of 33 subjects.

Empathic Touch Study



Homework

- Work on T3
- Friday
 - Hear half of CS6350 term projects.
 - Spend rest of class reviewing for final.
- Now: review for final.