



# Measuring Tinnitus via Self-Report Questionnaires

Jesse Mark Bowers, Shiwei Fu, Shuyu Jia, Yumeng Wu, Zhehui Chen

# Outline

- Intro & Background
  - Data Description & EDA
  - Correlation Analysis
  - Milestone 1 – Validity
  - Milestone 2 - Emotion
  - Conclusion
-

# Introduction and EDA

-- Tinnitus related information and background

-- Are there any patterns to the data we need to be aware of

*Zhehui Chen*

# What is tinnitus



**Tinnitus** is when you experience ringing or other noises (roaring, clicking, hissing, buzzing) in one or both of your ears.

However, the sounds you hear that are **NOT** being produced by any external source.

# Questionnaire Datasets

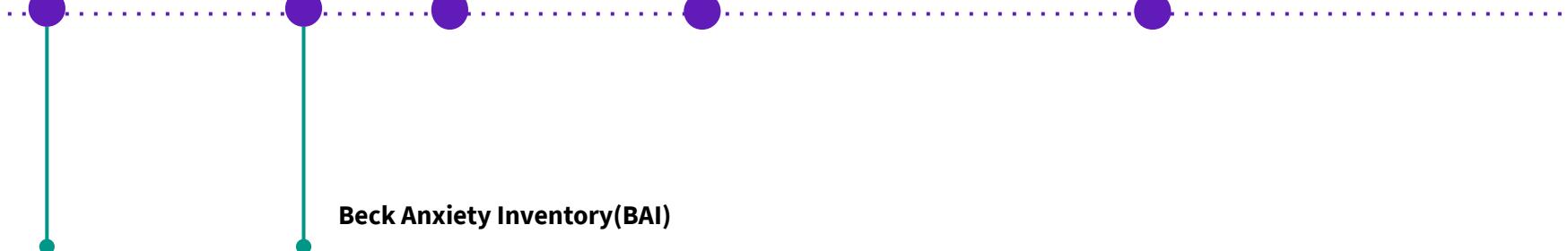
Assessing Tinnitus Severity

Subscales

Tinnitus Handicap Index (THI)

Tinnitus Functional Index (TFI)

Tinnitus Primary Function Questionnaire (TPFQ)



Self-reported Emotional Reaction

Beck Depression Inventory (BDI)

Beck Anxiety Inventory(BAI)

# THI

ID	Question	Subscale
Q1	1. Because of your tinnitus, is it difficult for you to concentrate?	Functional
Q2	2. Does the loudness of your tinnitus make it difficult for you to hear people?	Functional
Q4	4. Does your tinnitus make you feel confused?	Functional
Q7	7. Because of your tinnitus, do you have trouble falling to sleep at night?	Functional
Q9	9. Does your tinnitus interfere with your ability to enjoy your social activities (such as going out to dinner, to the movies)?	Functional
Q12	12. Does your tinnitus make it difficult for you to enjoy life?	Functional
Q13	13. Does your tinnitus interfere with your job or household responsibilities?	Functional
Q14	14. Because of your tinnitus, do you find that you are often irritable?	Functional
Q15	15. Because of your tinnitus, is it difficult for you to read?	Functional
Q18	18. Do you find it difficult to focus your attention away from your tinnitus and on other things?	Functional
Q20	20. Because of your tinnitus, do you often feel tired?	Functional
Q24	24. Does your tinnitus get worse when you are under stress?	Functional
Q3	3. Does your tinnitus make you angry?	Emotional
Q6	6. Do you complain a great deal about your tinnitus?	Emotional
Q10	10. Because of your tinnitus, do you feel frustrated?	Emotional
Q16	16. Does your tinnitus make you upset?	Emotional
Q17	17. Do you feel that your tinnitus problem has placed stress on your relationships with members of your family and friends?	Emotional
Q21	21. Because of your tinnitus, do you feel depressed?	Emotional
Q22	22. Does your tinnitus make you feel anxious?	Emotional
Q25	25. Does your tinnitus make you feel insecure?	Emotional
Q5	5. Because of your tinnitus, do you feel desperate?	Catastrophic
Q8	8. Do you feel as though you cannot escape your tinnitus?	Catastrophic
Q11	11. Because of your tinnitus, do you feel that you have a terrible disease?	Catastrophic
Q19	19. Do you feel that you have no control over your tinnitus?	Catastrophic

25 questions; Responses on a scale of 0, 2, 4

# TFI

ID	Question	Subscale
Q1	1. What percentage of your time awake were you consciously AWARE OF your tinnitus?	INTRUSIVE
Q2	2. How STRONG or LOUD was your tinnitus?	INTRUSIVE
Q3	3. What percentage of your time awake were you ANNOYED by your tinnitus?	INTRUSIVE
Q4	4. Did you feel IN CONTROL in regard to your tinnitus?	SENSE OF CONTROL
Q5	5. How easy was it for you to COPE with your tinnitus?	SENSE OF CONTROL
Q6	6. How easy was it for you to IGNORE your tinnitus?	SENSE OF CONTROL
Q7	7. Your ability to CONCENTRATE?	COGNITIVE
Q8	8. Your ability to THINK CLEARLY?	COGNITIVE
Q9	9. Your ability to FOCUS ATTENTION on other things besides your tinnitus?	COGNITIVE
Q10	10. How often did your tinnitus make it difficult to FALL ASLEEP or STAY ASLEEP?	SLEEP
Q11	11. How often did your tinnitus cause you difficulty in getting AS MUCH SLEEP as you needed?	SLEEP
Q12	12. How much of the time did your tinnitus keep you from SLEEPING as DEEPLY or as PEACEFULLY as you would have liked?	SLEEP
Q13	13. Your ability to HEAR CLEARLY?	AUDITORY
Q14	14. Your ability to UNDERSTAND PEOPLE who are talking?	AUDITORY
Q15	15. Your ability to FOLLOW CONVERSATIONS in a group or at meetings?	AUDITORY
Q16	16. Your QUIET RESTING ACTIVITIES?	RELAXATION
Q17	17. Your ability to RELAX?	RELAXATION
Q18	18. Your ability to enjoy "PEACE AND QUIET" ?	RELAXATION
Q19	19. Your enjoyment of SOCIAL ACTIVITIES?	QUALITY OF LIFE
Q20	20. Your ENJOYMENT OF LIFE?	QUALITY OF LIFE
Q21	21. Your RELATIONSHIPS with family, friends and other people?	QUALITY OF LIFE
Q22	22. How often did your tinnitus cause you to have difficulty performing your WORK OR OTHER TASKS, such as home maintenance, school work, or caring for children or	QUALITY OF LIFE
Q23	23. How ANXIOUS or WORRIED has your tinnitus made you feel?	EMOTIONAL
Q24	24. How BOTHERED or UPSET have you been because of your tinnitus?	EMOTIONAL
Q25	25. How DEPRESSED were you because of your tinnitus?	EMOTIONAL

25 Questions; Responses on a scale from 0 to 10

# TPFQ

ID	Question	Subscale
Q1	1 I have difficulty focusing my attention on some important tasks because of tinnitus.	Concentration
Q5	5 When there are lots of things happening at once, my tinnitus interferes with my ability to attend to the most important thing.	Concentration
Q7	7 My inability to think about something undisturbed is one of the worst effects of my tinnitus.	Concentration
Q16	16 I have trouble concentrating while I am reading in a quiet room because of tinnitus.	Concentration
Q20	20 I feel like my tinnitus makes it difficult for me to concentrate on some tasks.	Concentration
Q2	2 I lie awake at night because of my tinnitus.	Sleep
Q4	4 I have difficulty getting to sleep at night because of my tinnitus.	Sleep
Q11	11 I am tired during the day because my tinnitus has disrupted my sleep.	Sleep
Q14	14 When I wake up in the night, my tinnitus makes it difficult to get back to sleep.	Sleep
Q17	17 The difficulty I have sleeping is one of the worst effects of my tinnitus.	Sleep
Q3	3 I just wish my tinnitus would go away. It is so frustrating.	Emotion
Q8	8 My tinnitus is annoying.	Emotion
Q13	13 I am depressed because of my tinnitus.	Emotion
Q15	15 My emotional peace is one of the worst effects of my tinnitus.	Emotion
Q18	18 I am anxious because of my tinnitus.	Emotion
Q6	6 My tinnitus masks some speech sounds.	Hearing
Q9	9 One of the worst things about my tinnitus is its effect on my loss. speech understanding, over and above any effect of my hearing	Hearing
Q10	10 My tinnitus, not my hearing loss, interferes with my appreciation of music and songs.	Hearing
Q12	12 In addition to my hearing loss, my tinnitus interferes with my understanding of speech.	Hearing
Q19	19 The effects of tinnitus on my hearing are worse than the effects of my hearing loss.	Hearing

20 questions; Responses on scale of 0 to 100

# BAI

	Not at all	Mildly, but it didn't bother me much	Moderately – it wasn't pleasant at times	Severely – it bothered me a lot
Numbness or tingling	0	1	2	3
Feeling hot	0	1	2	3
Wobbliness in legs	0	1	2	3
Unable to relax	0	1	2	3
Fear of worst happening	0	1	2	3
Dizzy or lightheaded	0	1	2	3
Heart pounding / racing	0	1	2	3
Unsteady	0	1	2	3
Terrified or afraid	0	1	2	3
Nervous	0	1	2	3
Feeling of choking	0	1	2	3
Hands trembling	0	1	2	3
Shaky / unsteady	0	1	2	3
Fear of losing control	0	1	2	3
Difficulty in breathing	0	1	2	3
Fear of dying	0	1	2	3
Scared	0	1	2	3
Indigestion	0	1	2	3
Faint / lightheaded	0	1	2	3
Face flushed	0	1	2	3
Hot / cold sweats	0	1	2	3

21 questions;  
Responses on a scale of 0, 1, 2, 3



1.	0	I do not feel sad.	11.	0	I am no more irritated by things than I ever was.	20.	0	I am no more worried about my health than usual.
	1	I feel sad		1	I am slightly more irritated now than usual.		1	I am worried about physical problems like aches, pains, upset stomach, or constipation.
	2	I am sad all the time and I can't snap out of it.		2	I am quite annoyed or irritated a good deal of the time.		2	I am very worried about physical problems and it's hard to think of much else.
	3	I am so sad and unhappy that I can't stand it.		3	I feel irritated all the time.		3	I am so worried about my physical problems that I cannot think of anything else.
2.	0	I am not particularly discouraged about the future.	12.	0	I have not lost interest in other people.	21.	0	I have not noticed any recent change in my interest in sex.
	1	I feel discouraged about the future.		1	I am less interested in other people than I used to be.		1	I am less interested in sex than I used to be.
	2	I feel I have nothing to look forward to.		2	I have lost most of my interest in other people.		2	I have almost no interest in sex.
	3	I feel the future is hopeless and that things cannot improve.		3	I have lost all of my interest in other people.		3	I have lost interest in sex completely.
3.	0	I do not feel like a failure.	13.	0	I make decisions about as well as I ever could.			
	1	I feel I have failed more than the average person.		1	I put off making decisions more than I used to.			
	2	As I look back on my life, all I can see is a lot of failures.		2	I have greater difficulty in making decisions more than I used to.			
	3	I feel I am a complete failure as a person.		3	I can't make decisions at all anymore.			
4.	0	I get as much satisfaction out of things as I used to.	14.	0	I don't feel that I look any worse than I used to.			
	1	I don't enjoy things the way I used to.		1	I am worried that I am looking old or unattractive.			
	2	I don't get real satisfaction out of anything anymore.		2	I feel there are permanent changes in my appearance that make me look unattractive			
	3	I am dissatisfied or bored with everything.		3	I believe that I look ugly.			
5.	0	I don't feel particularly guilty	15.	0	I can work about as well as before.			
	1	I feel guilty a good part of the time.		1	It takes an extra effort to get started at doing something.			
	2	I feel quite guilty most of the time.		2	I have to push myself very hard to do anything.			
	3	I feel guilty all of the time.		3	I can't do any work at all.			
6.	0	I don't feel I am being punished.	16.	0	I can sleep as well as usual.			
	1	I feel I may be punished.		1	I don't sleep as well as I used to.			
	2	I expect to be punished.		2	I wake up 1-2 hours earlier than usual and find it hard to get back to sleep.			
	3	I feel I am being punished.		3	I wake up several hours earlier than I used to and cannot get back to sleep.			
7.	0	I don't feel disappointed in myself.	17.	0	I don't get more tired than usual.			
	1	I am disappointed in myself.		1	I get tired more easily than I used to.			
	2	I am disgusted with myself.		2	I get tired from doing almost anything.			
	3	I hate myself.		3	I am too tired to do anything.			
8.	0	I don't feel I am any worse than anybody else.	18.	0	My appetite is no worse than usual.			
	1	I am critical of myself for my weaknesses or mistakes.		1	My appetite is not as good as it used to be.			
	2	I blame myself all the time for my faults.		2	My appetite is much worse now.			
	3	I blame myself for everything bad that happens.		3	I have no appetite at all anymore.			
9.	0	I don't have any thoughts of killing myself.	19.	0	I haven't lost much weight, if any, lately.			
	1	I have thoughts of killing myself, but I would not carry them out.		1	I have lost more than five pounds.			
	2	I would like to kill myself.		2	I have lost more than ten pounds.			
	3	I would kill myself if I had the chance.		3	I have lost more than fifteen pounds.			
10.	0	I don't cry any more than usual.						
	1	I cry more now than I used to.						
	2	I cry all the time now.						
	3	I used to be able to cry, but now I can't cry even though I want to.						

**21 questions;  
Responses on a scale of 0, 1, 2, 3**

# Combined Dataset

Questionnaires			THI				TPFQ					TFI								BAI	BDI-II			
Study	Location	Hearing status	Age	Gender	Total/100	(F) %	(E) %	(C) %	Total %	(C) %	(E) %	(H) %	(S)%	Total/100	(I)%	(SC)%	(C)%	(SL)%	(A)%	(R)%	(Q)%	(E)%	Total/63	Total/60
A	UIUC	HL	52	F	84.00	91.67	87.50	60.00	89.70	86.80	91.00	92.00	89.00	81.60	95.00	90.00	75.00	86.67	88.33	75.00	65.00	83.33	16.00	18.00
A	UIUC	HL	60	F	8.00	0.00	0.00	40.00	5.05	0.20	20.00	0.00	0.00	11.20	40.00	30.00	10.00	10.00	3.33	0.00	0.00	0.00	0.00	1.00
A	UIUC	NH	40	M	6.00	4.17	0.00	20.00	1.60	3.40	2.40	0.40	0.20	6.00	10.00	30.00	0.00	0.00	10.00	0.00	0.00	0.00	0.00	1.00
A	UIUC	HL	47	M	18.00	20.83	12.50	20.00	31.25	20.00	43.00	20.00	42.00	29.20	70.00	66.67	16.67	10.00	23.33	40.00	10.00	3.33	1.00	0.00
A	UIUC	HL	45	M	12.00	8.33	6.25	30.00	10.00	10.00	6.00	0.00	24.00	8.00	20.00	16.67	3.33	3.33	0.00	20.00	0.00	3.33	0.00	1.00
A	UIUC	HL	57	M	42.00	54.17	25.00	40.00	71.25	76.00	74.00	76.00	59.00	55.20	36.67	56.67	53.33	73.33	70.00	66.67	47.50	40.00	3.00	9.00
A	UIUC	HL	58	F	62.00	54.17	75.00	60.00	68.75	87.00	61.00	57.00	70.00	79.20	76.67	83.33	80.00	76.67	80.00	80.00	80.00	76.67	11.00	0.00
A	UIUC	HL	49	M	10.00	12.50	0.00	20.00	7.75	7.00	9.00	15.00	0.00	6.80	20.00	13.33	0.00	0.00	20.00	0.00	2.50	0.00	3.00	0.00
A	UIUC	HL	53	M	46.00	54.17	31.25	50.00	60.50	70.00	58.00	52.00	62.00	66.80	90.00	76.67	80.00	50.00	80.00	43.33	52.50	66.67	11.00	15.00
A	UIUC	NH	25	M	2.00	4.17	0.00	0.00	0.75	0.00	2.00	0.00	1.00	2.80	20.00	0.00	3.33	0.00	0.00	0.00	0.00	0.00	3.00	9.00
A	UIUC	HL	47	M	12.00	12.50	6.25	20.00	7.00	9.00	16.00	3.00	0.00	8.40	36.67	6.67	0.00	0.00	20.00	0.00	2.50	3.33	1.00	0.00

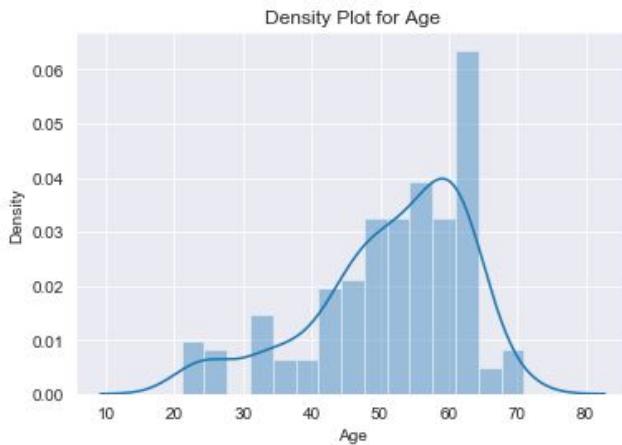
- Questionnaire information
- Demographic features
- Total scores and scores for the subscales of the five questionnaires (THI, TPFQ, TFI, BAI, BDI).

# Goals for the Project

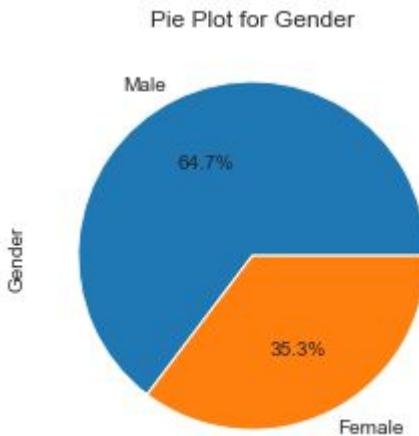
1. Find underlying **PATTERNS** through exploratory data analysis
2. Which is the **BEST** questionnaire for clinical practices ?
3. How does tinnitus **INFLUENCE** emotion?

# EDA - Demographic Features

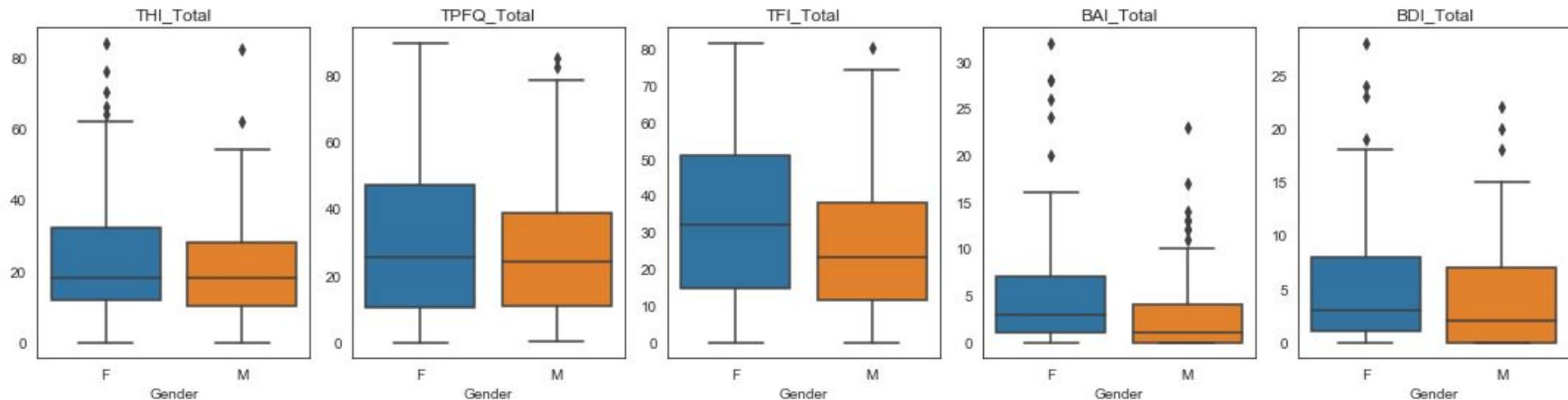
Age



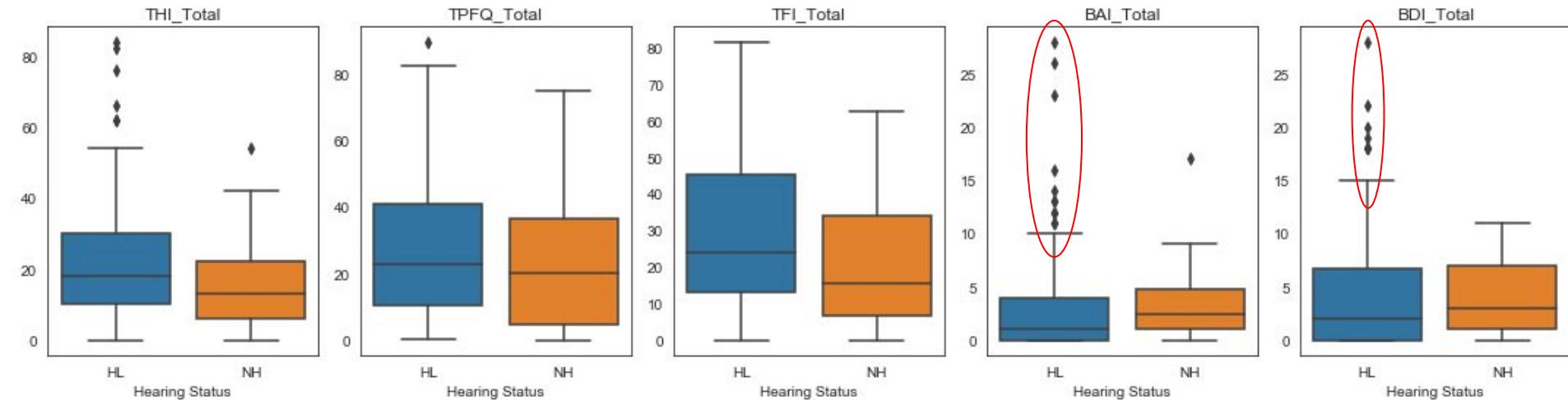
Gender



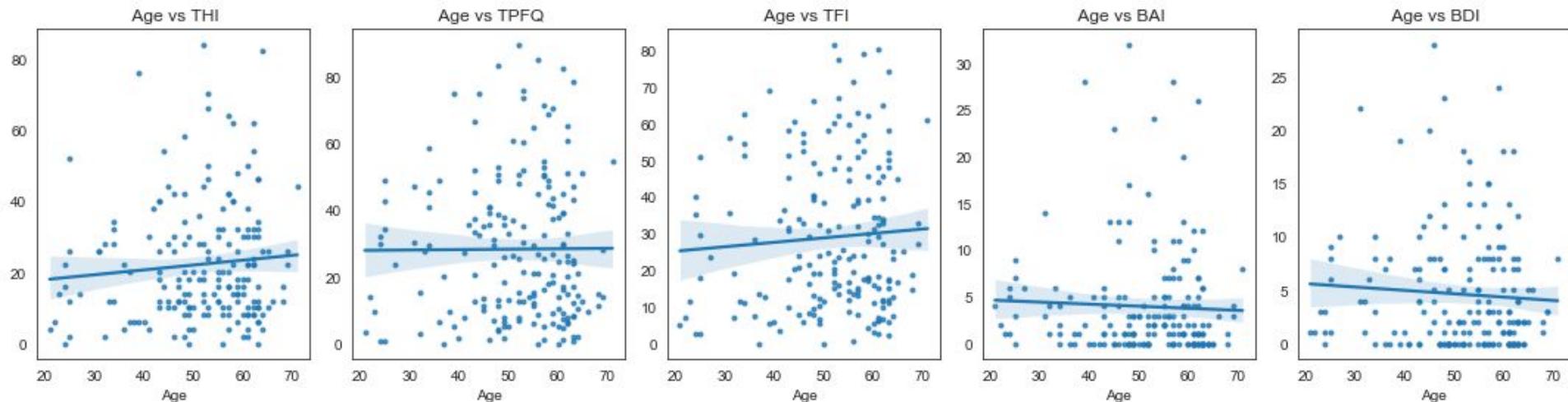
# EDA - Gender and Total Scores



# EDA - Hearing Status and Total Scores

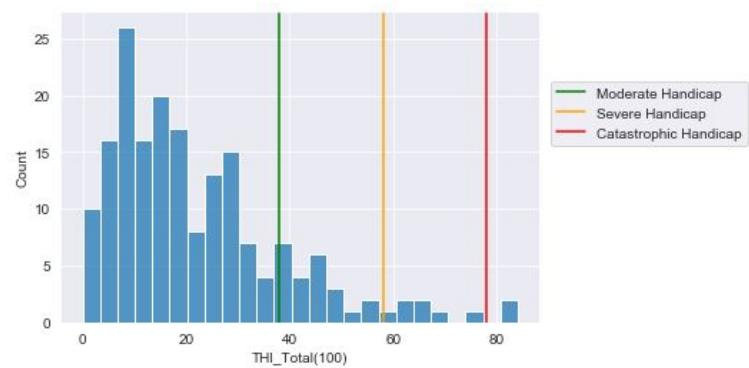


# EDA - Age and Total Scores

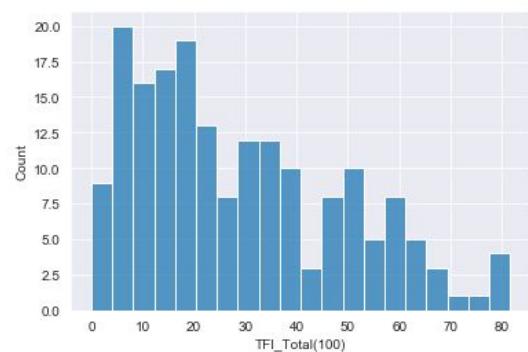


# EDA - Distribution of Tinnitus Scores

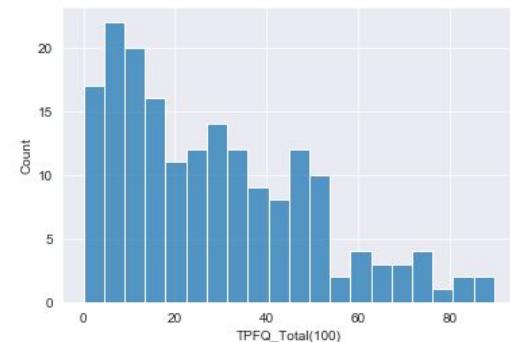
THI



TFI

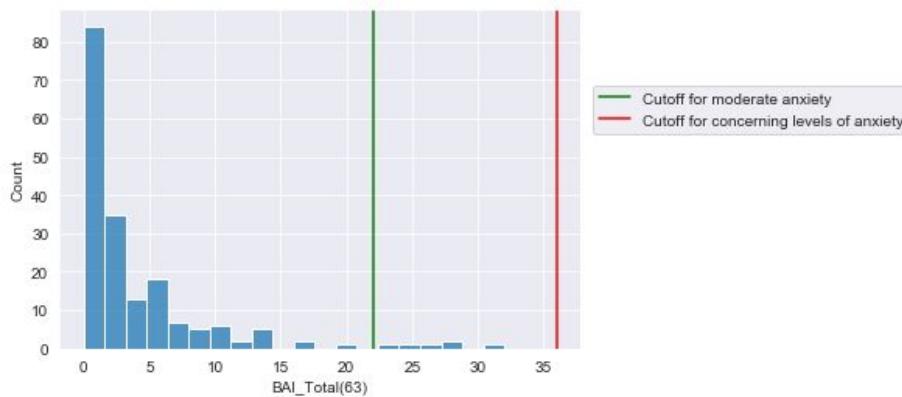


TPFQ

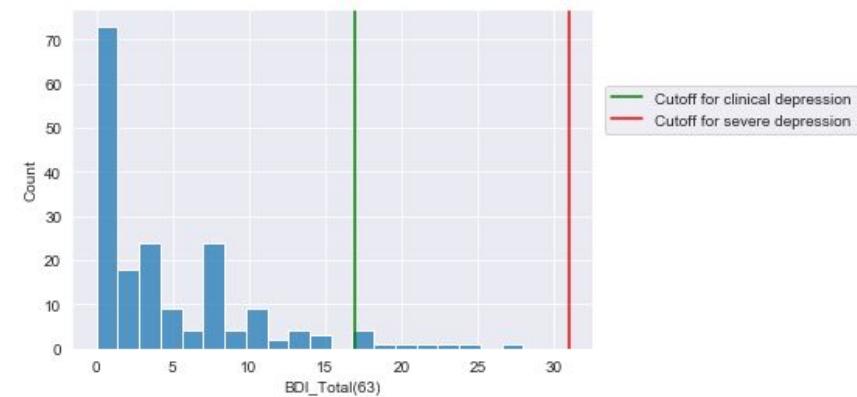


# EDA - Distribution of Emotion Scores

BAI



BDI



Very few observations to the right! Problem of ***Imbalance***!!!

# Conclusion for Intro & EDA

- Relationship

	Tinnitus	Emotion
Age	Little Influence	Little Influence
Gender	Little Influence	Little Influence
Hearing Loss	Little Influence	<b>NEGATIVE</b> Influence

- Distribution of Total Scores

Only a **SMALL** portion of the patients actually suffer from tinnitus or emotional problem.

# Correlation Analysis

-- Use heatmap to show the correlation among different subscales

*Shuyu Jia*

# Overview

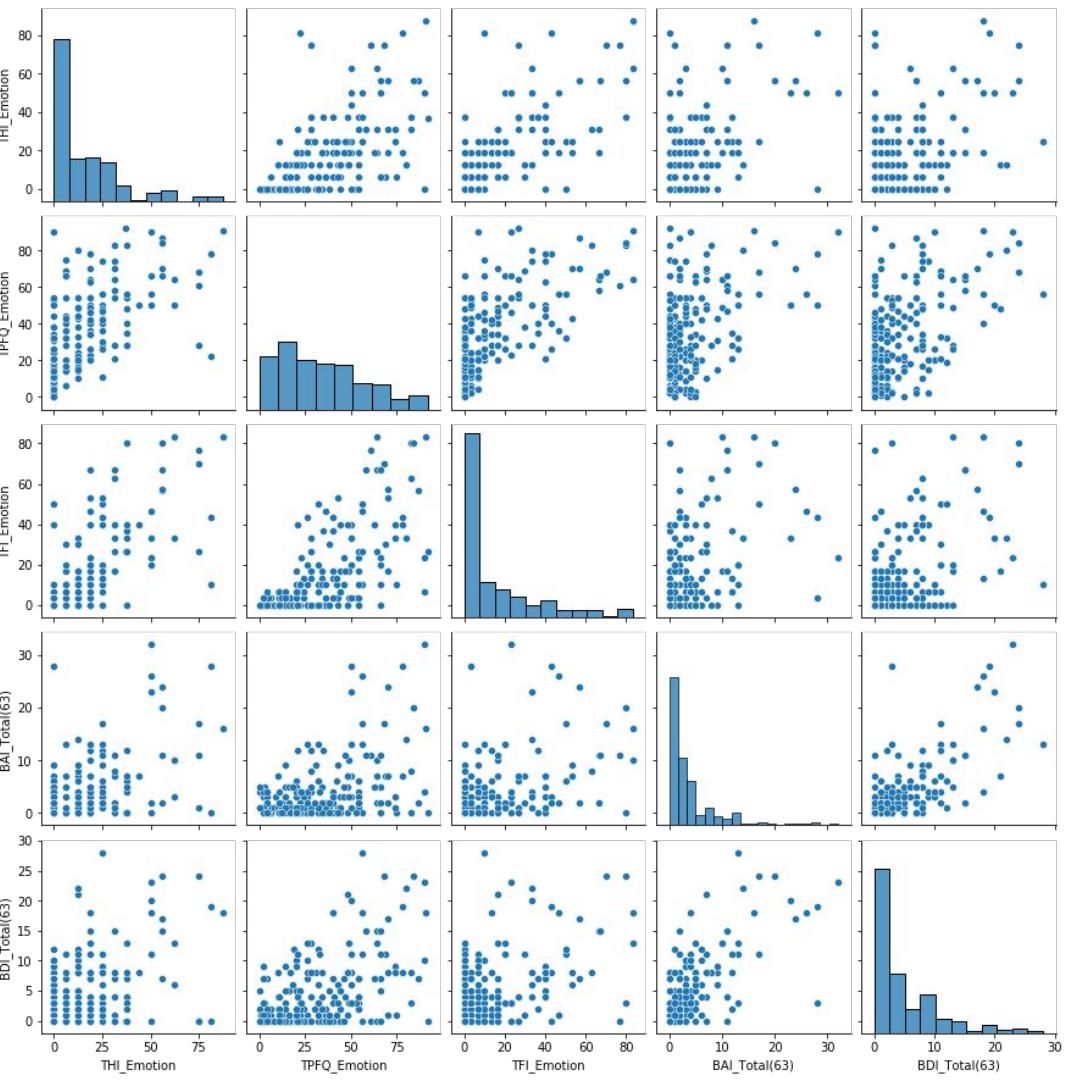
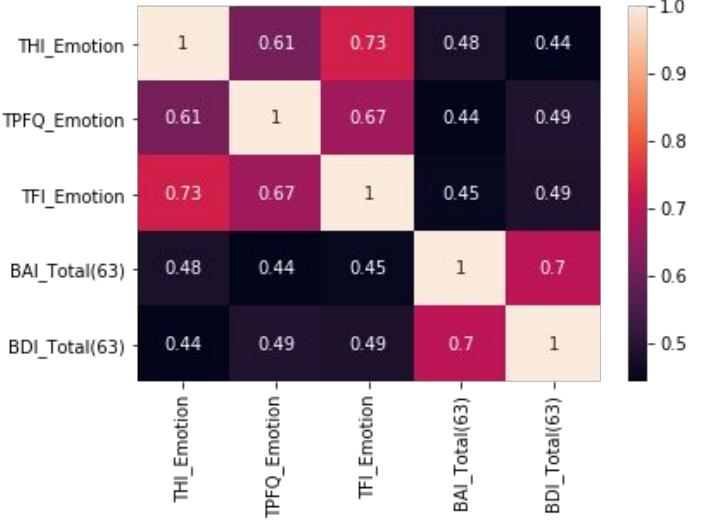
## Relationships Between Questionnaires

- **Emotional** subscales
- **Sleeping** subscales
- **Hearing** subscales

## Relationships Within Questionnaire

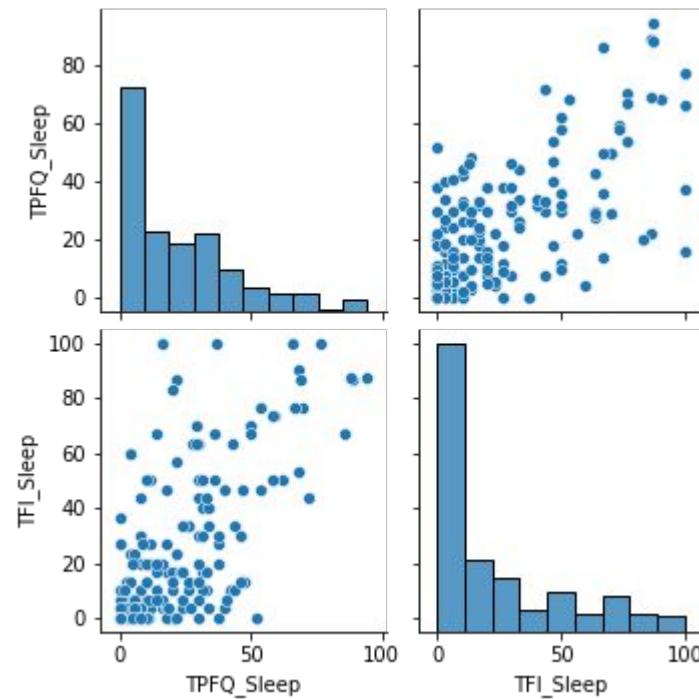
- THI
- TPFQ
- TFI

# Emotional Subscales



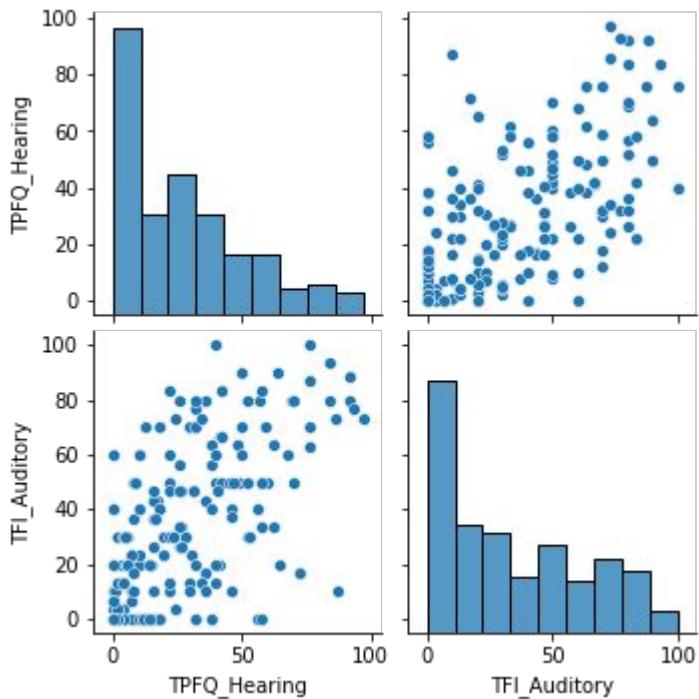
# Sleeping Subscales

The correlation between two sleeping subscale is **0.71**

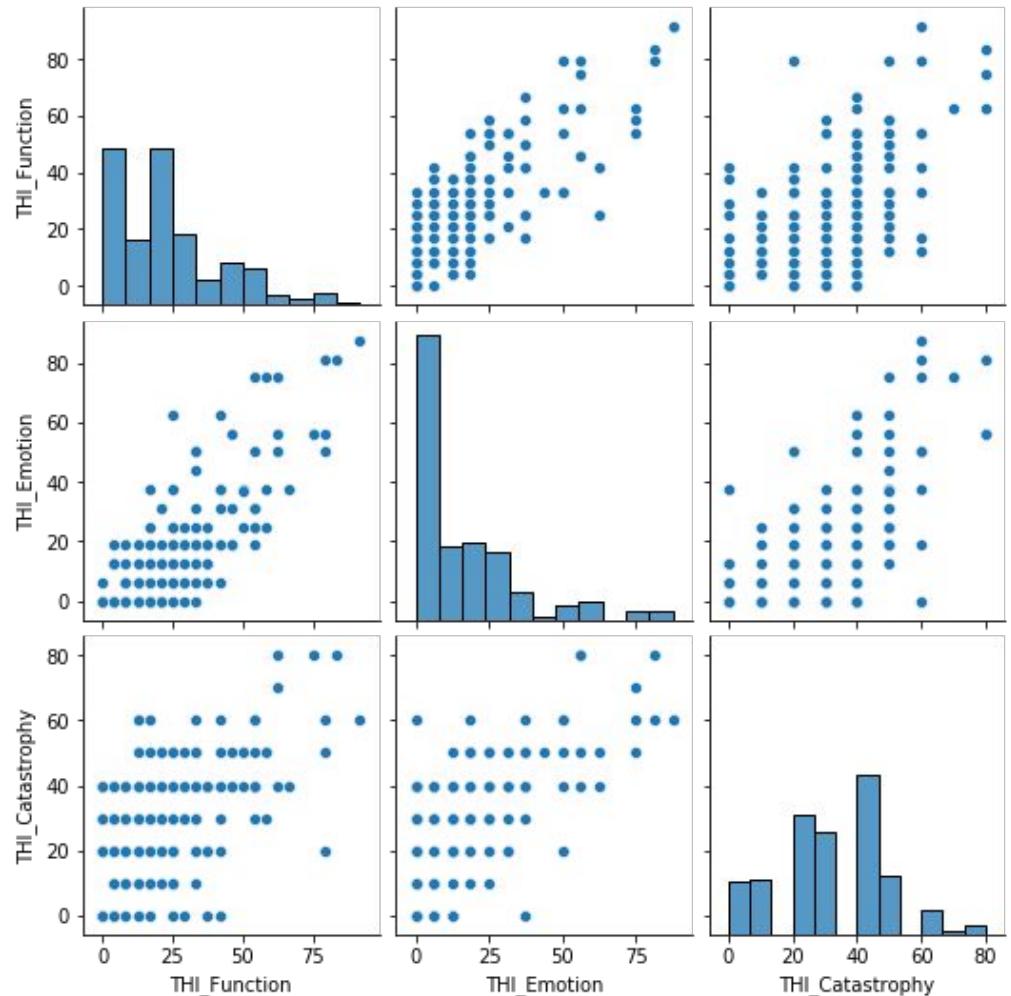
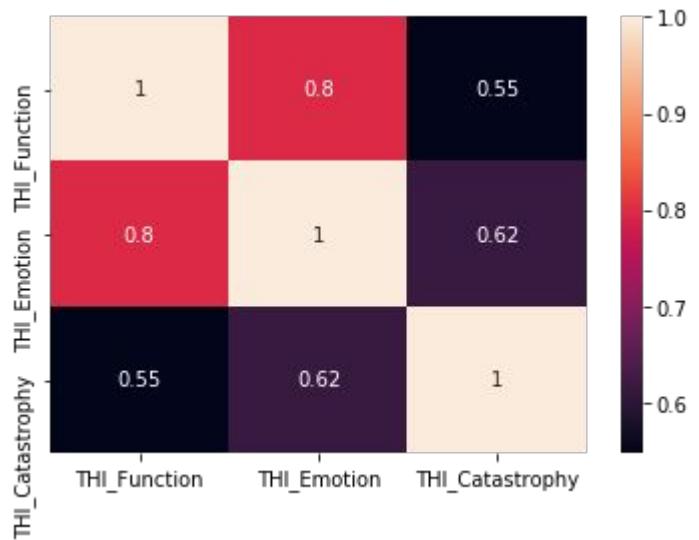


# Hearing / Auditory Subscales

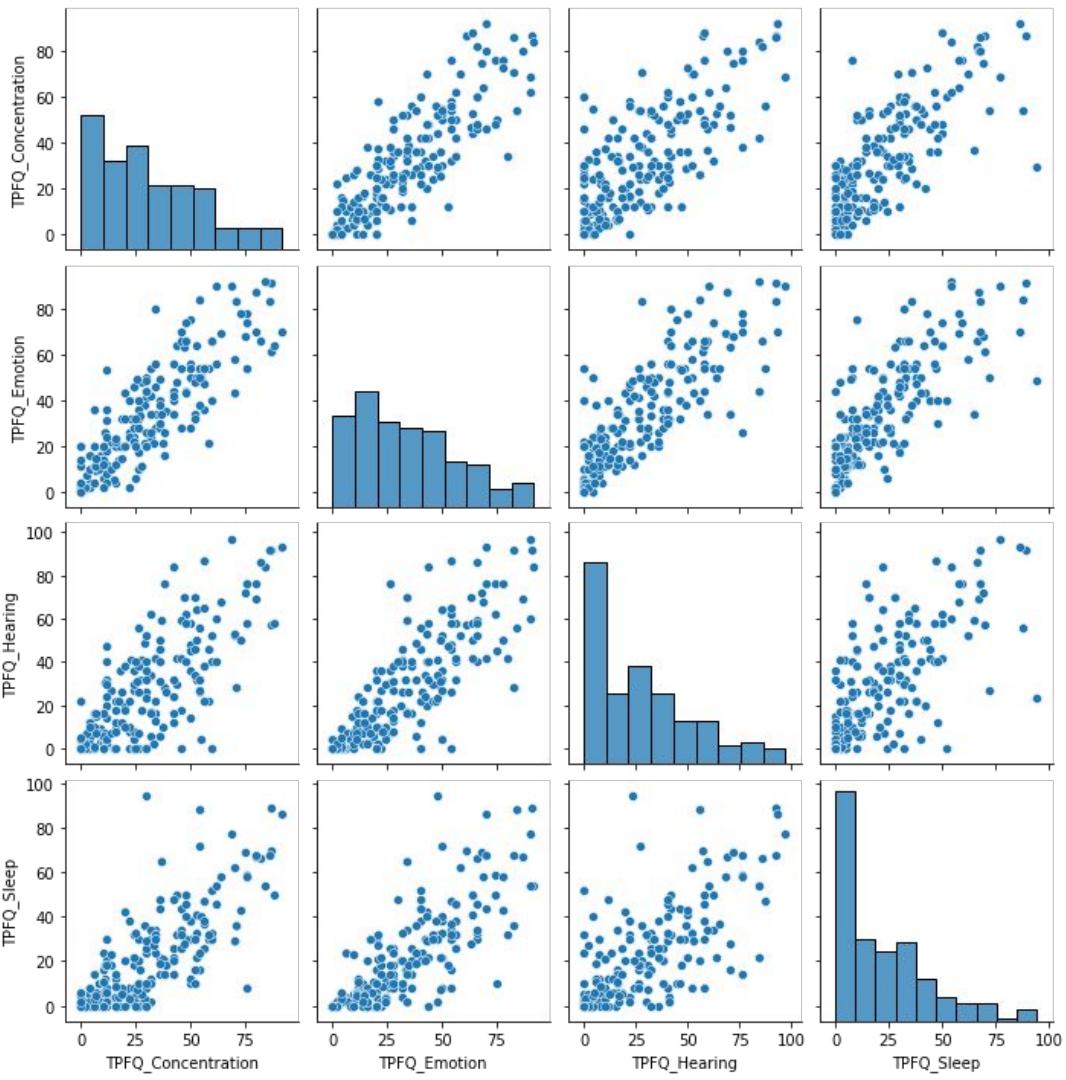
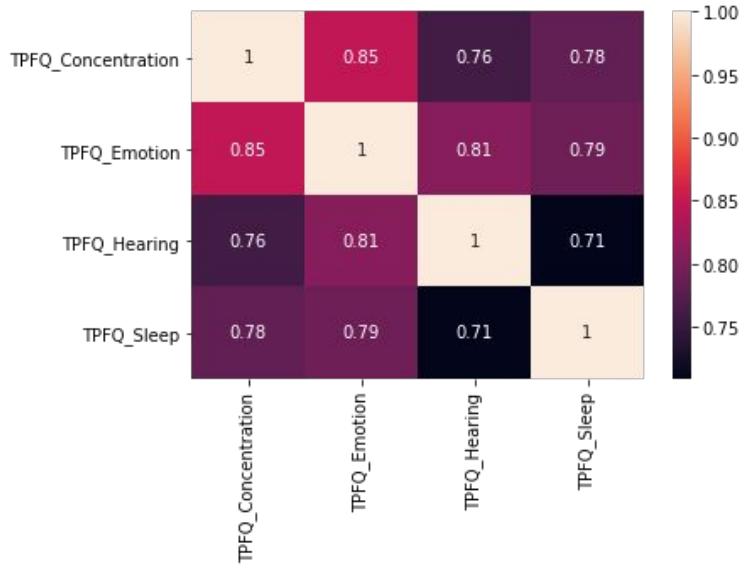
The correlation between two hearing related subscales is **0.65**



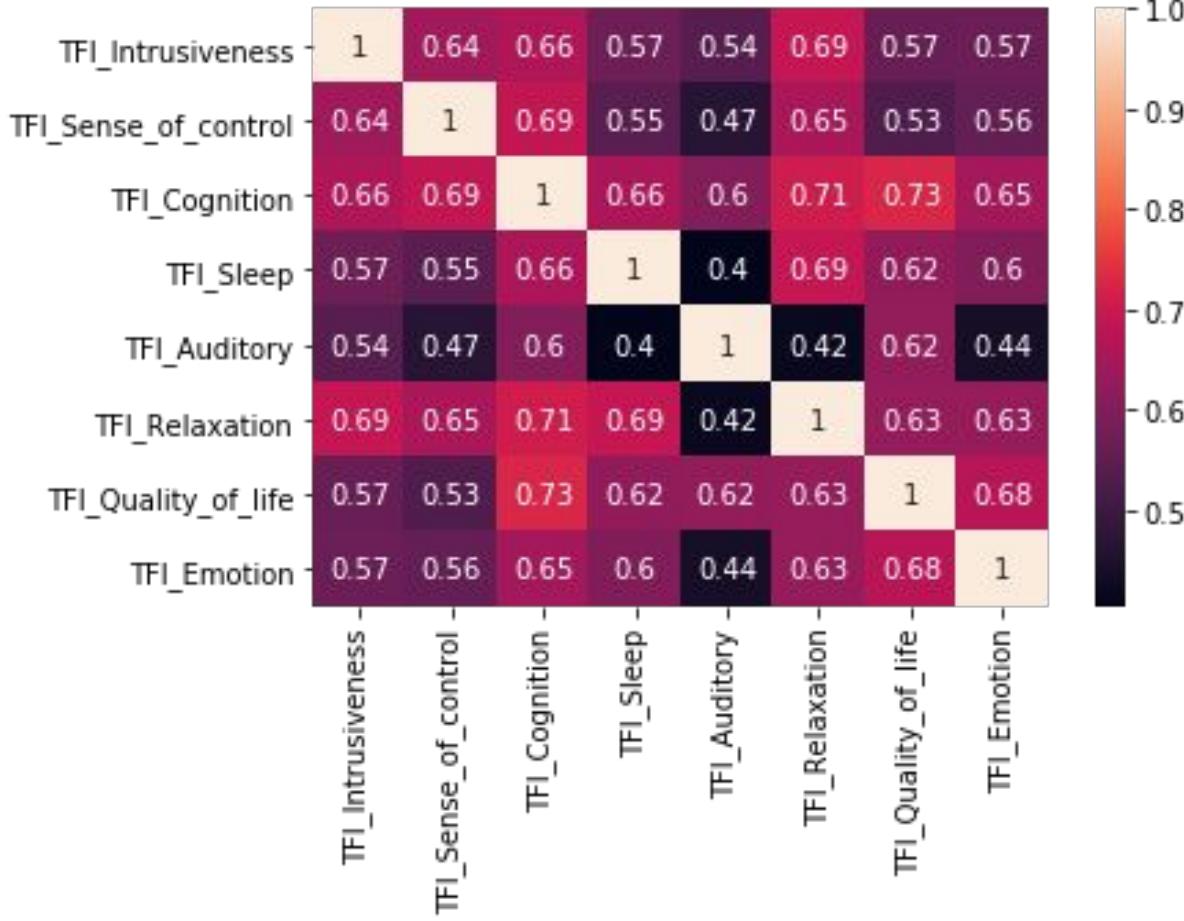
# THI Subscales



# TPFQ Subscales



# TFI Subscales



# Summary

**TFI** subscales are the **least** correlated among all 3

Correlations between common subscales are **moderately high**

# Milestone 1 – Validity

-- Find the survey which best explains tinnitus

*Jesse Bowers, Yumeng Wu, Shuyu Jia*

# Milestone 1 - Validity

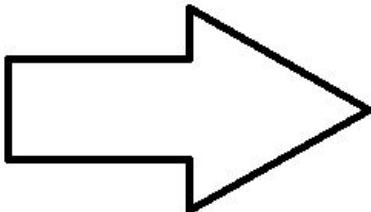
## What is Factor Analysis?

*Jesse Bowers*

# Factor Analysis

- Some attributes can only be measured *indirectly*.

**Overall Sleep Quality**  
+  
**Noise**



## Quality of Sleep Measures (Observed)

- I have difficulty getting to sleep at night because of my tinnitus.
- How much of the time did your tinnitus keep you from SLEEPING as DEEPLY or as PEACEFULLY as you would have liked?
- How often did your tinnitus cause you difficulty in getting AS MUCH SLEEP as you needed?
- Because of your tinnitus, do you often feel tired?

# Types of Factor Analysis

- Confirmatory Factor Analysis (CFA)
  - **KNOW** which questions are related
  - Measure **goodness of fit**
- Exploratory Factor Analysis (EFA)
  - **Do NOT** know which questions are related
  - Identify **hidden attributes** driving survey responses

# Expressing Factor Analysis

- The loading matrix describes *how strongly* each question relates to each attribute

Loading Matrix		Sleep	Depression
Q1	Feel upset	0.0	1.0
Q2	Peaceful Sleeping	-1.0	0.0
Q3	Lie Awake at Night	0.9	0.9
Q4	Are you often tired	1.2	0.5

# Outline Validity

- Adequacy
  - EFA
  - CFA
  - External Validity
-

# Milestone 1 – Validity

Adequacy

**Is each survey suitable for factor analysis?**

*Shuyu Jia*

# Adequacy Tests --- Is the data suitable for Factor Analysis?

## Bartlett's Test of Sphericity

- H<sub>0</sub>: Correlation matrix = Identity matrix
- H<sub>A</sub>: Correlation matrix  $\neq$  Identity matrix
- If p-value is **not significant**, conducting factor analysis will **not yield meaningful results**.

## Kaiser-Meyer-Olkin (KMO) Test

- The **inverse of the correlation matrix** should be **near diagonal** in order for factor analysis to be appropriate.
- The **closer** the inverse correlation matrix to be diagonal, the **higher** the KMO score.

	Good If	THI	TPFQ	TFI
Bartlett Sphere P-Value	<5%	<1%	<1%	<1%
KMO	>0.8	0.88	0.91	0.94

# Cronbach's Alpha --- Internal Consistency

Measure the **reliability of the scale**

Ex: “Does tinnitus make you feel stressed?”

- Yes; Sometimes; No
- Always; Sometimes; Rarely; Never
- 1, 2, 3, 4, 5

Cronbach's Alpha	Good If	THI	TPFQ	TFI
	>0.7	<b>0.921</b>	<b>0.950</b>	<b>0.968</b>

# Adequacy Summary

THI, TFI and TPFQ are **all suitable** for factor analysis

THI, TFI and TPFQ are **all internal consistent**

**TFI** has the **highest** internal consistency

**THI** has the **lowest** internal consistency

# Milestone 1 – Validity

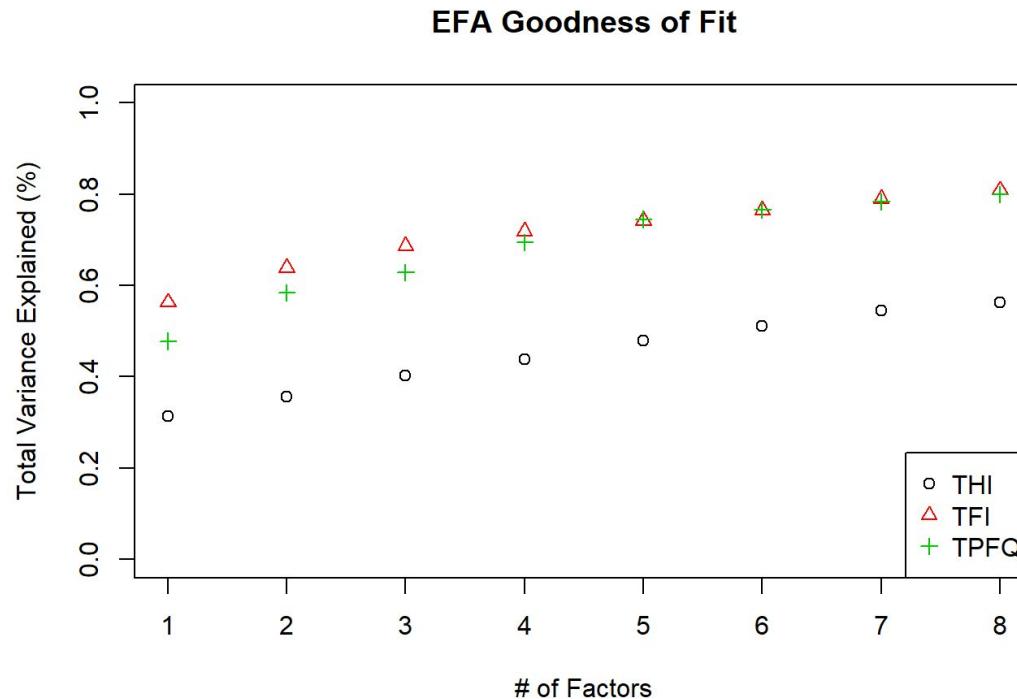
## EFA

Find the factors(subscales) of questions using factor loadings

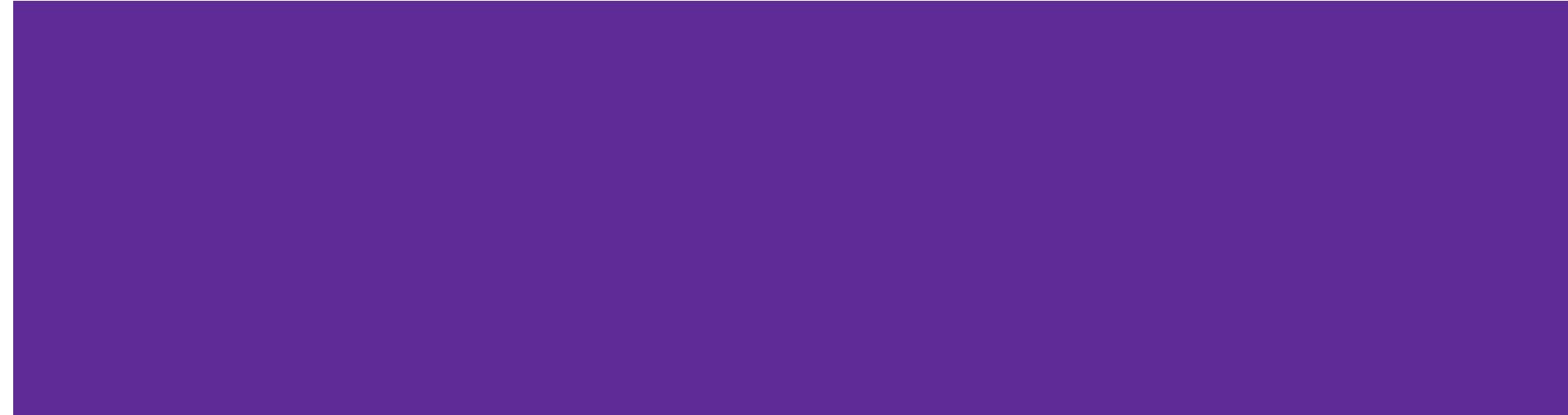
Do our fitted subscales match the existing subscales?

*Yumeng Wu*

# Goodness of Fit - EFA



THI



# THI

Question	Factor 1	Factor 2	Factor 3	Question	Factor 1	Factor 2	Factor 3
1. Because of yo	0.63	0.19	0.09	14. Because of y	0.38	0.25	0.25
2. Does the loud	0.51	0.52	0.09	15. Because of y	0.61	0.30	0.09
3. Does your tinn	0.46	0.19	0.09	16. Does your tir	0.57	0.29	0.09
4. Does your tinn	0.41	0.19	0.09	17. Do you feel t	0.39	0.77	0.09
5. Because of yo	0.09	0.23	0.09	18. Do you find i	0.78	0.09	0.09
6. Do you compl	0.53	0.19	0.09	19. Do you feel t	0.31	0.09	0.19
7. Because of yo	0.61	0.19	0.09	20. Because of y	0.37	0.09	0.32
8. Do you feel as	0.40	0.19	0.09	21. Because of y	0.09	0.09	1.00
9. Does your tinn	0.09	0.67	0.09	22. Does your tir	0.21	0.15	0.37
10. Because of y	0.50	0.26	0.09	23. Do you feel t	0.26	0.10	0.19
11. Because of y	0.09	0.09	0.48	24. Does your tir	0.44	0.30	0.19
12. Does your tinn	0.09	0.64	0.09	25. Does your tir	0.26	0.26	0.09
13. Does your tinn	0.09	0.50	0.30				

# THI - Factor1 : Severity

Question	Factor 1 Severity	Factor 2	Factor 3
18. Do you find it <b>difficult to focus</b> your attention away from your tinnitus and on other things?	0.78	-0.15	-0.07
1. Because of your tinnitus, is it <b>difficult for you to concentrate?</b>	0.63	0.15	-0.14
15. Because of your tinnitus, is it <b>difficult for you to read?</b>	0.61	-0.10	0.03
7. Because of your tinnitus, do you have trouble falling to <b>sleep</b> at night?	0.61	-0.15	0.10
16. Does your tinnitus make you <b>upset?</b>	0.57	0.00	0.07
6. Do you <b>complain</b> a great deal about your tinnitus?	0.53	0.14	-0.05
10. Because of your tinnitus, do you feel <b>frustrated?</b>	0.50	0.26	-0.01
3. Does your tinnitus make you <b>angry?</b>	0.46	0.17	0.05
24. Does your tinnitus get worse when you are under stress?	0.44	-0.20	0.18
4. Does your tinnitus make you feel confused?	0.41	0.11	0.00
8. Do you feel as though you cannot escape your tinnitus?	0.40	0.11	0.05
14. Because of your tinnitus, do you find that you are often irritable?	0.38	0.25	0.15
20. Because of your tinnitus, do you often feel tired?	0.37	0.04	0.32
19. Do you feel that you have no control over your tinnitus?	0.31	0.08	-0.16
23. Do you feel that you can no longer cope with your tinnitus?	0.26	0.20	0.16
25. Does your tinnitus make you feel insecure?	0.26	0.26	-0.07

# THI - Factor2 : Social

Question	Factor 1 Severity	Factor 2 Social	Factor 3
17. Do you feel that your tinnitus problem has placed stress on your <b>relationships with members</b> of your family and friends?	-0.09	<b>0.77</b>	-0.06
9. Does your tinnitus interfere with your ability to enjoy your <b>social activities</b> (such as going out to dinner, to the movies)?	-0.01	<b>0.67</b>	-0.02
12. Does your tinnitus make it difficult for you to <b>enjoy life</b> ?	0.02	<b>0.64</b>	0.14
2. Does the loudness of your tinnitus make it difficult for you to <b>hear people</b> ?	0.15	<b>0.52</b>	-0.17
13. Does your tinnitus interfere with your <b>job or household responsibilities</b> ?	-0.01	<b>0.50</b>	0.30
25. Does your tinnitus make you feel <b>insecure</b> ?	0.26	0.26	-0.07
10. Because of your tinnitus, do you feel <b>frustrated</b> ?	0.50	0.26	-0.01
14. Because of your tinnitus, do you find that you are often <b>irritable</b> ?	0.38	0.25	0.15
5. Because of your tinnitus, do you feel <b>desperate</b> ?	0.09	0.23	0.08

- Factor 2
  - Top five questions: primary factor
  - Others: alternative factor
  - Social

# THI - Factor3 : Depression

Question	Factor 1 Severity	Factor 2 Social	Factor 3 Depression
21. Because of your tinnitus, do you feel <b>depressed</b> ?	-0.04	0.00	1.00
11. Because of your tinnitus, do you feel that you have a <b>terrible disease</b> ?	0.20	0.01	0.48
22. Does your tinnitus make you feel <b>anxious</b> ?	0.21	0.15	0.37
20. Because of your tinnitus, do you often feel <b>tired</b> ?	0.37	0.04	0.32
13. Does your tinnitus interfere with your job or household responsibilities?	-0.01	0.50	0.30

- Factor 3 - Depression

# THI - Conclusions

Existing \ EFA	Severity	Social	Depression
Catastrophic	3	1	1
Emotional	4	2	2
F_Functional	8	4	0

- THI
  - Have an overall severity factor
  - Separate out social impacts
  - Separate out depression from other emotions
  - Got a completely different result from the existing questionnaire

**TPFQ**

# TPFQ - Factor1 : Sleep

Question	Factor 1 Sleep	Factor 2	Factor 3	Factor 4	Legacy
2 I lie <b>awake</b> at night because of my tinnitus.	0.99				S_Sleep
4 I have difficulty getting to <b>sleep</b> at night because of my tinnitus.	0.98				S_Sleep
17 The difficulty I have <b>sleeping</b> is one of the worst effects of my tinnitus.	0.85				S_Sleep
14 When I wake up in the night, my tinnitus makes it difficult to <b>get back to sleep</b> .	0.71				S_Sleep
11 I am <b>tired</b> during the day because my tinnitus has disrupted my sleep.	0.71				S_Sleep

- **Factor 1** has exactly the same questions as the **Sleep** subscale in the legacy questionnaire.

# TPFQ - Factor2 : Hearing

Question	Factor 1 Sleep	Factor 2 Hearing	Factor 3	Factor 4	Legacy
6 My tinnitus masks some <b>speech sounds</b> .		<b>0.90</b>			H_Hearing
12 In addition to my hearing loss, my tinnitus interferes with my <b>understanding of speech</b> .		<b>0.90</b>			H_Hearing
9 One of the worst things about my tinnitus is its effect on my loss. speech understanding, over and above any effect of my <b>hearing</b>		<b>0.89</b>			H_Hearing
10 My tinnitus, not my hearing loss, interferes with my <b>appreciation of music and songs</b> .		<b>0.66</b>		0.28	H_Hearing
19 The effects of tinnitus on my <b>hearing</b> are worse than the effects of my hearing loss.		<b>0.50</b>	0.28		H_Hearing
5 When there are lots of things happening at once, my tinnitus interferes with my ability to <b>attend to the most important thing</b> .		0.34	0.24		C_Concentration
8 My tinnitus is <b>annoying</b> .		0.25	0.25		E_Emotion

- **Factor 2:**

Except for the last two questions, all other questions belong to the **Hearing** subscale.

# TPFQ - Factor3 : Concentration

Question	Factor 1 Sleep	Factor 2 Hearing	Factor 3 Concentration	Factor 4	Legacy
20 I feel like my tinnitus makes it difficult for me to <b>concentrate</b> on some tasks.			<b>0.94</b>		C_Concentration
16 I have trouble <b>concentrating</b> while I am reading in a quiet room because of tinnitus.			<b>0.82</b>		C_Concentration
1 I have difficulty <b>focusing my attention</b> on some important tasks because of tinnitus.			<b>0.66</b>		C_Concentration
7 My inability to <b>think about something undisturbed</b> is one of the worst effects of my tinnitus.			<b>0.60</b>		C_Concentration
19 The effects of tinnitus on my hearing are worse than the effects of my hearing loss.		0.50	0.28		H_Hearing
8 My tinnitus is <b>annoying</b> .		0.25	0.25		E_Emotion
5 When there are lots of things happening at once, my tinnitus interferes with my ability to <b>attend to the most important thing</b> .		0.34	0.24		C_Concentration
3 I just wish my tinnitus would go away. It is so <b>frustrating</b> .			0.23		E_Emotion

- **Factor 3**

- 5 questions belong to the **Concentration** subscale.
- Mixed with emotional questions.

# TPFQ - Factor4 : Emotion

Question	Factor 1 Sleep	Factor 2 Hearing	Factor 3 Concentration	Factor 4 Emotion	
18 I am anxious because of my tinnitus.				<b>0.78</b>	E_Emotion
13 I am depressed because of my tinnitus.				<b>0.77</b>	E_Emotion
15 My emotional peace is one of the worst effects of my tinnitus.				<b>0.64</b>	E_Emotion
10 My tinnitus, not my hearing loss, interferes with my appreciation of music and songs.		<b>0.66</b>		0.28	H_Hearing

Emotion
My tinnitus is annoying.
My emotional peace is one of the worst effects of my tinnitus.
I am depressed because of my tinnitus.
I am anxious because of my tinnitus.
I just wish my tinnitus would go away. It is so frustrating.

- **Factor 4:** Contains most of the questions in the emotional subscale
- **TPFQ:** Similar to the legacy questionnaire with some related emotions added to the concentration subscale

**TFI**

# TFI

- The reproduced TFI has almost the same structure as the existing questionnaire.
- Only two questions belong to the wrong subscale
  - **Q4** belongs to **SENSEOFCONTROL** in the legacy questionnaire.
  - **Q22** belongs to **QUALITYOFLIFE** in the legacy questionnaire.

Question	AUDITORY	COGNITIVE	SLEEP	RELAXATION	EMOTIONAL	QUALITY OF LIFE	INTRUSIVE	SENSEOFCONTROL
4. Did you feel IN CONTROL in regard to your tinnitus?				0.30				0.29
22. How often did your tinnitus cause you to have difficulty performing your WORK OR OTHER TASKS, such as home maintenance, school work, or caring for children or others?		0.34				0.31		

# Conclusions - EFA

THI

- Not reproduced by EFA
- **Not a good choice**

TPFQ

- Reproduced by EFA, mostly
- **Acceptable**

TFI

- Reproduced by EFA, successfully
- **Best**

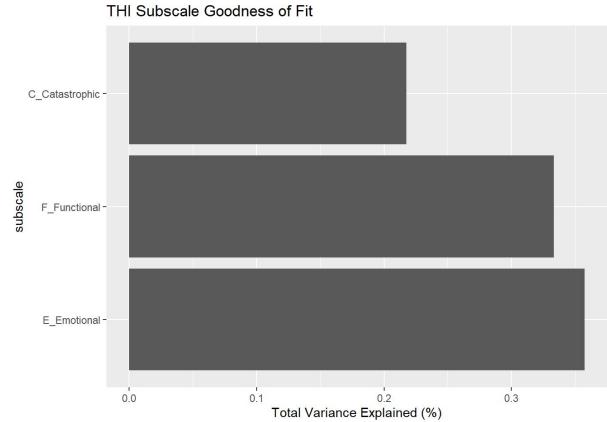
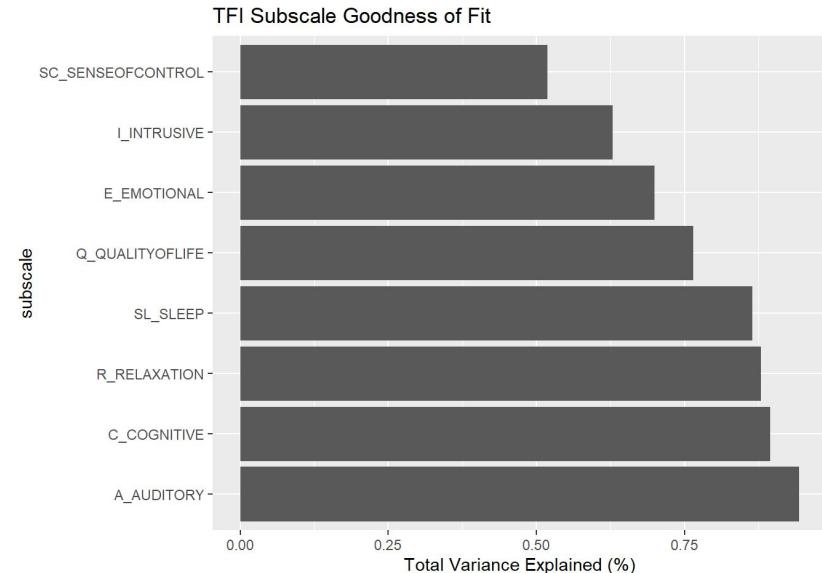
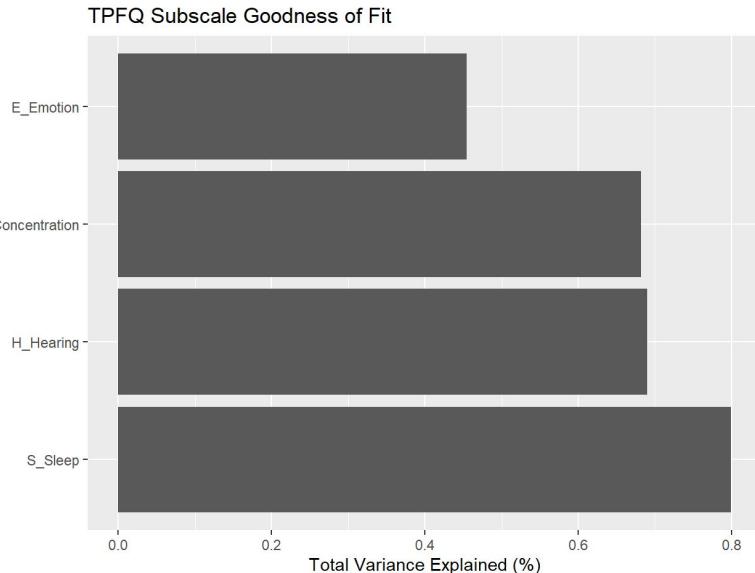
# Milestone 1 – Validity

## CFA

How well are a survey's responses explained by its own subscales?

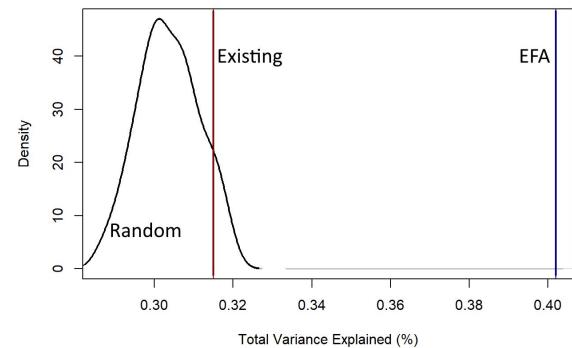
*Jesse Bowers*

# Individual Subscale Quality

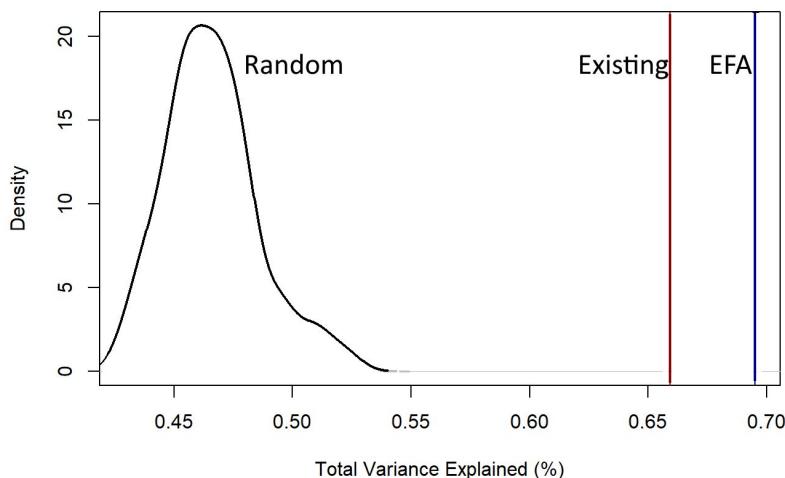


THI: Goodness of Fit

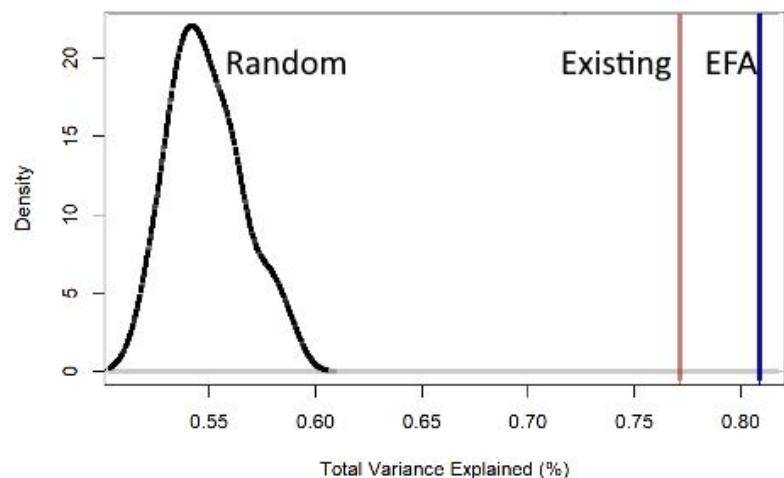
# Combined Subscale Quality



TPFQ: Goodness of Fit



TFI: Goodness of Fit



# Milestone 1 – Validity

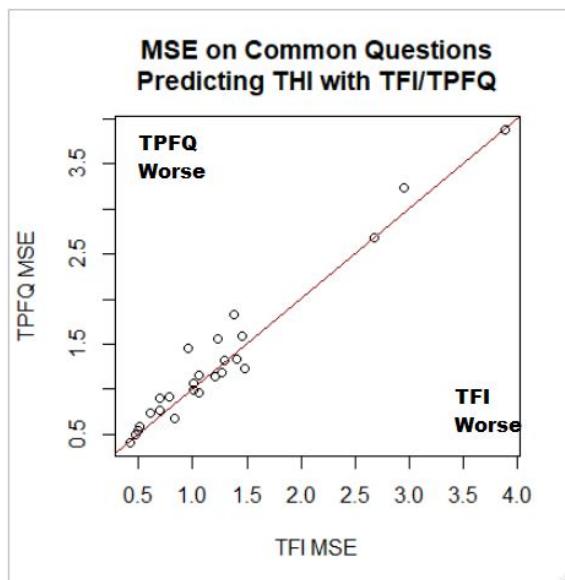
## External Validity

How well does one survey predict another survey?

*Jesse Bowers*

# Survey Prediction

- We fit a linear model to predict the questions of one survey with the subscales of another survey (ordinal proportional odds model).



Input	Overall Variation Explained (%)	Predicted Survey		
		THI	TPFQ	TFI
THI	50%		47%	
TPFQ	61%			63%
TFI	65%	72%		

# Subscale to Subscale Prediction

- We fit a linear model to predict the subscales of one survey with the subscales of another survey.

Predicting THI	Explained Variance (%)	
Predicted Subscale	from TPFQ	from TFI
THI-F_Functional	69%	70%
THI-E_Emotion	51%	61%
THI-C_Catastrophic	36%	36%

Predicted Subscale	Explained Variance (%)
TFI-SL_SLEEP	78%
TFI-C_COGNITIVE	71%
TFI-R_RELAXATION	66%
TFI-Q_QUALITYOFLIFE	62%
TFI-A_AUDITORY	61%
TFI-E_EMOTIONAL	56%
TFI-I_INTRUSIVE	51%
TFI-SC_SENSEOFCONTROL	48%

Predicted Subscale	Explained Variance (%)
TPFQ-S_Sleep	78%
TPFQ-C_Concentration	74%
TPFQ-H_Hearing	68%
TPFQ-E_Emotion	67%

# Milestone 1 – Validity

## Conclusions

*Jesse Bowers, Yumeng Wu*

# Conclusion for Milestone 1

- TPFQ and TFI perform similarly. THI performs poorly
- **TFI** has a slight advantage, likely due to having **twice as many factors** and a more customized fit
- The choice comes down to parsimony.
  - Do you want a simple model (TPFQ) which performs well?
  - Do you want a more complete model (TFI) which performs slightly better?

# Milestone 2 - Emotion

Model the emotional disturbance from tinnitus based on the scores from BDI, BAI and the emotional subscales

*Shiwei Fu, Shuyu Jia*

# Milestone 2 - Emotion

Regression

*Shuyu Jia*

# Problem Overview

Response (Y): **BAI; BDI**

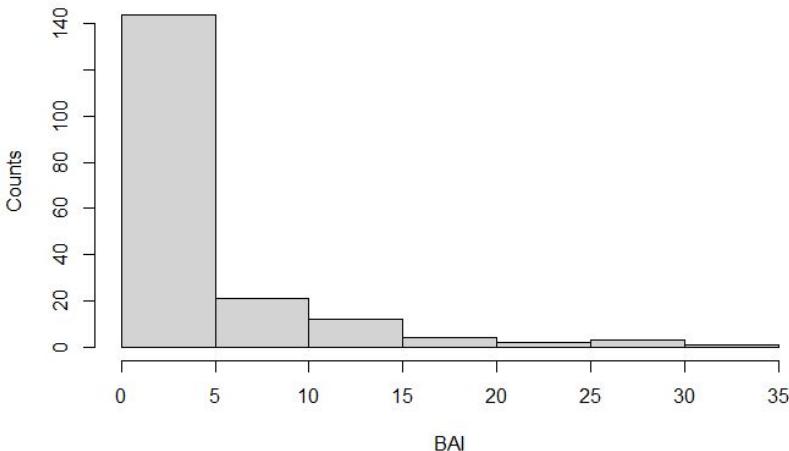
Predictors (X): **Emotional subscales**

Problem Type: **Regression**

Method: Linear Regression; Log Transformation; Decision Trees; Random Forests;  
Gradient Boosting

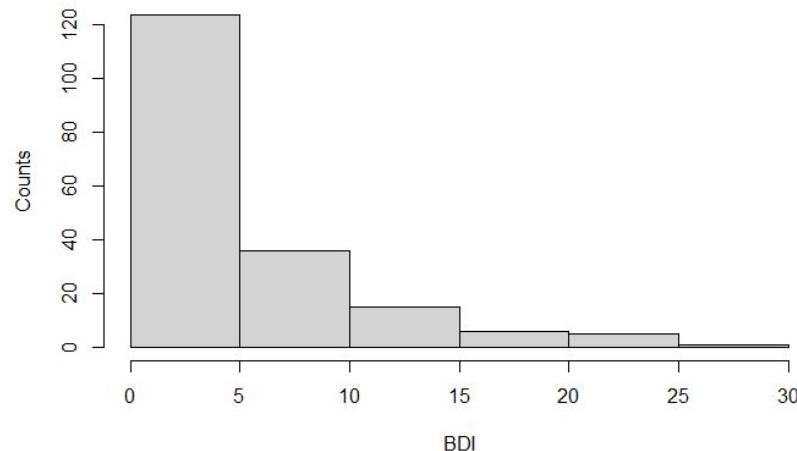
# Imbalanced Response (Y)

Histogram of BAI total score



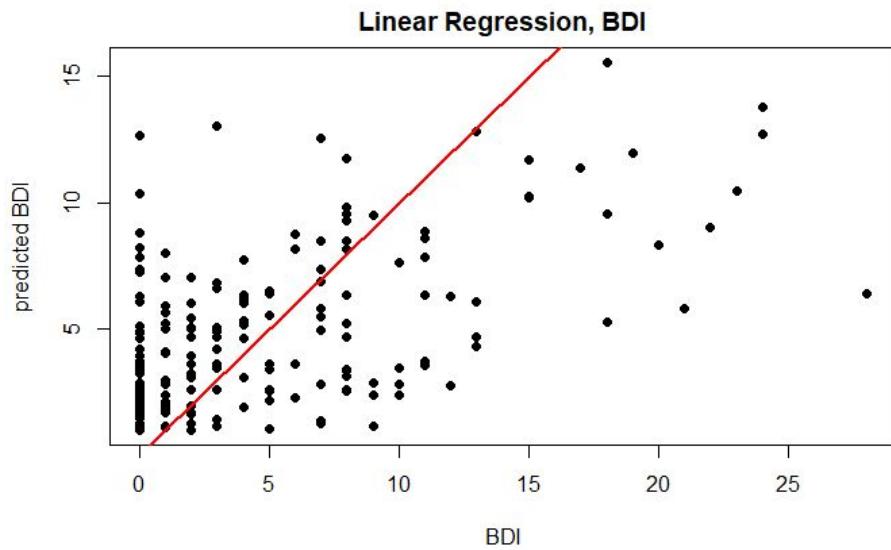
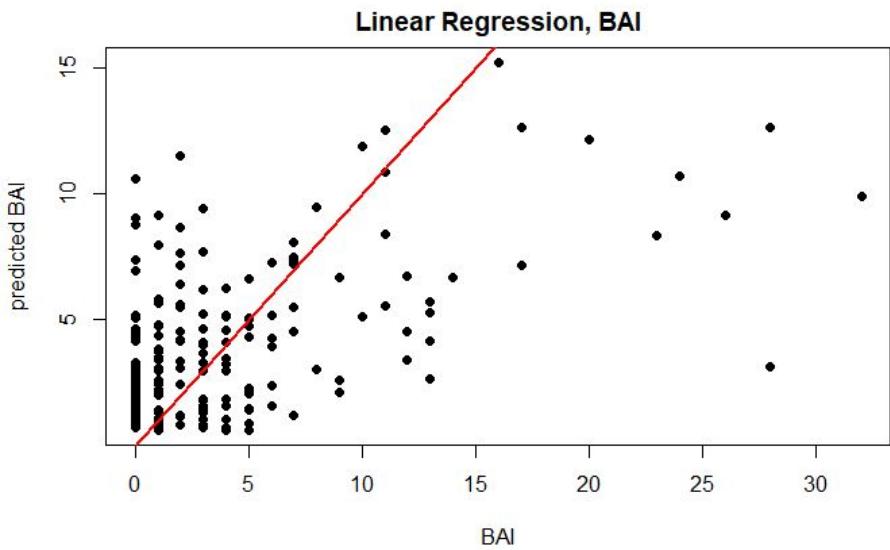
**28.3%** of BAI scores are zeros

Histogram of BDI total score

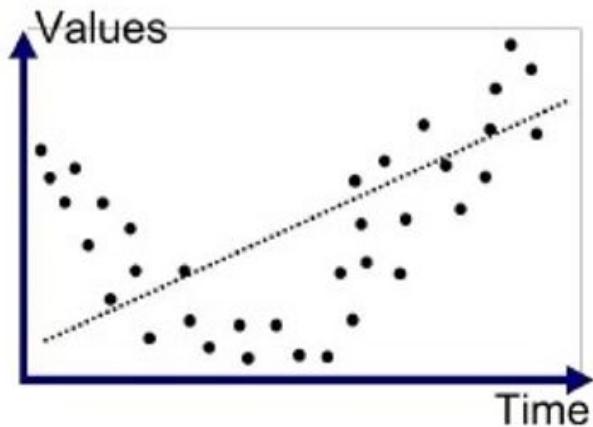


**27.8%** of BDI scores are zeros

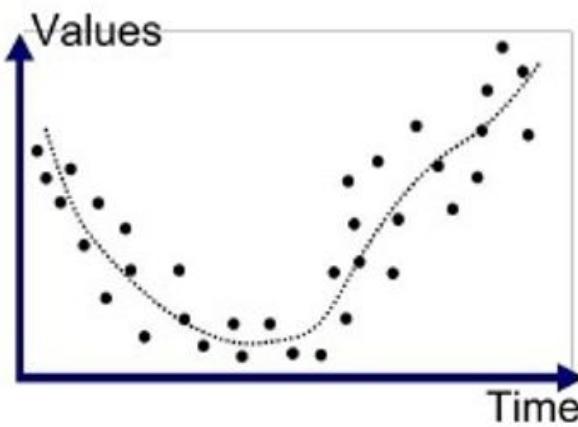
# Linear Regression



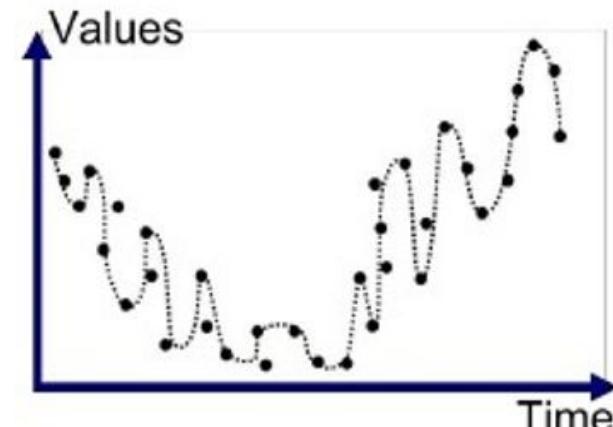
# Underfitting



Underfitted

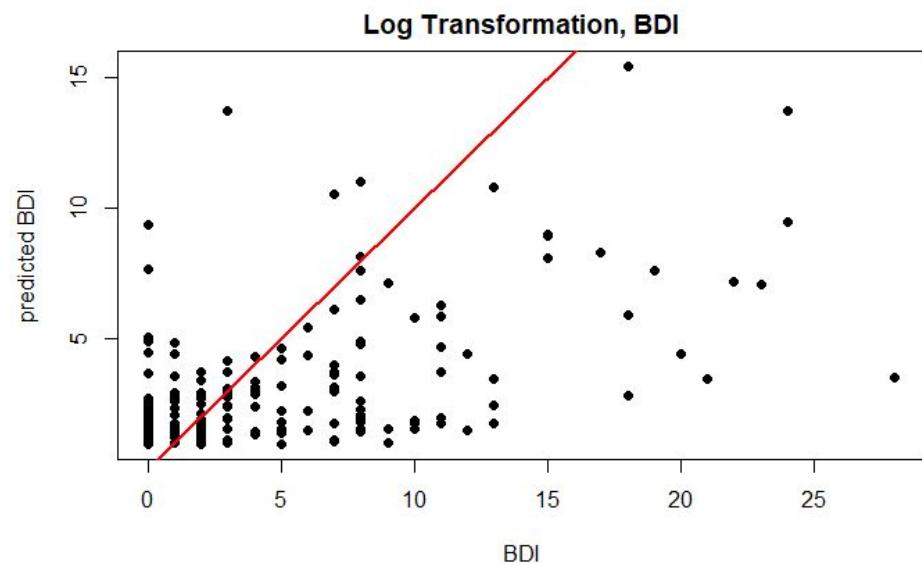
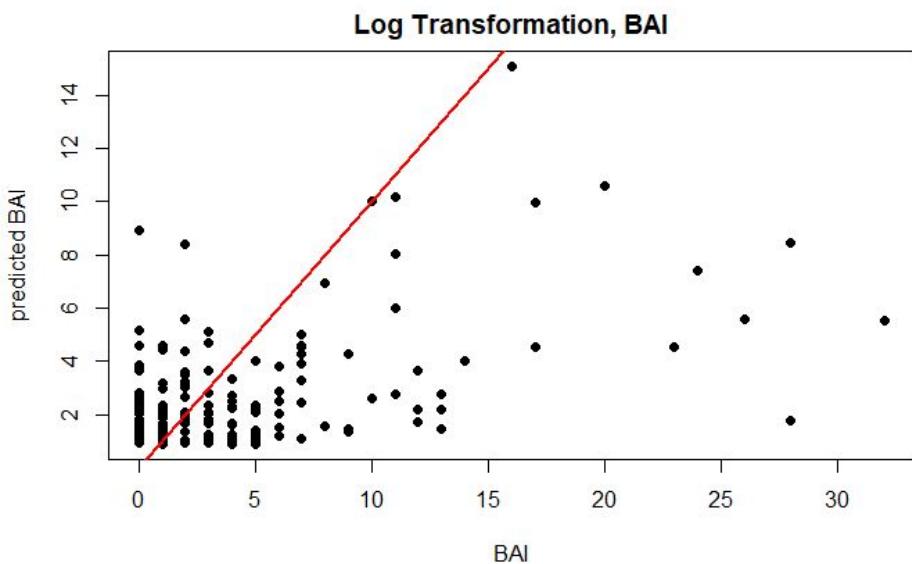


Good Fit/R robust

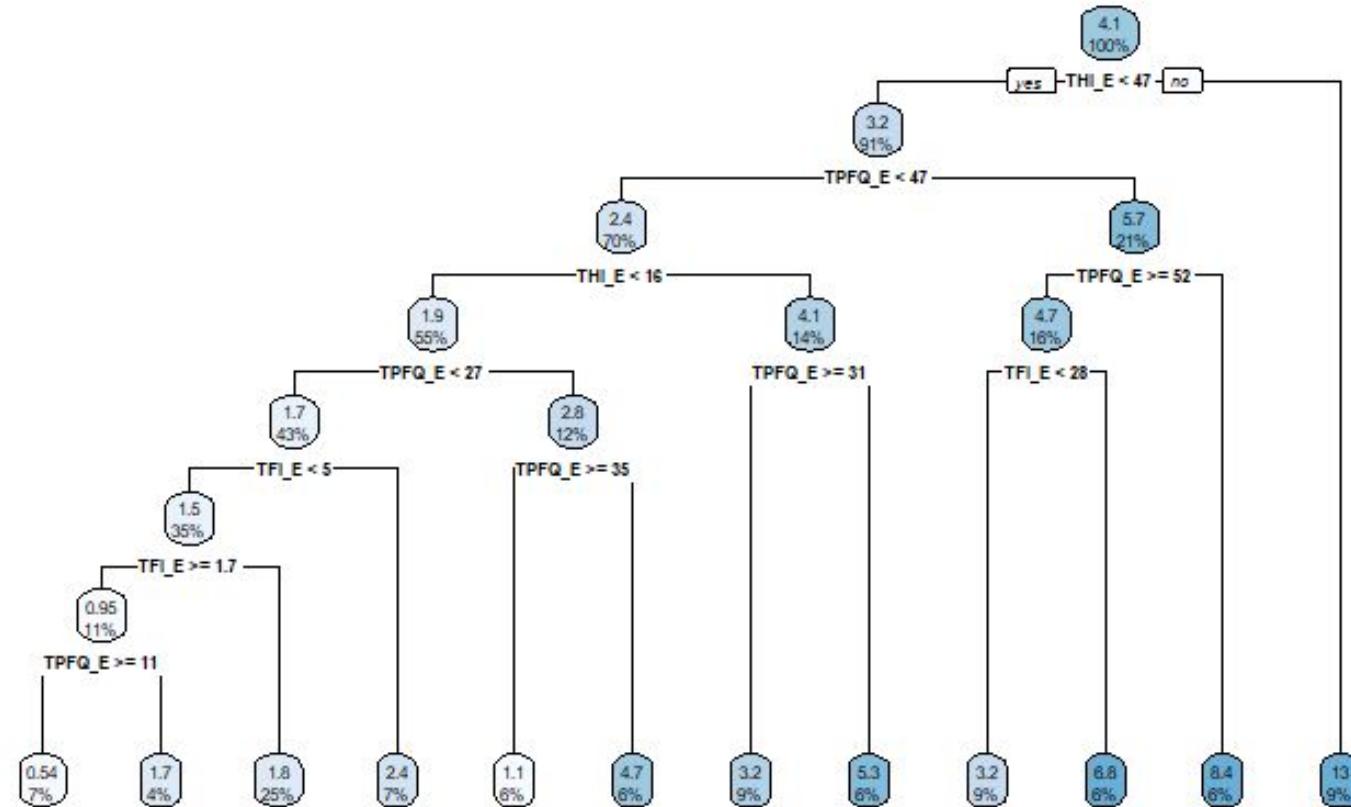


Overfitted

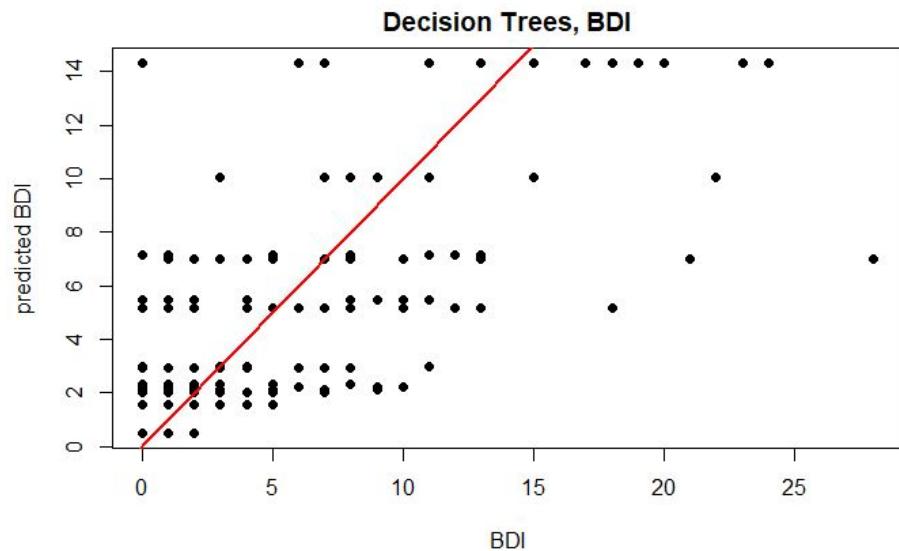
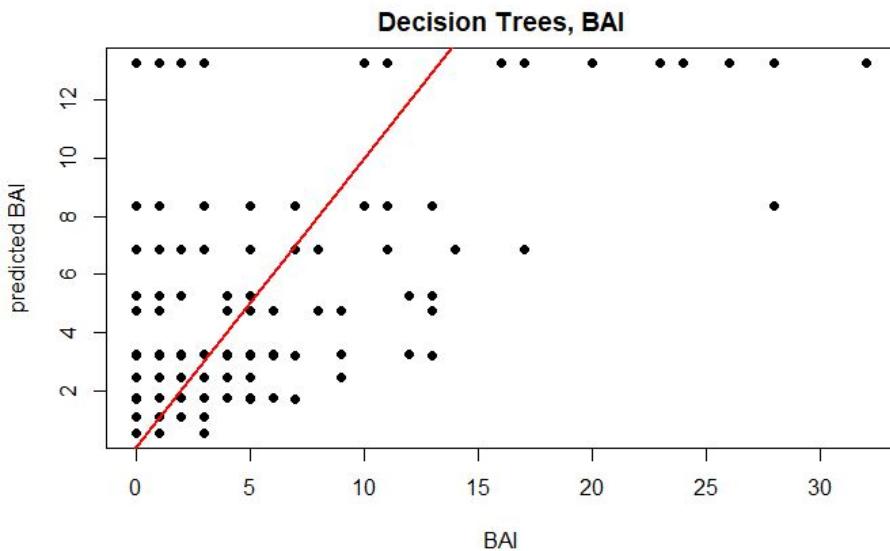
# Log Transformation



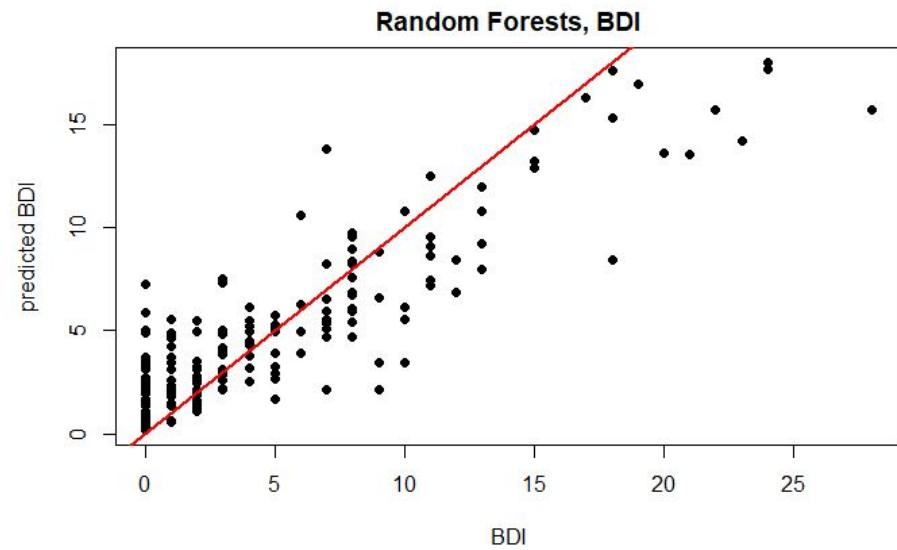
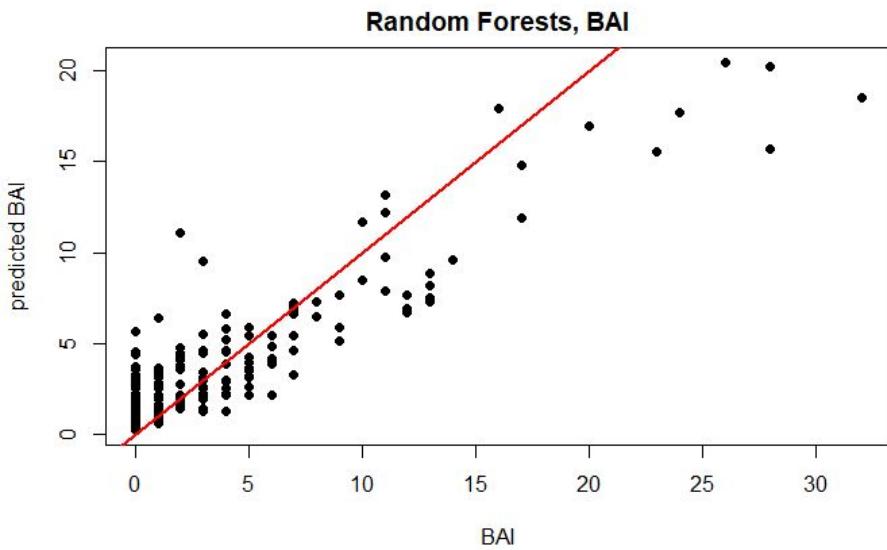
# Decision Tree



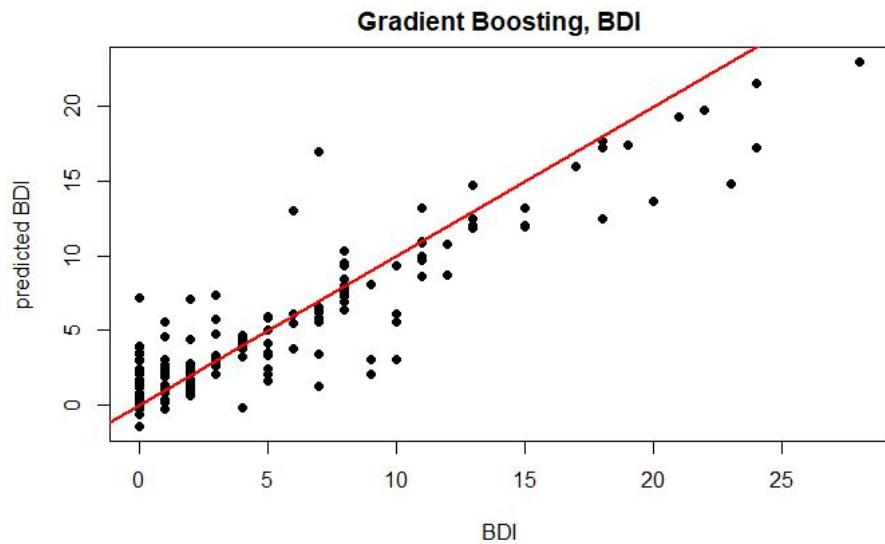
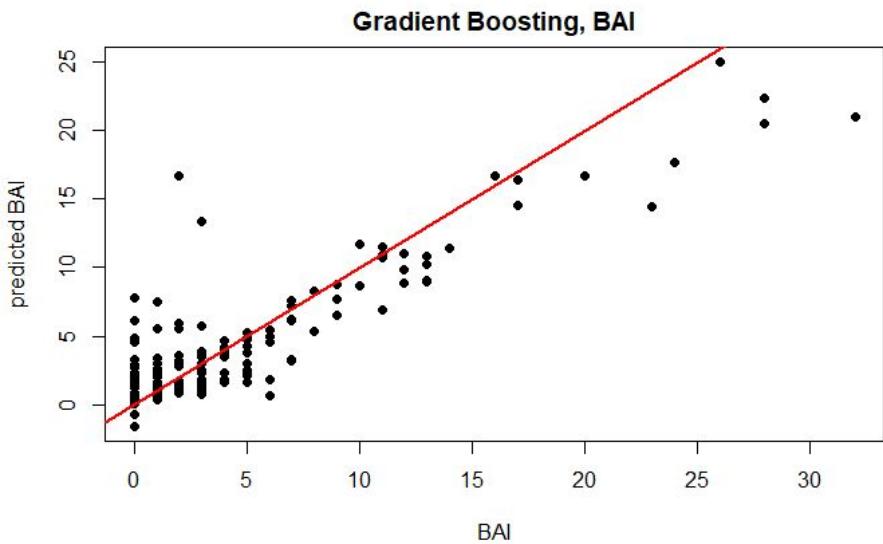
# Decision Trees



# Random Forests



# Gradient Boosting



# Summary

Mean Absolute Errors:

	Linear Regression	Log transform	Decision Tree	Random Forest	<b>Gradient Boosting</b>
BAI ~ Emotion	3.29	3.10	3.00	1.94	<b>1.69</b>
BDI ~ Emotion	3.61	3.45	3.10	2.10	<b>1.58</b>

# Previously best performed questionnaire - TFI

Response (Y): **BAI; BDI**

Predictors (X): **TFI subscales**

Problem Type: **Regression**

Method: Linear Regression; Log Transformation; Decision Trees; Random Forests;  
Gradient Boosting

# Summary

Mean Absolute Errors:

	Linear Regression	Log transform	Decision Tree	Random Forest	Gradient Boosting
BAI ~ Emotion	3.29	3.10	3.00	1.94	<b>1.69</b>
BDI ~ Emotion	3.61	3.45	3.10	2.10	<b>1.58</b>
BAI ~ TFI	3.31	3.12	2.91	1.53	<b>0.23</b>
BDI ~ TFI	3.64	3.45	3.12	1.68	<b>0.25</b>

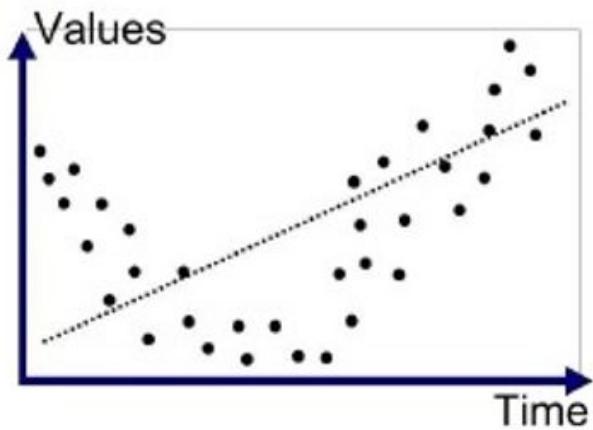
# Overfitting

Train-test split

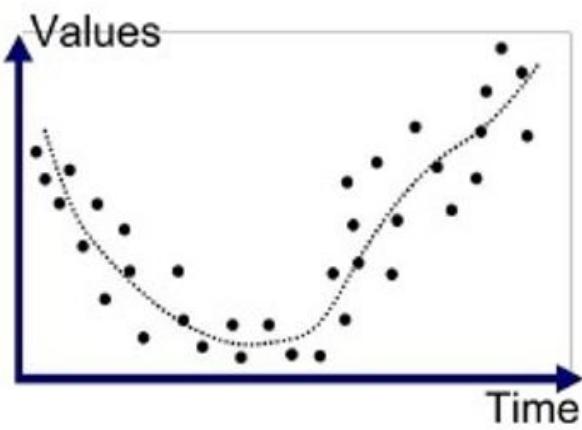
Gradient Boosting	BAI ~ TFI	BDI ~ TFI	BAI ~ Emotion	BDI ~ Emotion
Training MAE	0.36	0.31	1.99	1.64
<b>Testing MAE</b>	<b>3.48</b>	<b>5.06</b>	<b>3.47</b>	<b>5.20</b>

Random Forest	BAI ~ TFI	BDI ~ TFI	BAI ~ Emotion	BDI ~ Emotion
Training MAE	2.13	2.00	1.74	1.69
<b>Testing MAE</b>	<b>2.59</b>	<b>4.52</b>	<b>2.50</b>	<b>4.13</b>

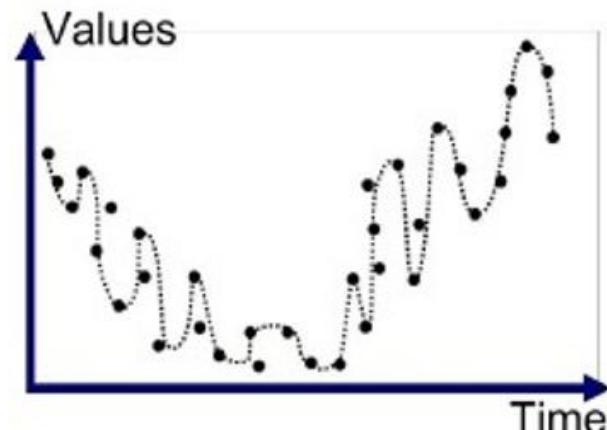
# Overfitting



Underfitted



Good Fit/Robust



★ Overfitted

# Regression Summary

It is **possible** to model the emotional disturbance using techniques like **Random Forests** and **Gradient Boosting**, but these models can be highly **overfitting** and are not very useful when predicting new data.

TFI subscales are **NOT** a better set of predictors than emotional subscales

**BAI** can generally be modeled better than BDI.

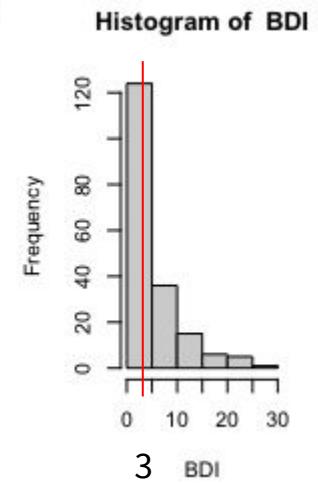
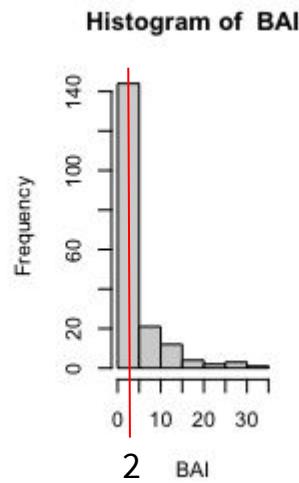
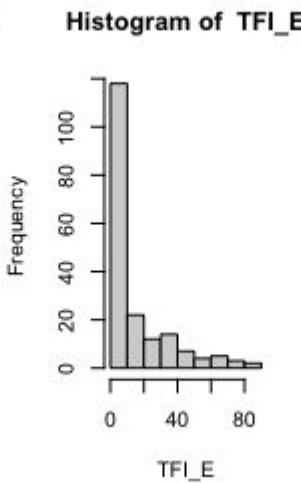
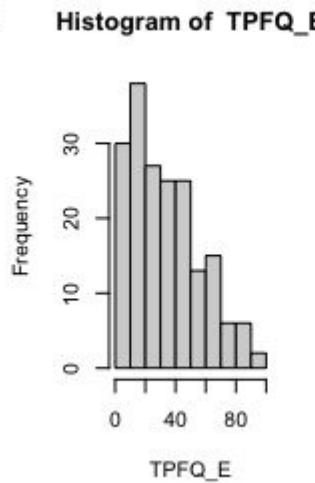
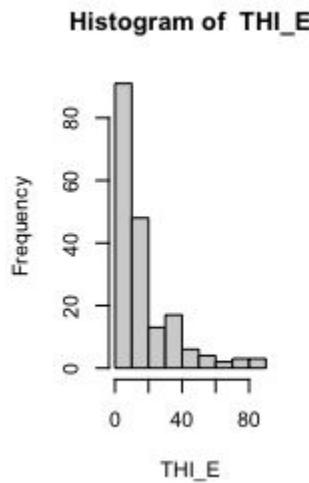
# Milestone 2 - Emotion

Classification

*Shiwei Fu*

# Overview

## 1. Data (Emotional subscales vs BAI & BDI)



## 2. Fit models (Phase I - simply fitting models)

What did we do?

1. Set the **median** of BAI and BDI as their cut-off respectively (0 - disturbed; 1- not)
2. Fit **logistic regression** models on **BAI and BDI** respectively
3. Fit **logistic regression** on **combined BAI and BDI** results
4. Set **0.5** as cut-off for predicted probability
5. Warning: Fitting and testing done on the same dataset

# Results

BAI vs 3 Emotional Subscales

Pred BAI	0	1
0	38	48
1	21	80

NIR = 0.54

Accuracy = **0.63**

BDI vs 3 Emotional Subscales

Pred BDI	0	1
0	60	36
1	24	67

NIR = 0.51

Accuracy = **0.68**

BAI & BDI vs 3 Emotional Subscales

Pred BAI & BDI	0	1
0	71	25
1	39	52

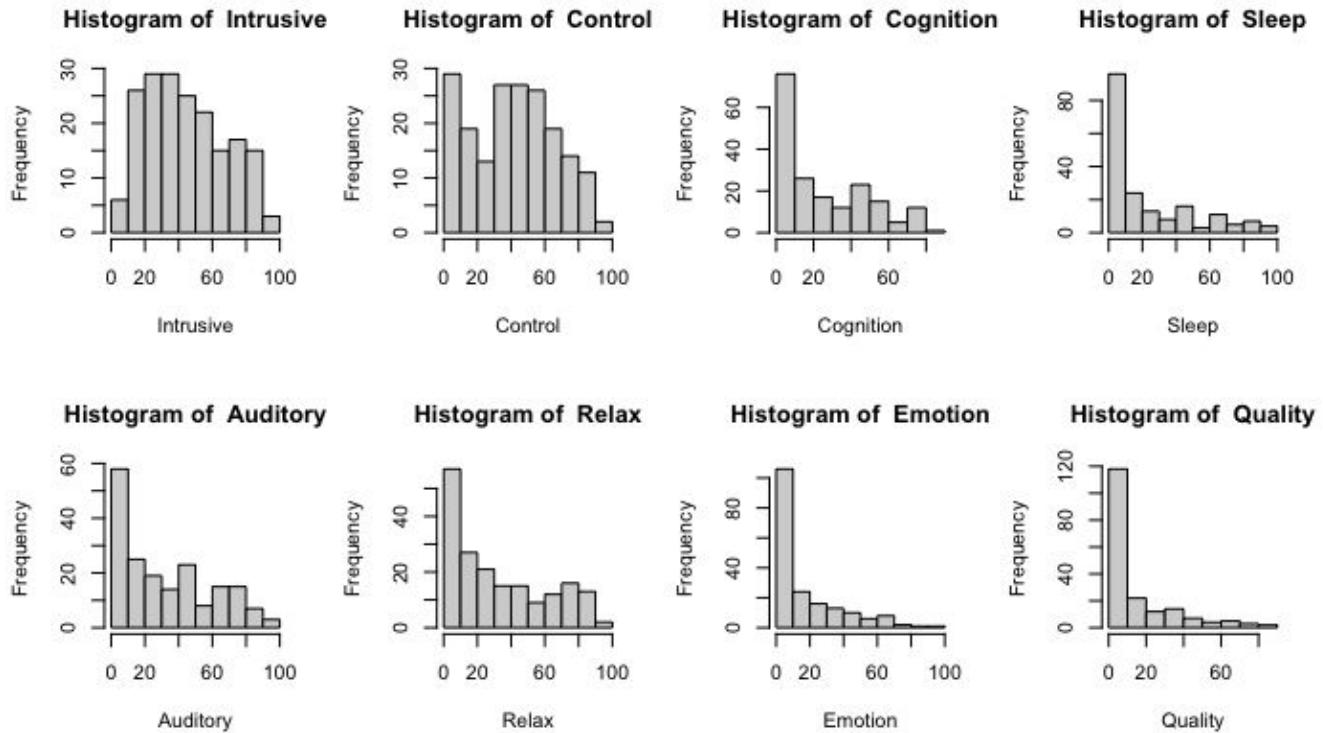
NIR = 0.61

Accuracy = **0.66**

Warning: Fitting and testing done on the same dataset; But results are already bad

## 2. Fitting models (Phase II - Improving predictors)

TFI Subscales



# Results

BAI vs (3 Emotional Subscales + TFI)

Pred BAI	0	1
0	47	39
1	26	57

NIR = 0.54

Accuracy = 0.63 → **0.66**

BDI vs (3 Emotional Subscales + TFI)

Pred BDI	0	1
0	62	34
1	21	70

NIR = 0.51

Accuracy = 0.68 → **0.70**

BAI & BDI vs (3 Emotional Subscales + TFI)

Pred BAI & BDI	0	1
0	84	30
1	20	53

NIR = 0.61

Accuracy = 0.66 → **0.73**

Warning: Fitting and testing done on the same dataset; But results are already bad

## 2. Fitting models (Phase III - Improving cut-off)

### **How BAI identify someone being emotionally disturbed**

The total score is calculated by finding the sum of the 21 items.

Score of 0-21 = low anxiety

Score of 22-35 = moderate anxiety

Score of 36 and above = potentially concerning levels of anxiety

### **How BDI identify someone being emotionally disturbed**

1-10 \_\_\_\_\_ These ups and downs are considered normal

11-16 \_\_\_\_\_ Mild mood disturbance

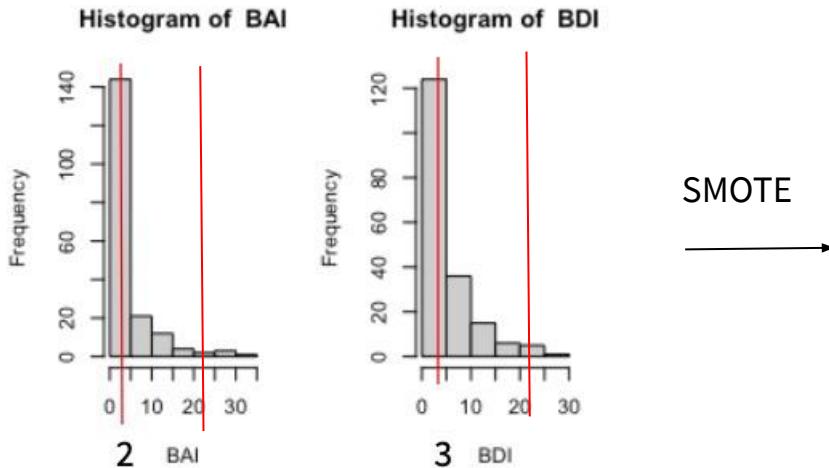
17-20 \_\_\_\_\_ Borderline clinical depression

21-30 \_\_\_\_\_ Moderate depression

31-40 \_\_\_\_\_ Severe depression

over 40 \_\_\_\_\_ Extreme depression

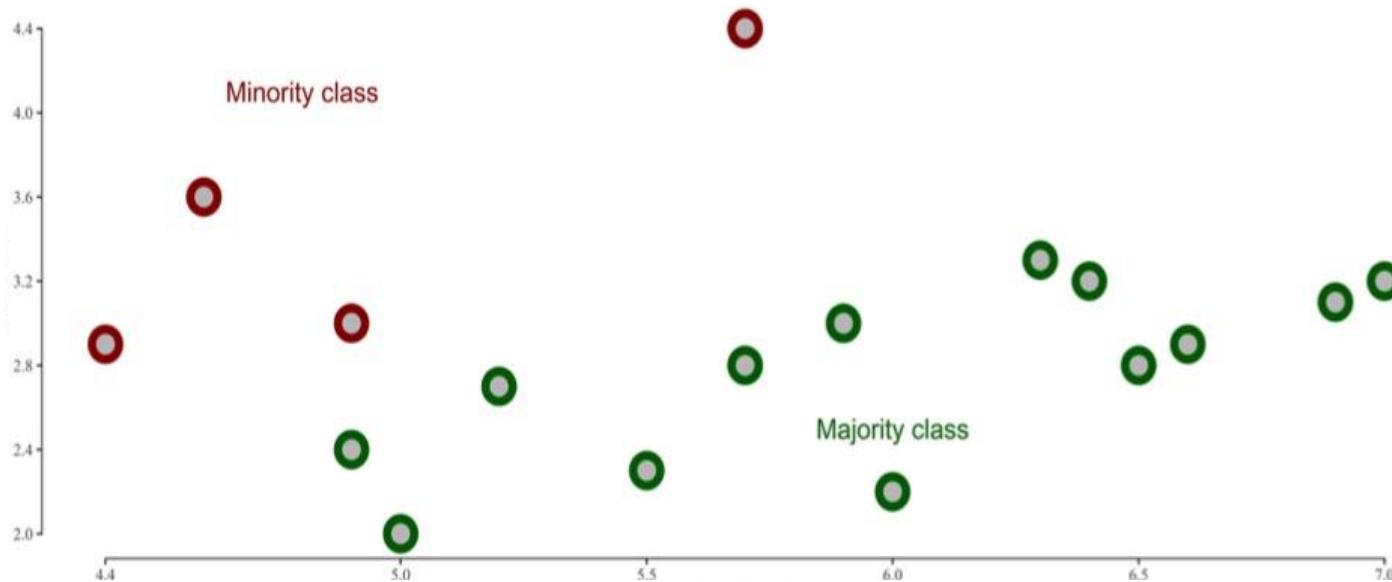
# Up Sampling



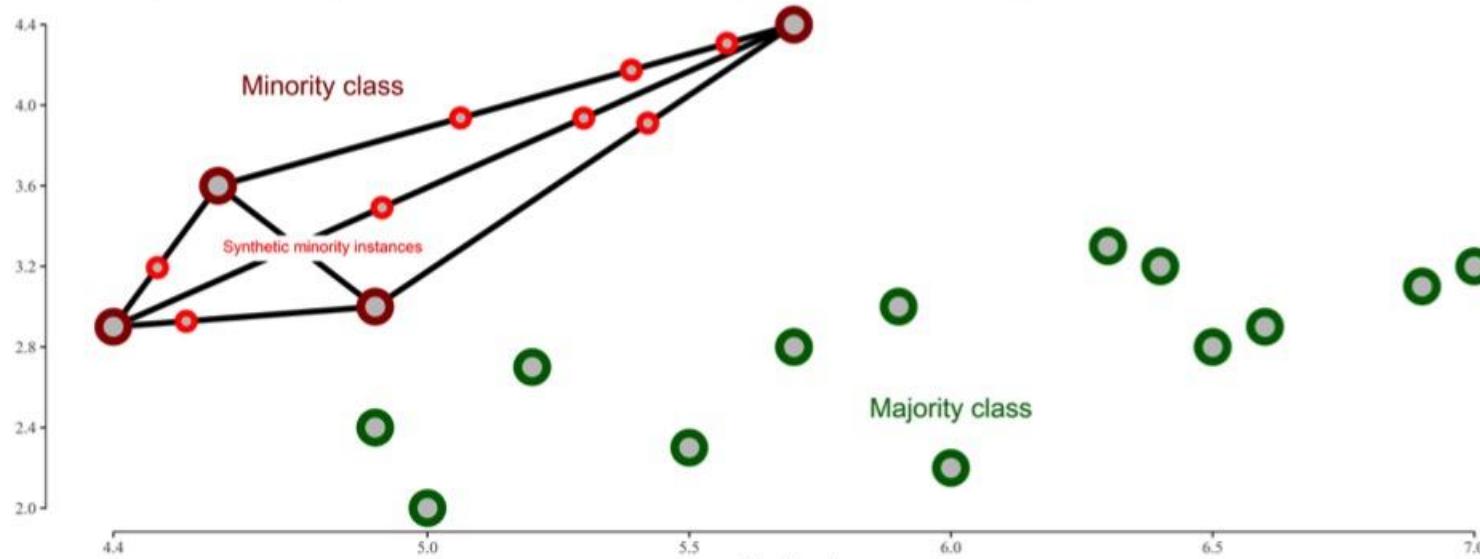
After upsampling BAI & BDI	
Value 0	Value 1
168	175

Before upsampling BAI & BDI	
Value 0	Value 1
13	174

# How SMOTE (Synthetics Minority Oversampling Technique) works



# How SMOTE (Synthetics Minority Oversampling Technique) works



# Results

BAI & BDI vs 3 Emotional Subscales

Pred BAI & BDI	0	1
0	129	40
1	36	138

NIR = 0.50

Accuracy = **0.79**

BAI & BDI vs (3 Emotional Subscales + TFI)

Pred BAI & BDI	0	1
0	178	2
1	18	163

NIR = 0.50

Accuracy = **0.89**

# Classification Summary

1. The result from classification after up-sampling looks promising
2. Logistic regression seems adequate
3. Including more variables other than 3 emotional subscales could help
4. Part of the data is not real. More real data needed, before making a solid conclusion

# Final Conclusion

*Shiwei Fu*

# Final Conclusion

Milestone 1: Which questionnaire is the best?

- TFI and TPFQ are good candidates
- TFI performs slightly better but is more complicated

Milestone 2: Is it possible to model the emotional disturbance by tunnus?

- Yes, it is possible
- Regression on BAI and BDI may not be useful, but classification methods are promising

# Questions?

Thank you for listening!

