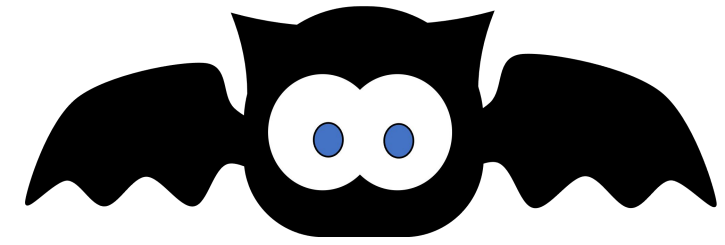


WPI



BATS: Development of a Biosignal Analysis Toolkit and Pipeline for Polytrauma Research

Nathan Draudt (BME), Claire Nicolas (BME),
Carlos Velasquez (CS), Lauren Wasserman (CS)



Contents

- I. Background
- II. Design Process
- III. BATS: Final System
- IV. Verification & Validation Testing
- V. User Testing: Demographics
- VI. Results
- VII. Conclusion
- VIII. Acknowledgments
- IX. Learn More

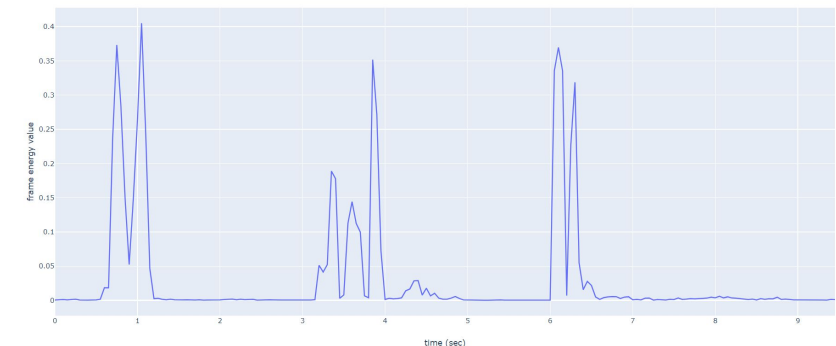
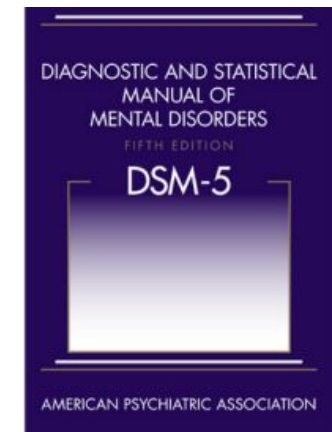
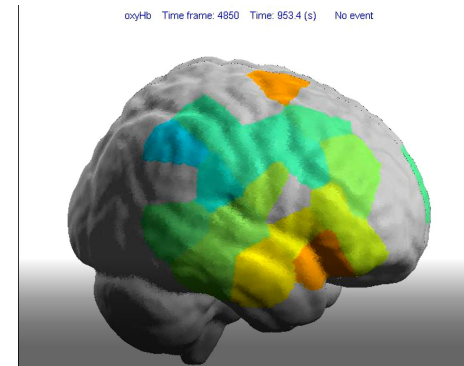


Background: What is Polytrauma?

— Comorbidities

- Post Traumatic Stress Disorder (**PTSD**)
- Major Depressive Disorder (**MDD**)
- Generalised Anxiety Disorder (**GAD**)
- Chronic Pain
- Postconcussive Syndrome (**PCS**)

— Diagnosis





Need Statement

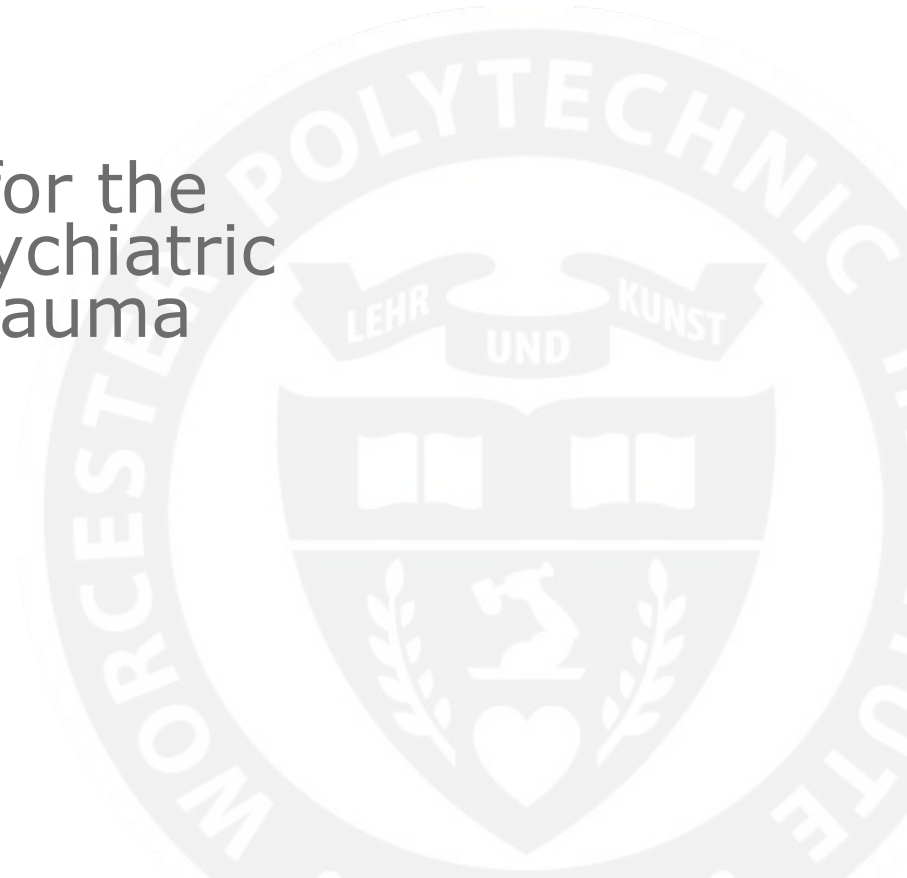
A way to improve data analysis and data storage for polytrauma researchers to facilitate multifaceted polytrauma research.





Goals

Develop a web-based pipeline that allows for the simultaneous analysis of biosignals and psychiatric evaluations to facilitate multifaceted polytrauma research.



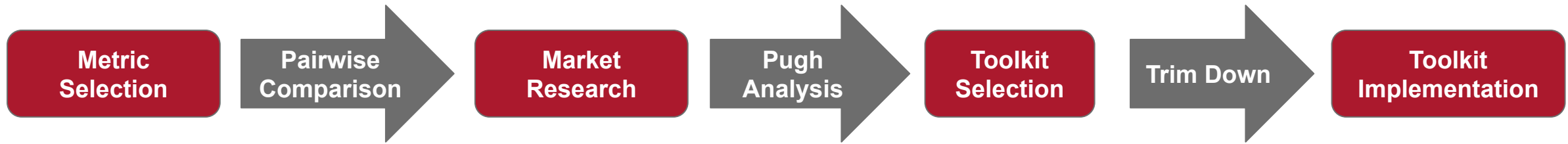


Design Process: Needs

- **Primary Stakeholders:** Researchers using BATS
- **Their Needs:**
 - Creative freedom to complete whatever analysis they choose
 - Have easy to read signal processing
 - Create biomarkers
 - Works with Matlab & Python code
- **General Needs:**
 - Create multi-signal analysis for easy diagnosis & tools
 - Save biodata in an online easily accessible database
 - Process data with biosignal algorithms and statistical tools within the tool
 - Allow for saving and reprocessing of datasets



Design Process: Algorithm Development



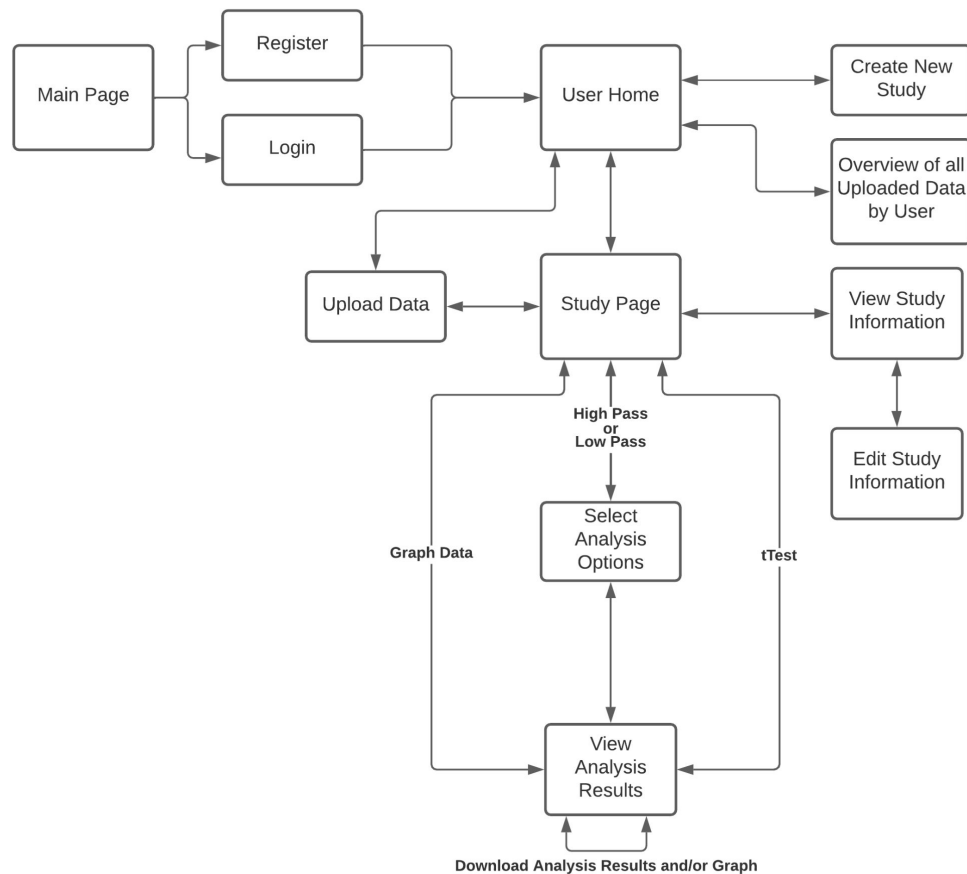
	Open Source	Easy Structure	Visualisation	Noise Reduction	Python	Java	Weighting
Open Source	x	1	1	1	1	1	5
Easy Structure	0	x	1	1	0	0	2
Visualisation	0	0	x	0	0	0	0
Noise Reduction	0	0	1	x	0	0	1
Python	0	1	1	1	x	0	3
Java	0	1	1	1	1	x	4

Table 1: Pairwise Comparison Chart for Toolkit Development



Design Process: System Development

Prototype 1: Flow Diagram



Prototype 2: Low Fidelity BATS Study Page

DATA			
Name of data	Last Modified	By...	Data Type
ID 0012-Vocal	9/13/21 10AM	NDraudt	.mvm
ID 0012-EEG	7/1/21 10AM	Claire	.raw

Add new data

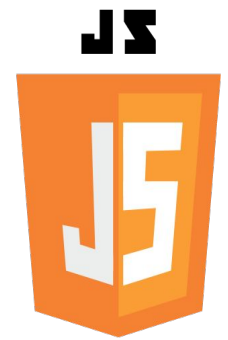
People w/ access: NDraudt; Claire; LauWes; CarlosV +



BATS: Technology



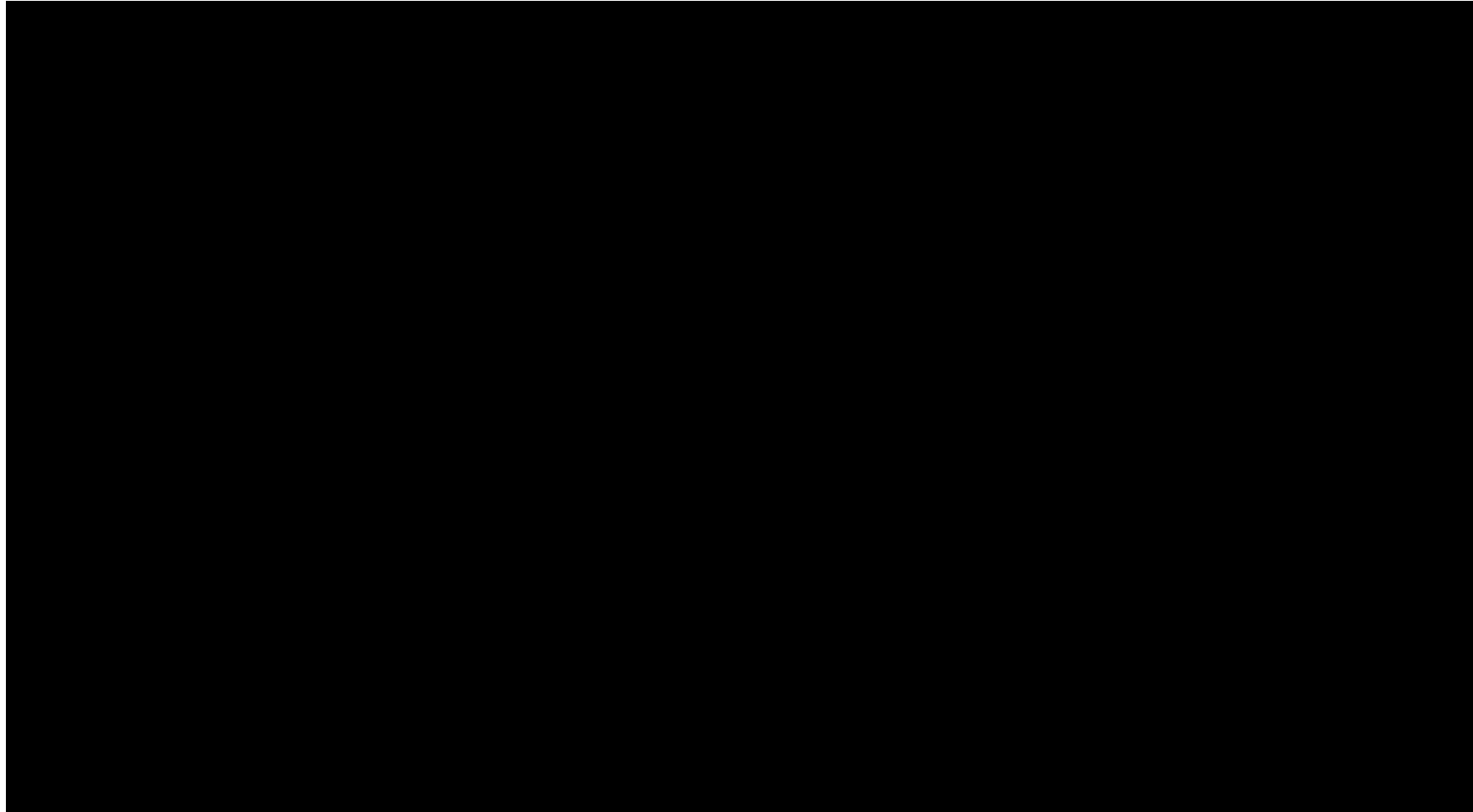
Backend



Frontend



BATS: Login & Registration





BATS: Final System

The screenshot displays the BATS web application interface. At the top, there is a navigation bar with links for 'Home', 'About', and 'View Data' on the left, and 'Help & Support' and 'Logout' on the right. Below the navigation bar, a 'Welcome User' message is shown, followed by two buttons: 'New Study' and 'Add New Data'. The main content area is titled 'Studies' and includes a sub-link 'Click on a row to view a study'. A table lists two studies:

Study Name	Abstract	Creator	Study Contact	Institutions Involved	Is IRB Approved	Visibility
BATS User Study	To assess BATS, our team decided to conduct a user study that simulates ways in which a user would use the application and assess the usability and effectiveness of our system for a wide variety of potential users.	User	BATS Team	WPI	yes	yes
Modeling of Speech Patterns of Adults with Major Depressive Disorder	The goal of this study is to confirm that there is a speech pattern in people with diagnosed MDD and those without.	User	MDD Team	WPI	yes	yes

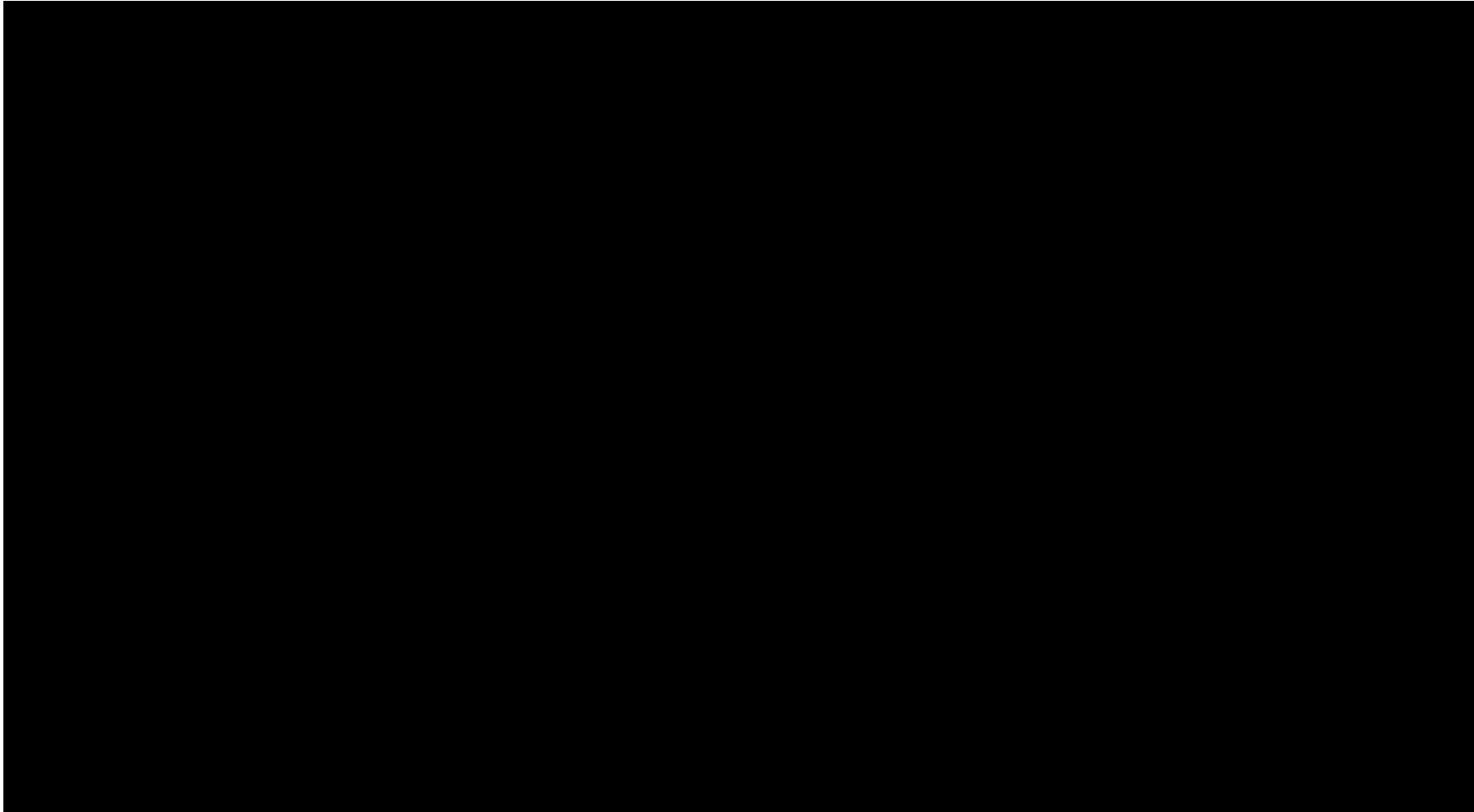
Below the 'Studies' section, there is another navigation bar with 'Home', 'About', and 'View Data' on the left, and 'Help & Support' and 'Logout' on the right. The main content area is titled 'BATS User Study' and includes three buttons: 'Back', 'View Study Info', and 'Add New Data'. The 'Data' section is titled 'Data' and includes a sub-link 'Click on a row to graph its data'. A table lists three data entries:

Name of Data	Filename	File Extension	Data Type
T_Test_Data	test_d	csv	Log Data
Collected From Audio	test_d	csv	Log Data
Wave Data	Test_Wave	csv	Speech

The 'Analysis Tools' section is titled 'Analysis Tools' and includes a sub-link 'To use an analysis tool, click on one from the below toolkits'. Two toolkits are listed: 'Graphing Toolkit' and 'Statistical Toolkit'. At the bottom of the page, there is a footer with 'BATS 2022' on the left and the WPI logo on the right.



BATS: Uploading New Data





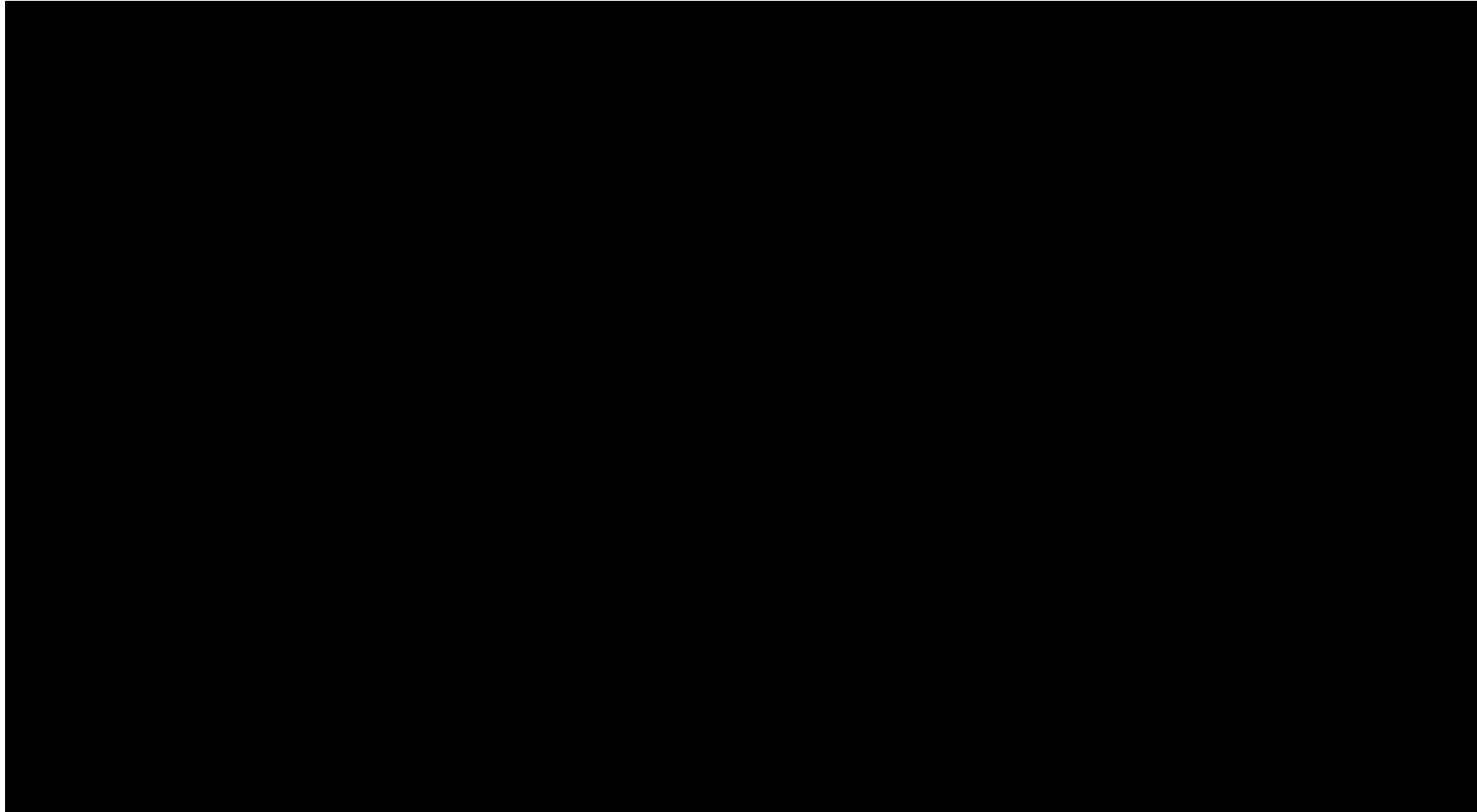
BATS: Available Analysis Tools

Graphing Toolkit			
Name	Description	For File Type	For Data Type
Graph CSV Data	Produces a graph from .csv data.	.csv	All
High Pass Filter	Filters out unwanted low frequencies.	.csv	All
Low Pass Filter	Filters out unwanted high frequencies.	.csv	All

Statistical Toolkit			
Name	Description	For File Type	For Data Type
tTest	Determines if there is a statistical different between the mean of two groups.	.csv	All



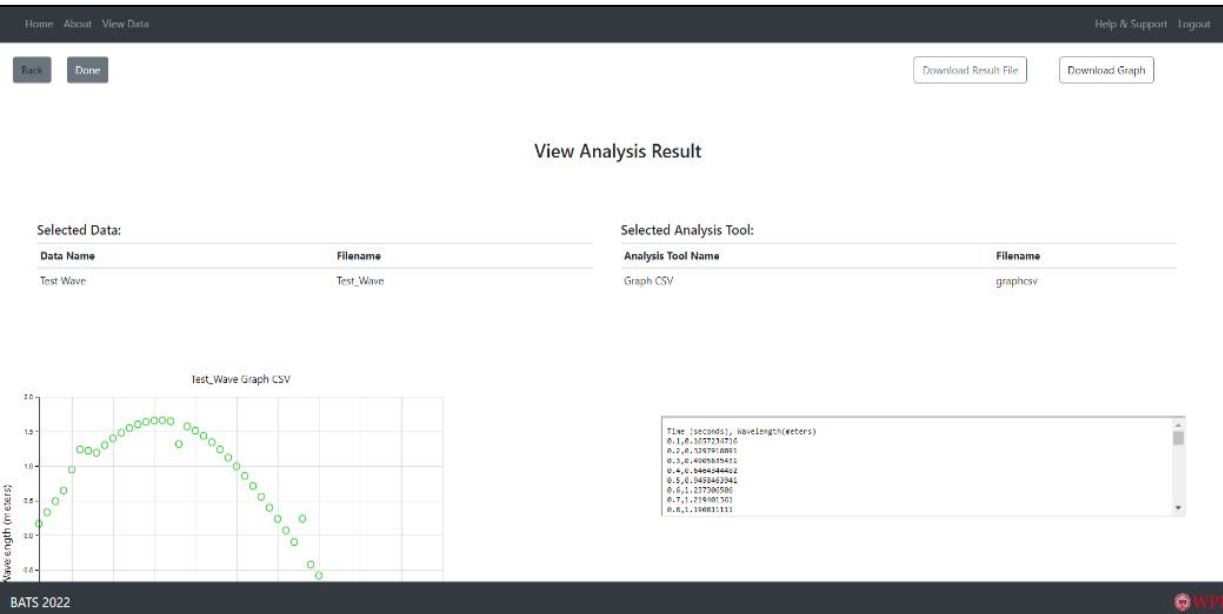
BATS: Analysis Results



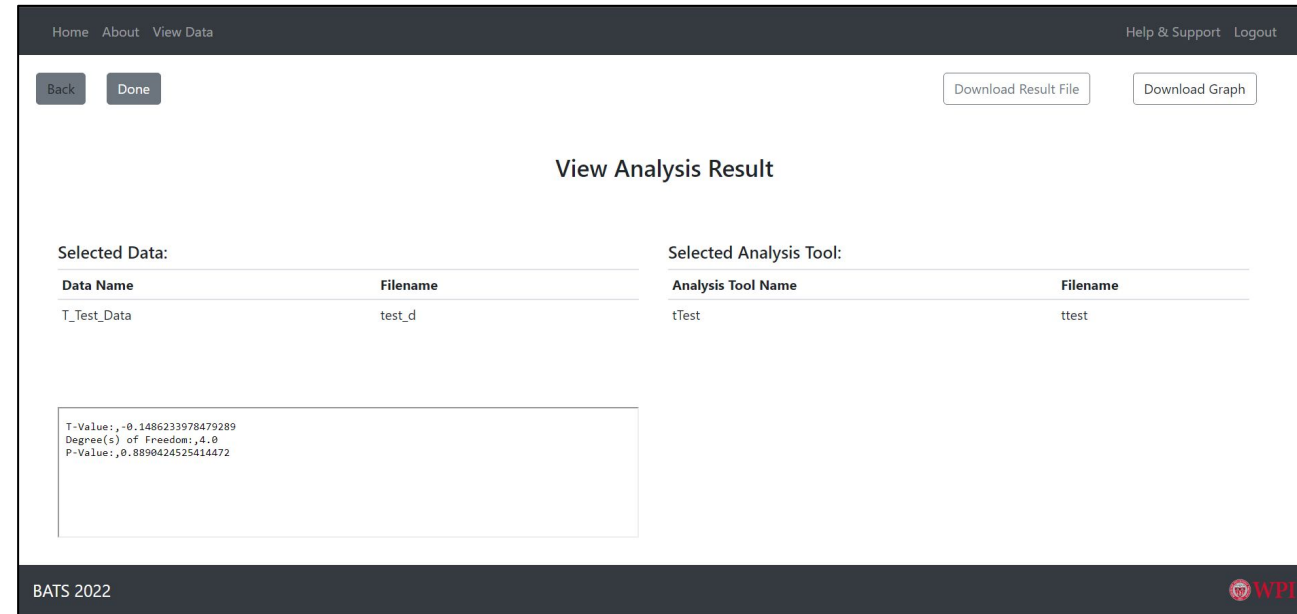


BATS: Final System (Continued)

Analysis Results



Graph CSV



tTest



BATS: Final System (Continued)

Prototype analysis toolkits



BATS: User Home & Study Page



Verification & Validation Testing

User Stories:

- Confirms system's ability to complete various activities
- Follows a hypothetical user via written narrative
- Tested:
 - Account Creation
 - Data uploading
 - Analyzing data
 - Analysis viewing
 - Downloading data

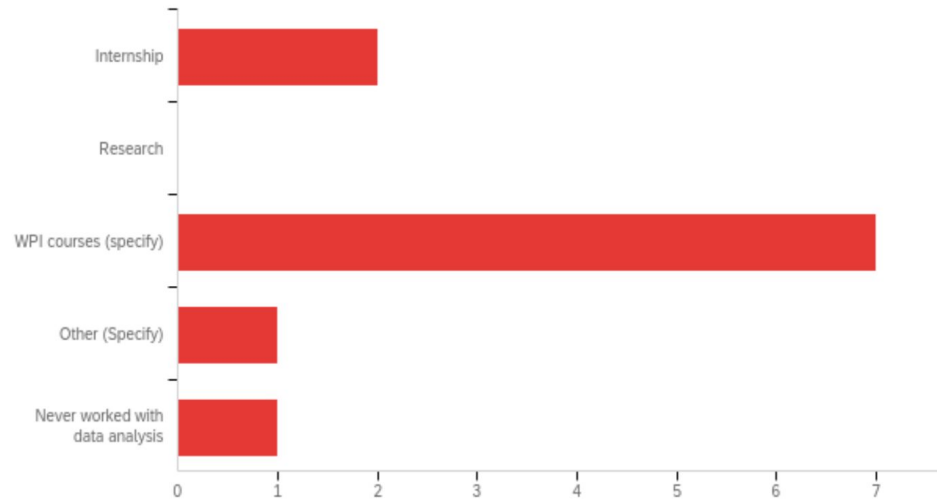
User Study:

- IRB approved
- Think-aloud and interview
- Scenarios:
 - Scenario 1:
 - Account creation
 - Study creation
 - Upload data
 - Scenario 2:
 - Graph data
 - Scenario 3:
 - Analyse data with tool
 - Downloading
- Interviews between each scenario

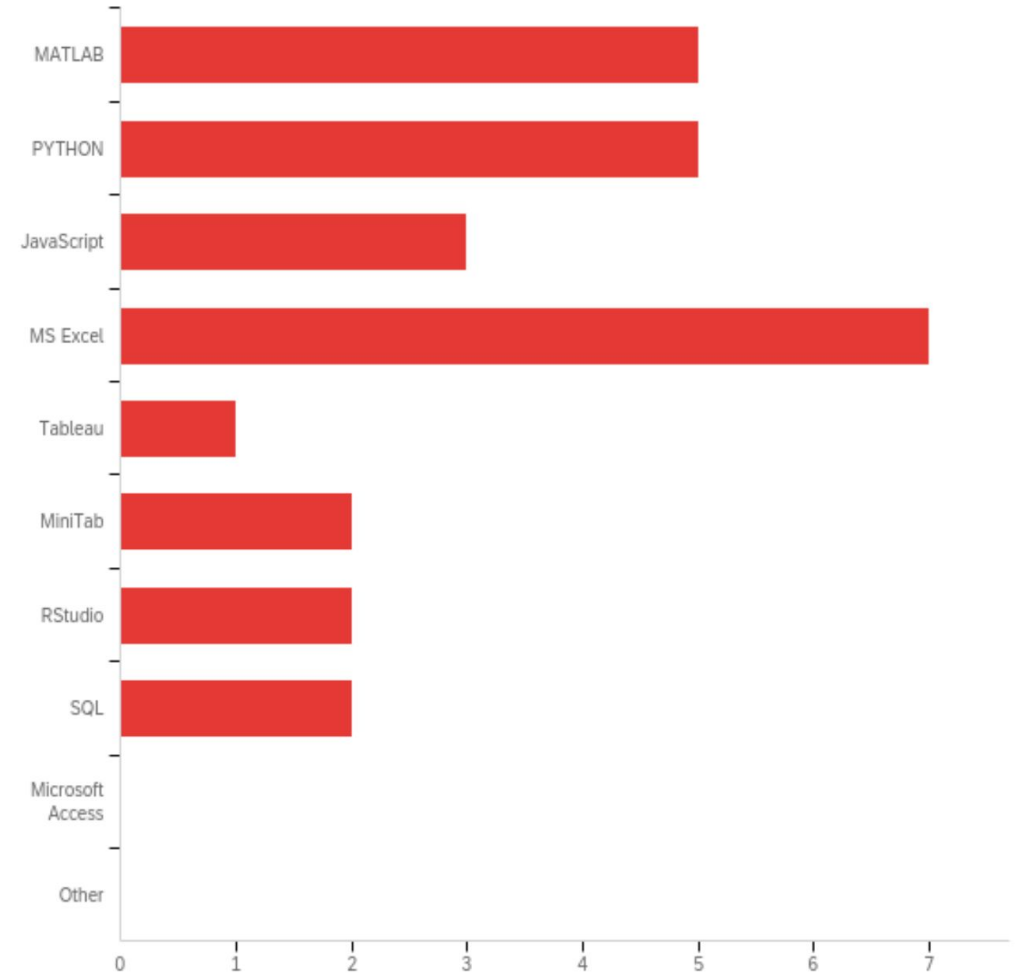


User Testing: Demographics

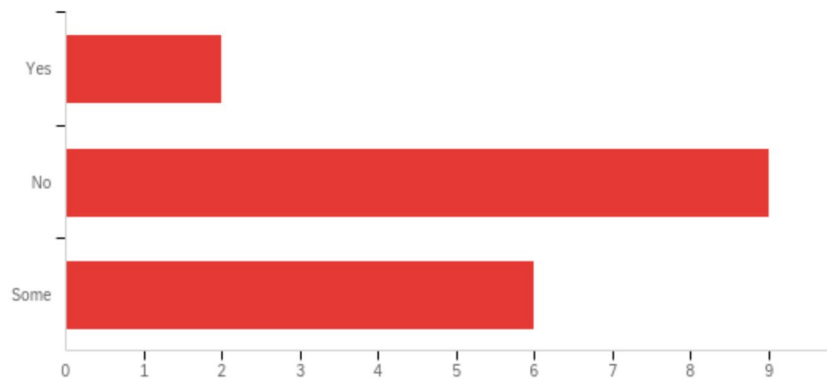
In what environment have you gained your data analysis experience?



Which of the following tools do you have experience with?

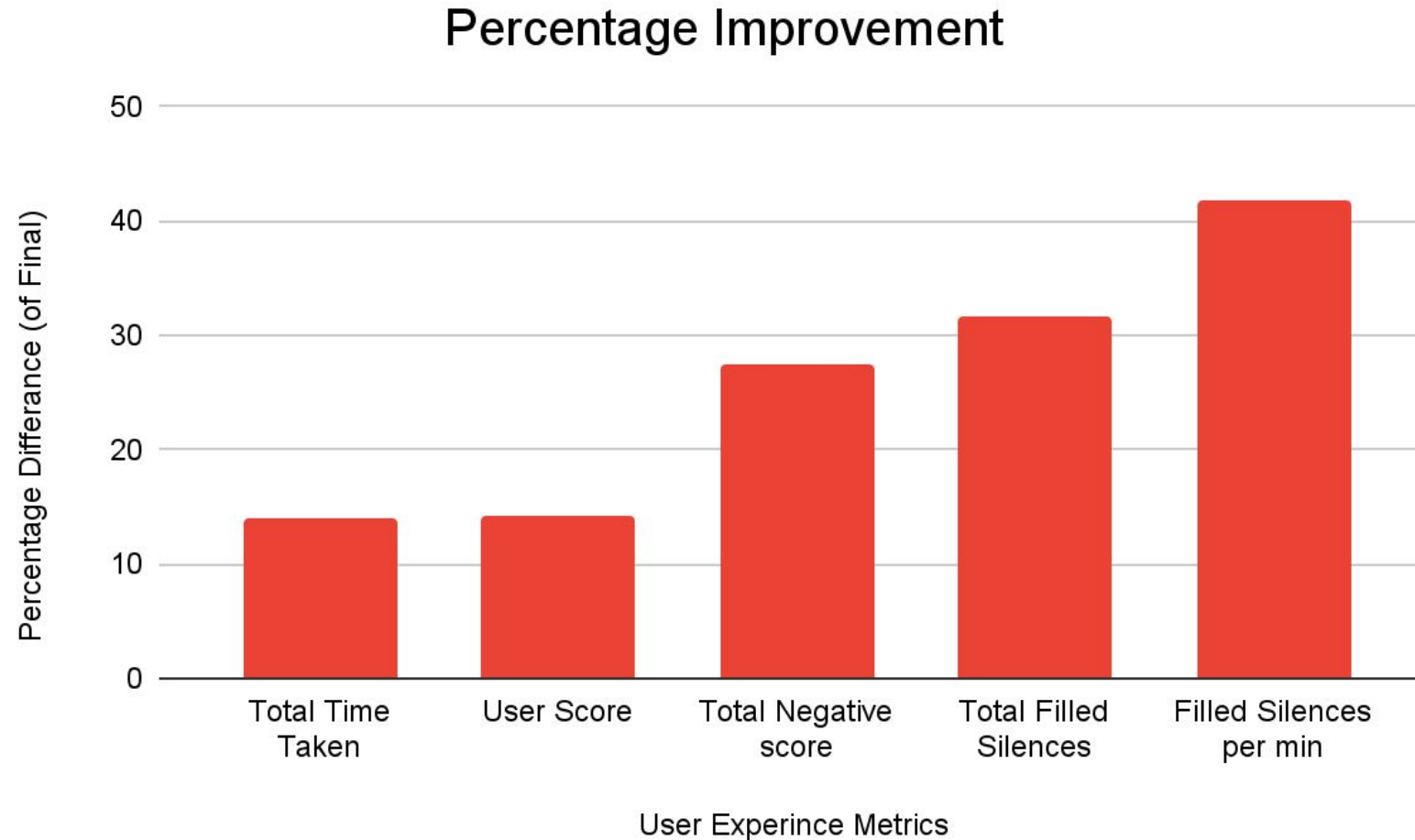


Do you have experience in data analysis?





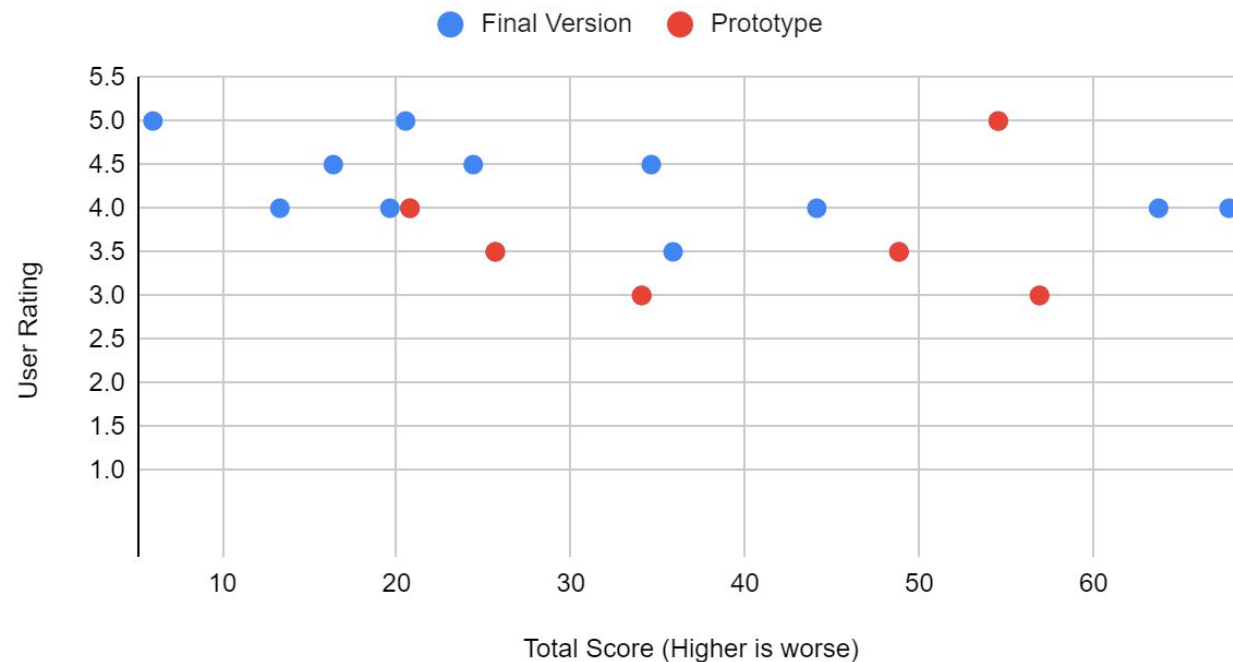
General Overview of Results





User Testing Results: Usability Score vs TNS

User Rating Vs Total Score

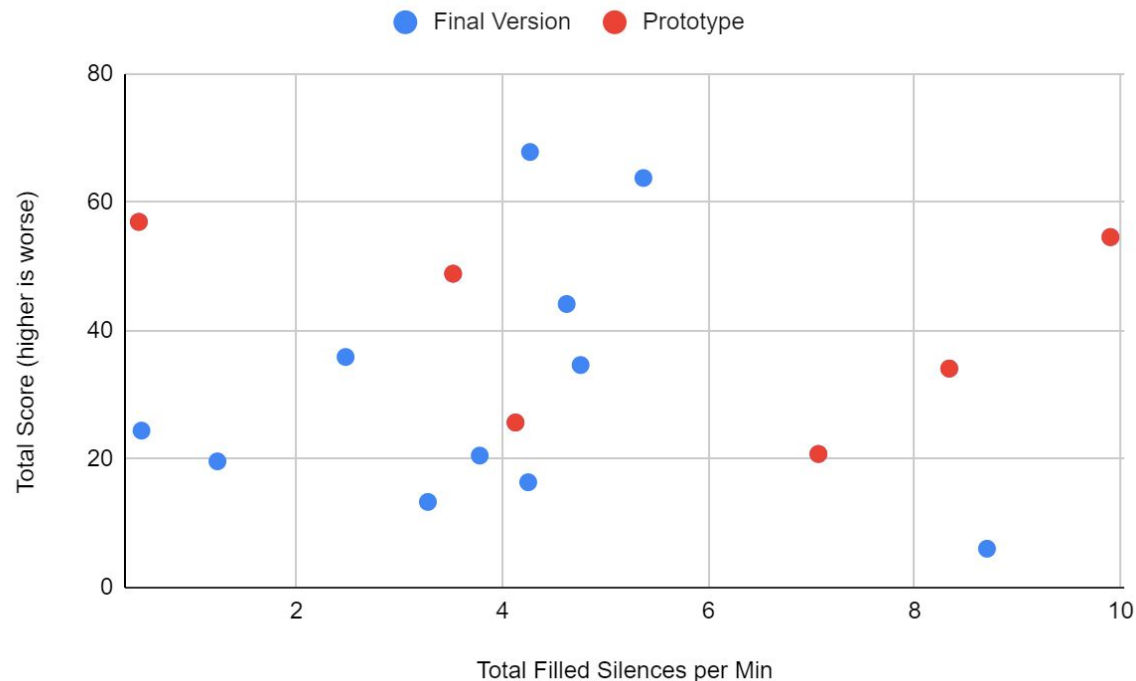


- Total Negative Score = time taken + 4(num questions asked) + 10(num tasks failed)
- User score = user ranking of the system [1, 5]
- $r(9) = -0.511$ $p = 0.0539$
- Users ranked the system low when they failed more



User Testing Results: Filled Silences

Total Score vs Total Filled Silences per Min



- Research shows that filled silences (um, ahh) correlate with higher mental load
- A positive correlation between Filled silenced per minute and Total Negative score would indicate successful use of these metrics
- With a correlation test result of $r(8)=0.509$ $p=0.0663$



Conclusion

- Functioning System Objectives
- User friendly (Improvements upon Prototypes)
- Interdisciplinary Learning
- Foundation for Future Works



Acknowledgments

- We would like to thank our advisors:
 - Adam Lammert
 - Mark Claypool
- Dr. Jean King, Anna Bean, Alicia Howell-Munson amongst others.
- The people who participated in our user study.



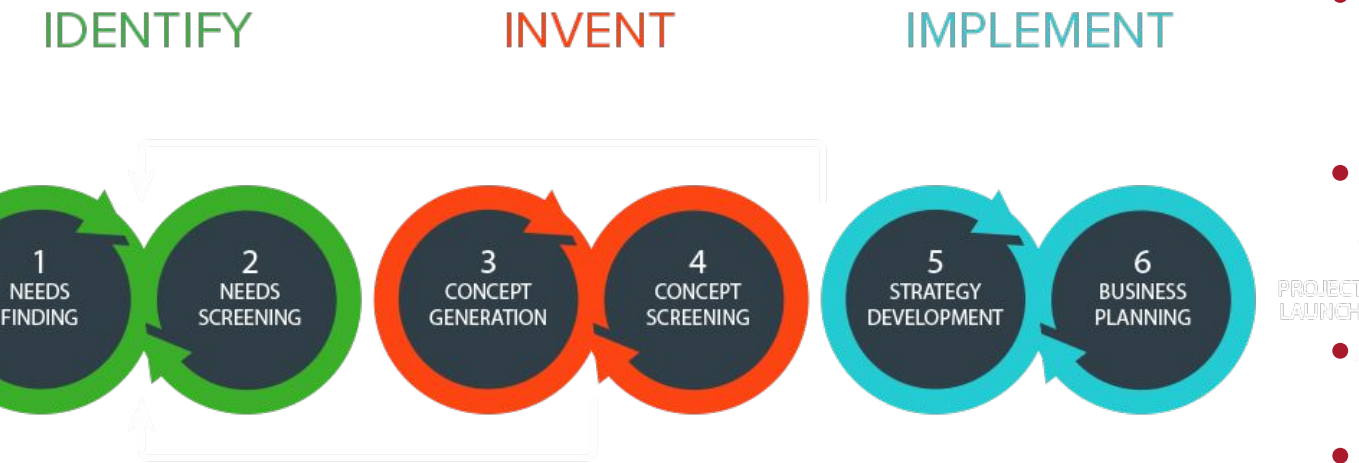
Learn more

To view our bibliography, learn more about the system, and watch BATS in action, please scan the QR code.





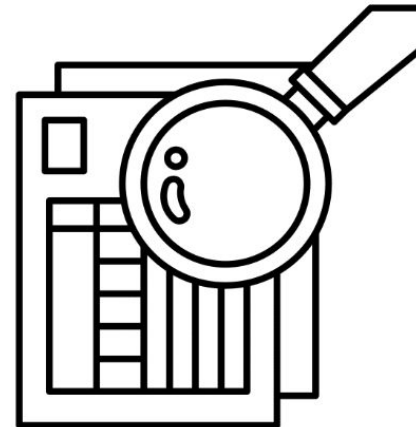
Layout: Two Content



- First level bullet, Verdana 22pt
- Line spacing 0.95, before paragraph 10pt

PROJECT LAUNCH

-
-
-



et color is

ullet




Layout: Title and Content

Verdana Bold 32pt


- First level bullet text, Verdana 24pt
- Line spacing 0.95, before paragraph 12pt
- Left justified
- Sentence case
- First level bullet color is accent1
 - Second level bullet Verdana 20pt
 - Line spacing 0.95, before paragraph 6pt
 - Third level
 - Third level
 - Fourth level




Color Scheme


 White-Background
R255 G255 B255


 Black
R0 G0 B0


 Red
R171 G25 B45


 Grey
R109 G109 B109

 Accent 1
R171 G25 B45

 Accent 2
R178 G183 B187

 Accent 3
R44 G106 B140

 Accent 4
R183 G160 B121

 Accent 5
R70 G160 B220

 Accent 6
R109 G109 B109



Contents

- First level bullet text, Verdana 24pt
- Line spacing 0.95, before paragraph 12pt
- Left justified
- Sentence case
- First level bullet color is accent1
 - Second level bullet Verdana 20pt
 - Line spacing 0.95, before paragraph 6pt
 - Third level
 - Third level
 - Fourth level



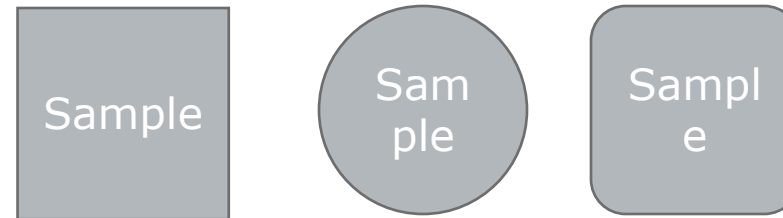
Default Settings

Theme Fonts:
Verdana (heading)
Verdana (body)

Text Box Default:
Verdana 16pt
Color: Black
Align: Center
Line Spacing: Multiple .95
Space Before: 6pt

*For labels only – use layout
placeholders for bulleted lists*

Drawing Style Default:



Line Style Default:





Default Table Style

Heading 1	Heading 2	Heading 3	Heading 4	Heading 5
Content	Content	Content	Content	Content
Content	Content	Content	Content	Content
Content	Content	Content	Content	Content
Content	Content	Content	Content	Content



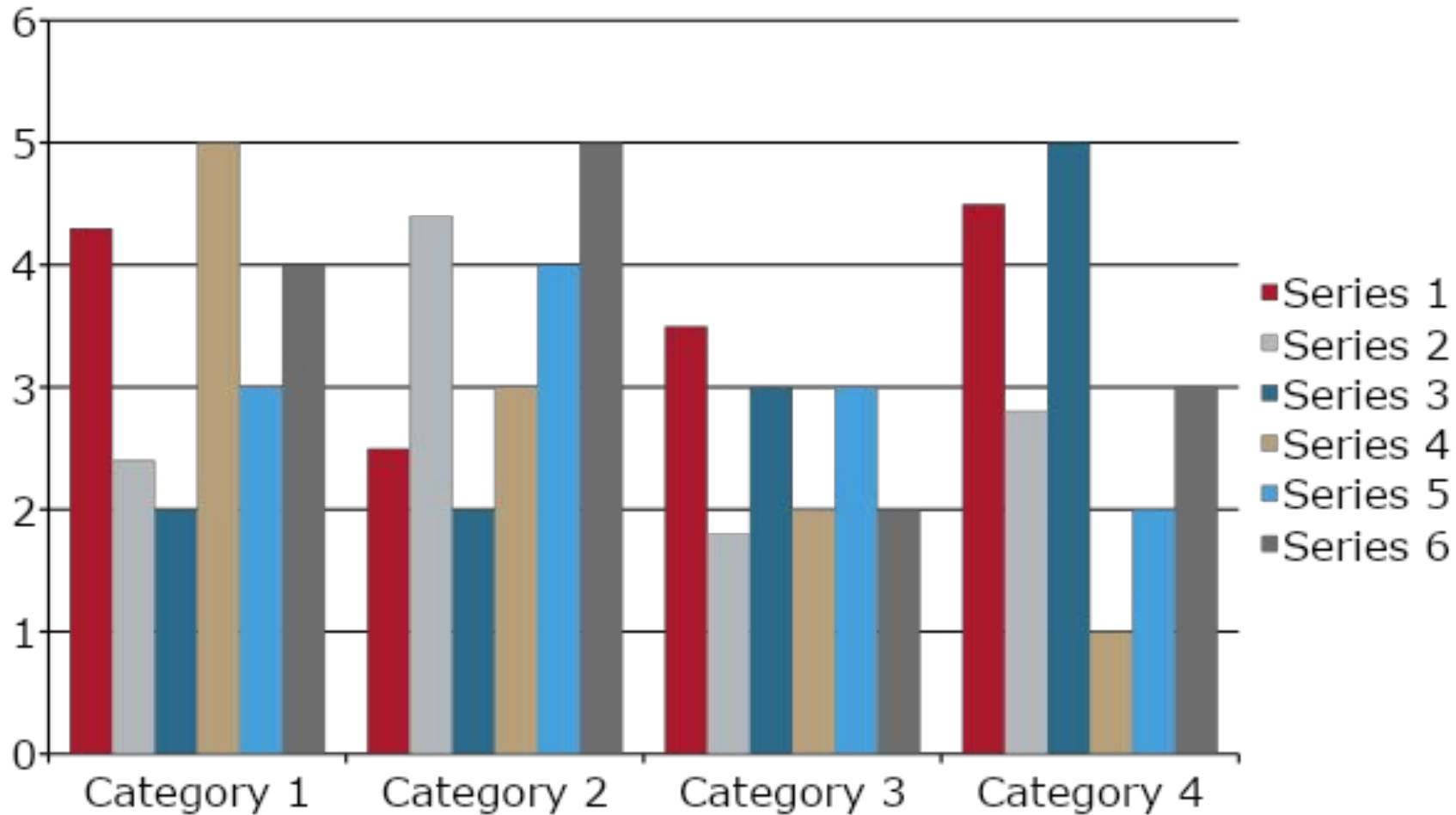
Layout: PhotoCaption



Photo description

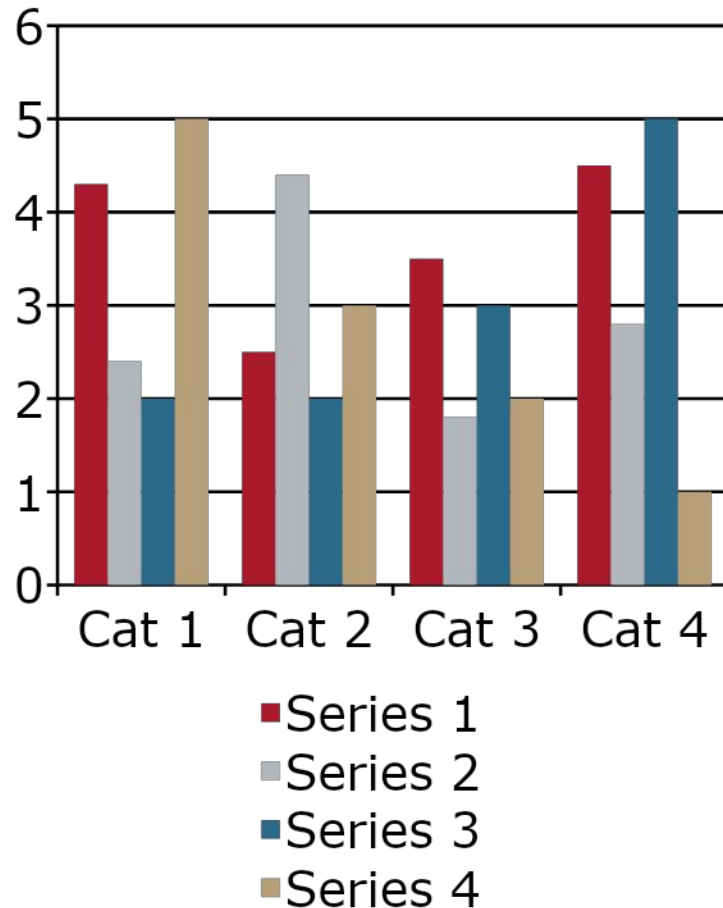
Layout: Content

Column Chart Sample



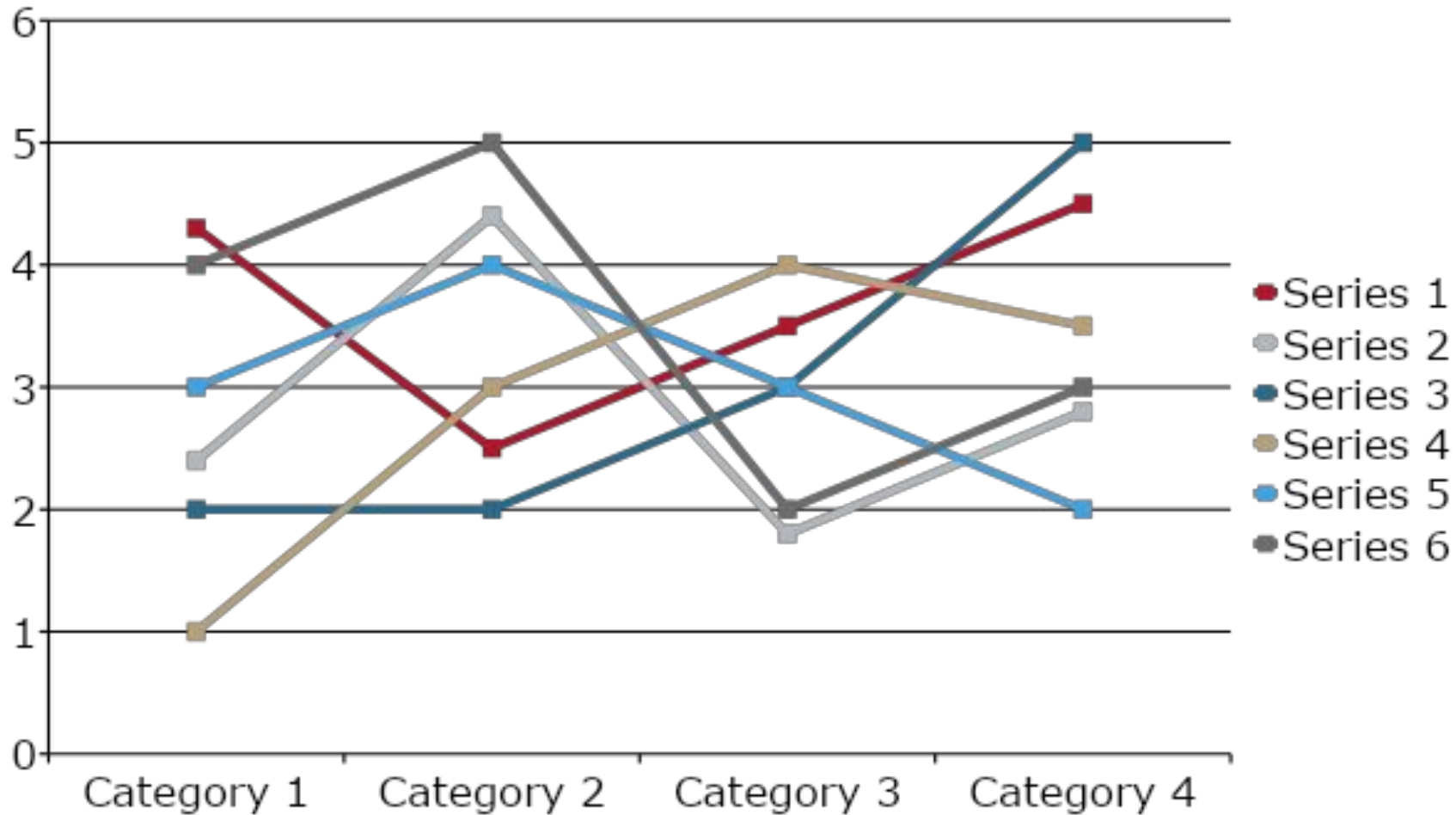


Layout: Two Content Column Chart Sample



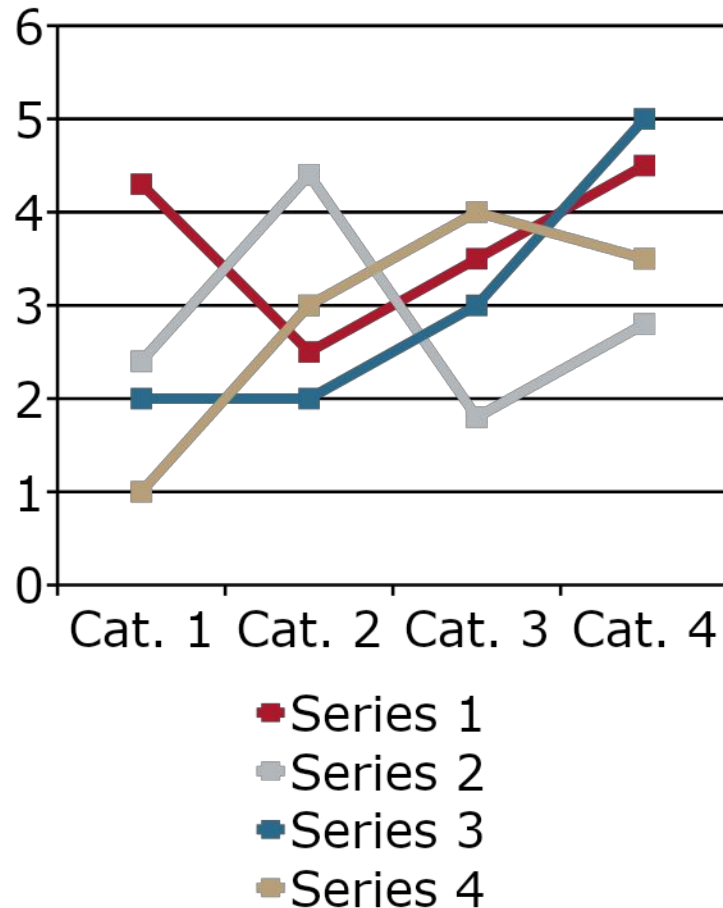
- First level bullet text
- Line spacing 0.95, before paragraph 12pt
- Left justified
- Sentence case
- First level bullet color is accent 2
 - Second bullet level
 - Line spacing 0.95, before paragraph 6pt

Layout: Content Line Chart Sample



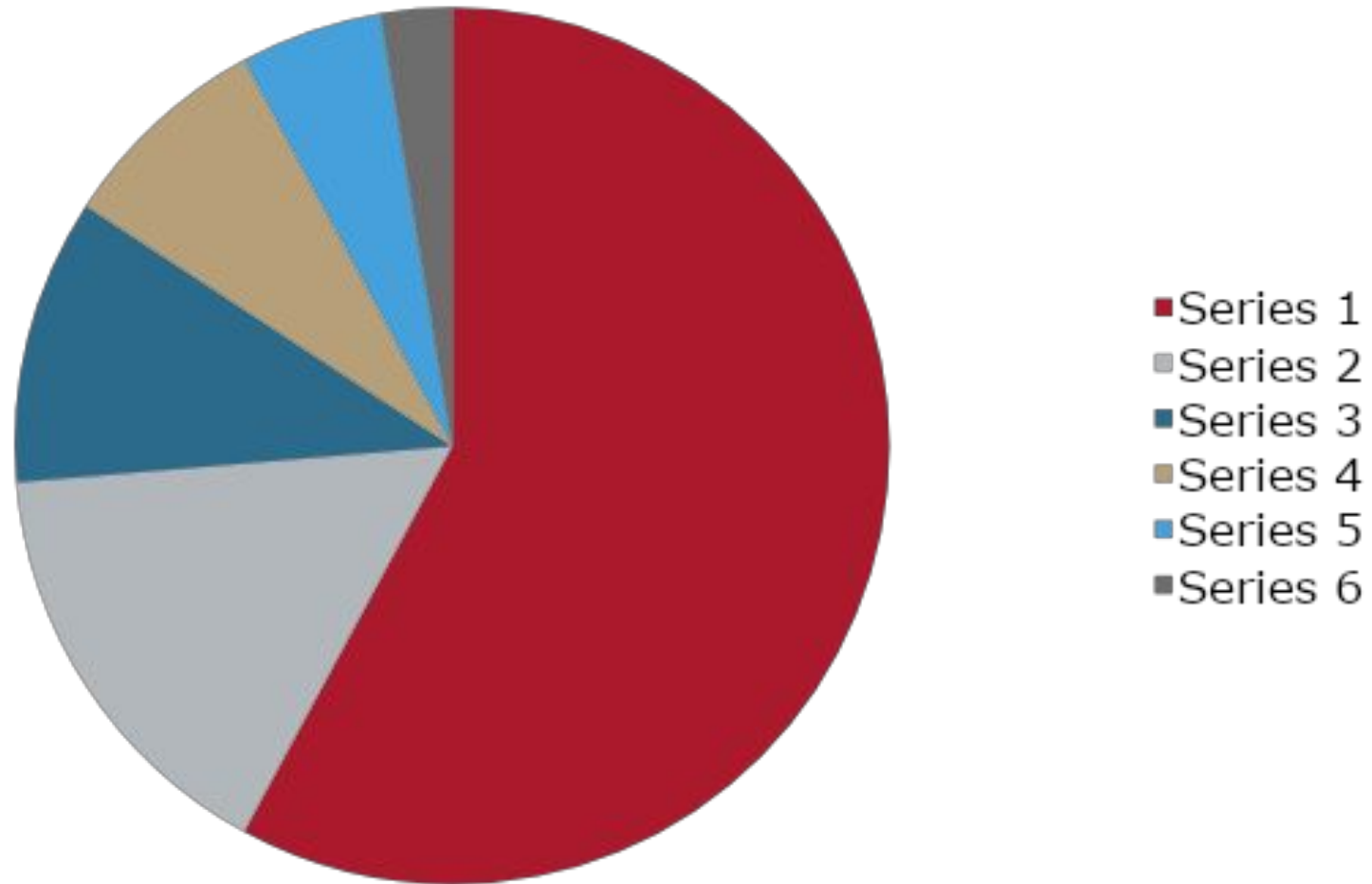


Layout: Two Content Line Chart Sample

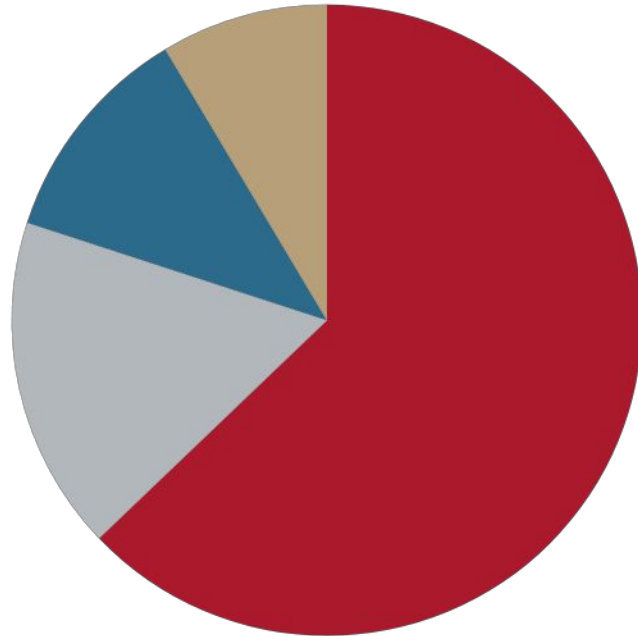


- First level bullet text
- Line spacing 0.95, before paragraph 12pt
- Left justified
- Sentence case
- First level bullet color is accent 2
 - Second bullet level
 - Line spacing 0.95, before paragraph 6pt

Layout: Content Pie Chart Sample



Layout: Two Content Pie Chart Sample



- Series 1
- Series 2
- Series 3
- Series 4

- First level bullet text
- Line spacing 0.95, before paragraph 12pt
- Left justified
- Sentence case
- First level bullet color is accent 2
 - Second bullet level
 - Line spacing 0.95, before paragraph 6pt