

# Understanding Data Accessibility for People with Intellectual and Developmental Disabilities (IDD)

**Keke Wu, Emma Petersen, Tahmina Ahmad,  
David Burlinson, Emily Shea Tanis, Danielle Albers Szafir**



# Accessibility

# Disability



# Accessibility by Disability



VISUAL



AUDITORY



MOTOR



COGNITIVE

# Data Visualization Accessibility



most researched

VISUAL



AUDITORY



MOTOR



COGNITIVE

# Data Visualization Accessibility



most researched

VISUAL



AUDITORY



MOTOR



largest population

COGNITIVE

# Data Visualization

**Data visualization** is the graphical representation of information and data. By using visual elements like charts, graphs, and maps, data visualization tools provide an accessible way to see and understand trends, outliers, and patterns in data.

# Data Visualization

**TL;DR**

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#1 Visualization is a cognitive tool.

# Data Visualization

**TL;DR** Data visualization is the graphical representation of information and data elements like charts, graphs, and maps, data tools provide an accessible way to see and understand trends, outliers, and patterns in data.

**#1 Visualization is a cognitive tool.**

**#2 Using visualization requires a good mastery of numeracy, graphicacy, and data & vis literacy.**

# Data Visualization

Data visualization is the graphical representation of information, graphs, and **Visualize the invisible!** arts, way to see and understand trends, outliers, and patterns in data.

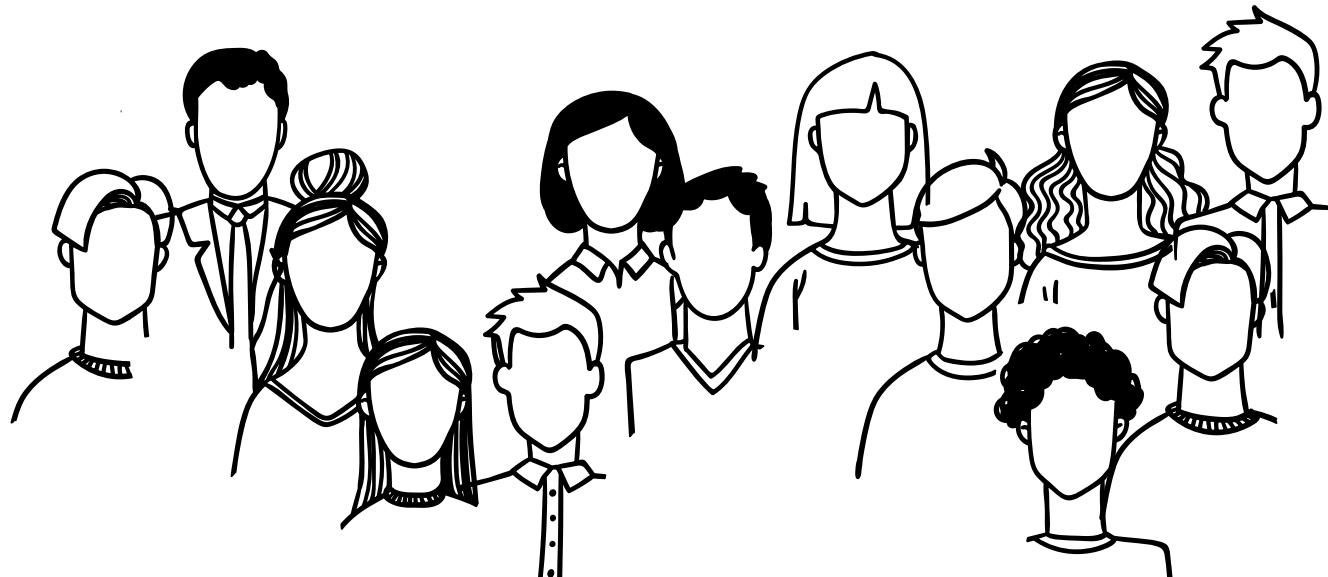
# Understanding Data Accessibility for People with Intellectual and Developmental Disabilities (IDD)



1,000,000,000



15 % of the  
population



1 in 6 children  
in the US



# What is IDD?



Related to Thought Process

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Related to Thought Process

Intellectual Functioning (e.g., reasoning, learning, problem-solving)

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Adaptive Behavior (e.g., social & practical skills)

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## People with IDD

# What is IDD?



## Related to Thought Process

Intellectual Functioning (e.g., reasoning, learning, problem-solving)

Adaptive Behavior (e.g., social & practical skills)



## People with IDD

Struggle with abstract thinking, spatial reasoning

# What is IDD?



## Related to Thought Process

Intellectual Functioning (e.g., reasoning, learning, problem-solving)

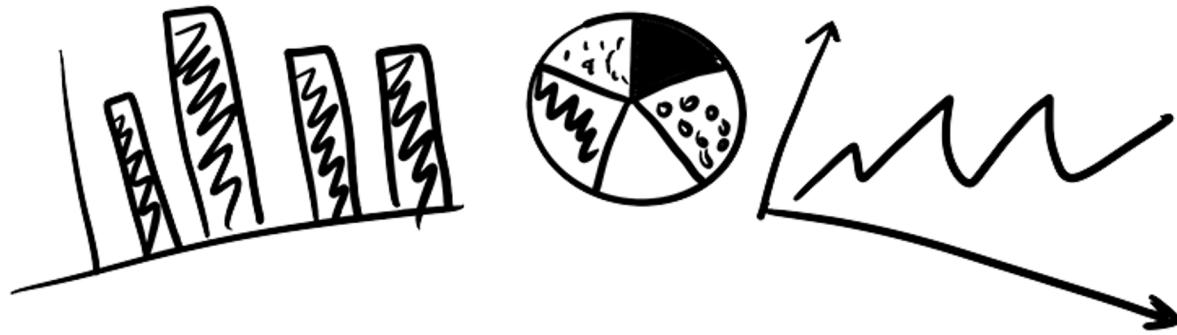
Adaptive Behavior (e.g., social & practical skills)



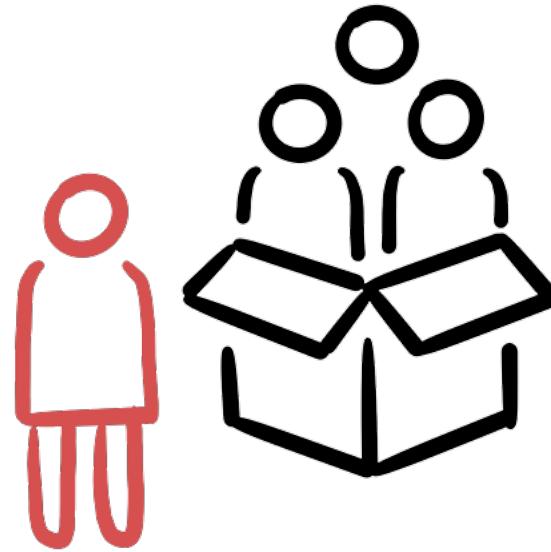
## People with IDD

Struggle with abstract thinking, spatial reasoning

Have limited exposure to mathematical & statistical training



People with IDD been Excluded from  
Data Visualization



People with IDD been Excluded from  
Data Visualization

**Access to data is...**

# **Access to data is...**

A basic human right

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A basic human right

The prerequisite for decision-making  
& independent living

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The prerequisite for decision-making  
& independent living

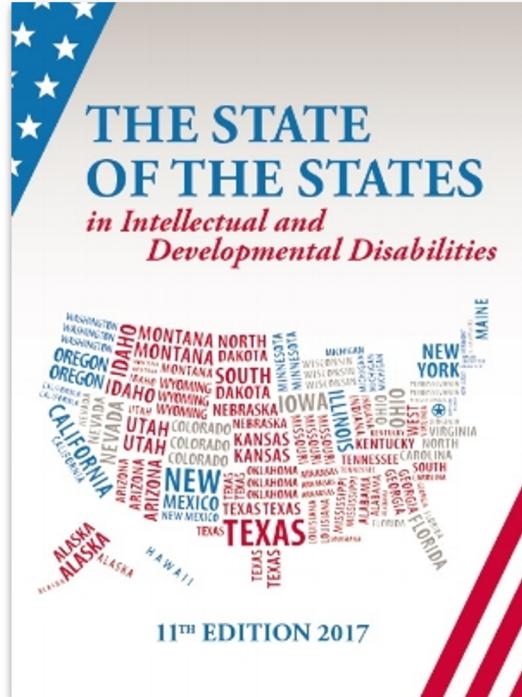
The key to social participation & self-advocacy

# Access to data is...

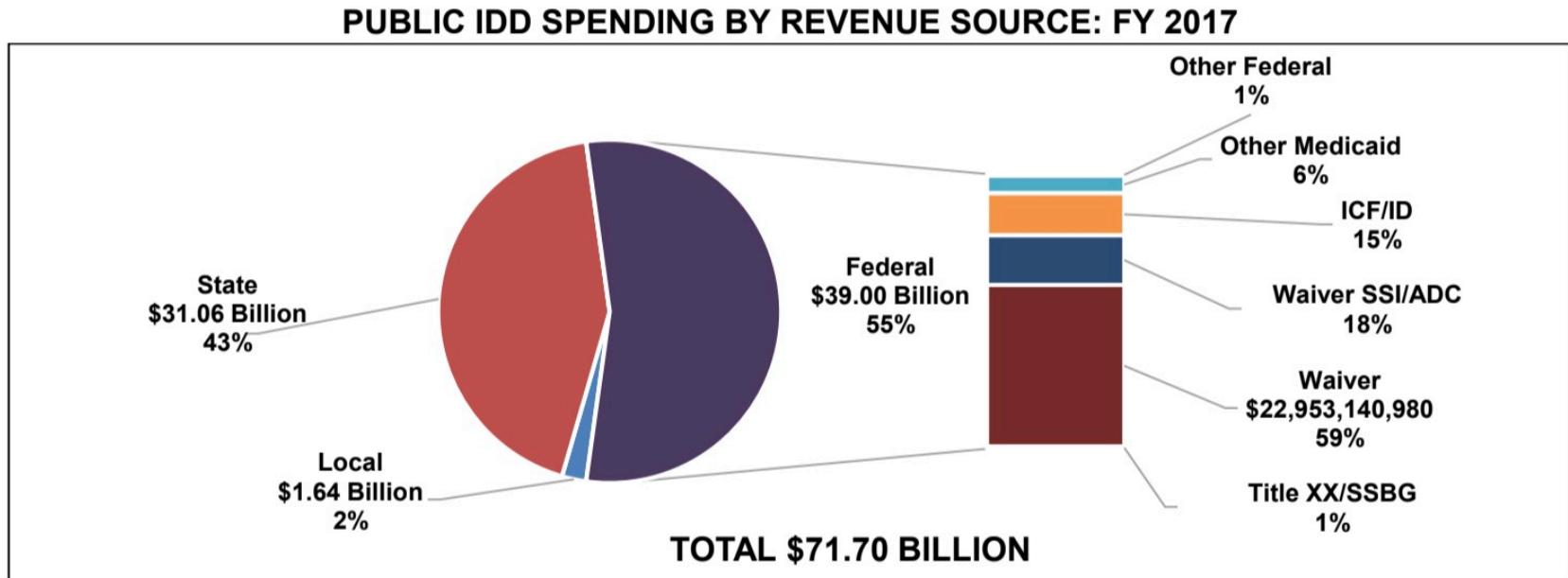
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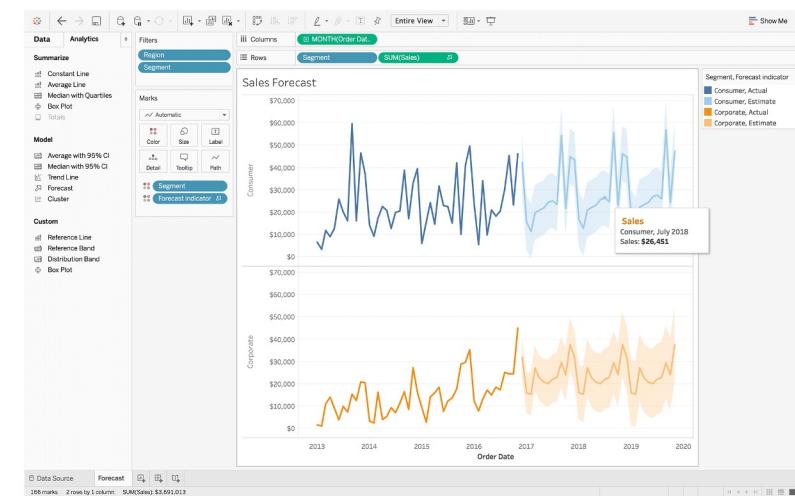
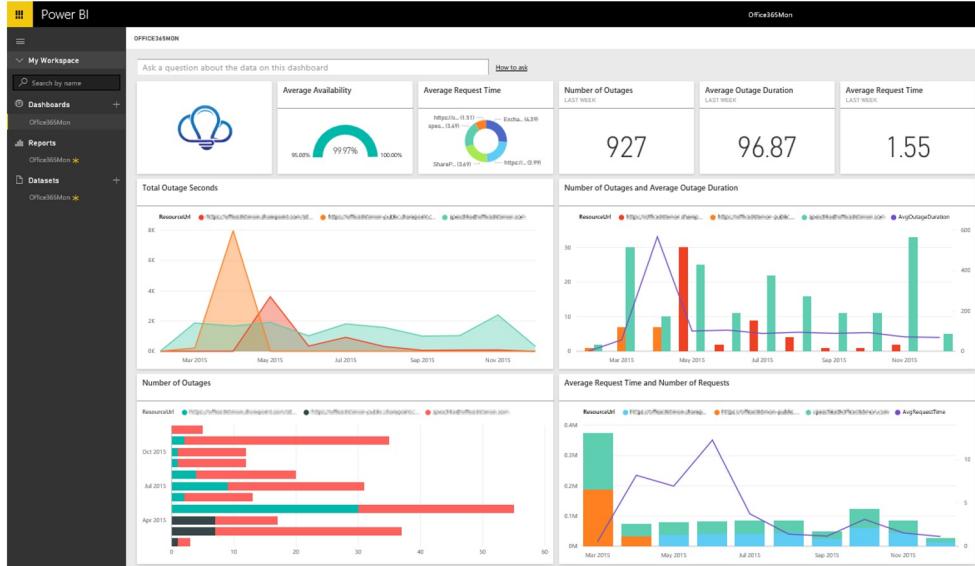
The key to social participation & self-advocacy



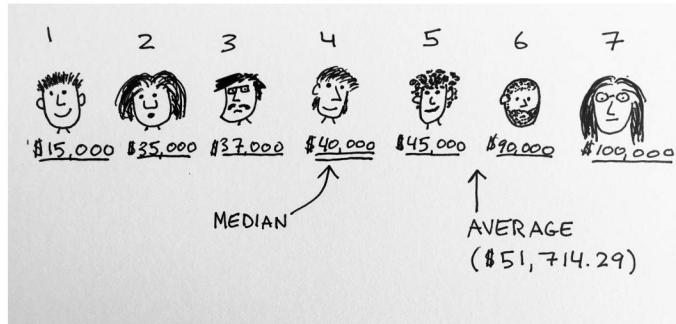
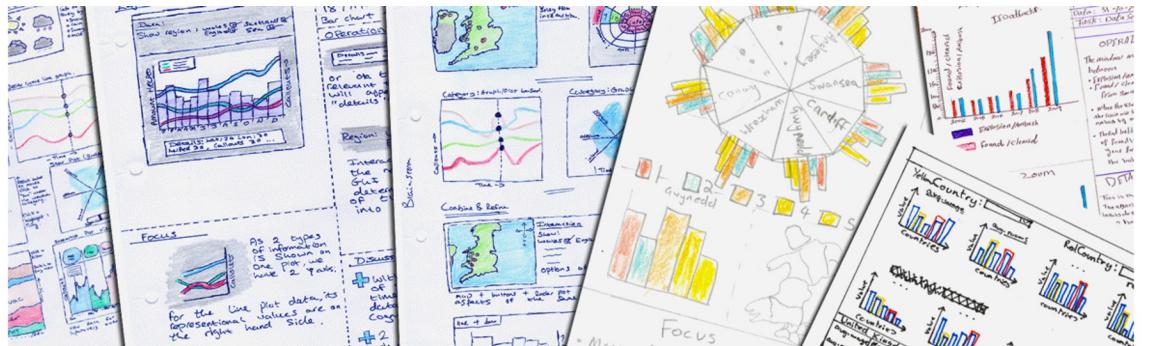
# Access to data is...



# Tableau / Power BI



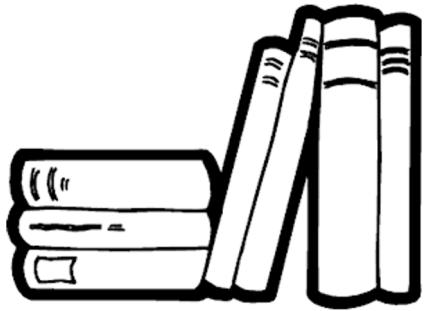
# Paper-based Sketch



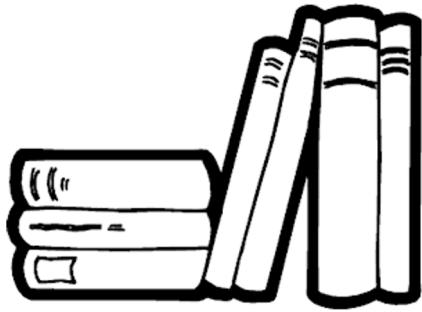


# **How do People with Intellectual and Developmental Disabilities Interpret Data Differently?**

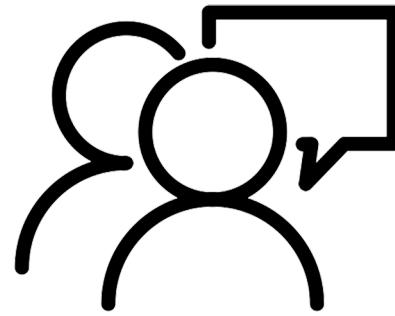




## Literature Review



Literature Review



Informal Interview

# Three Hypotheses

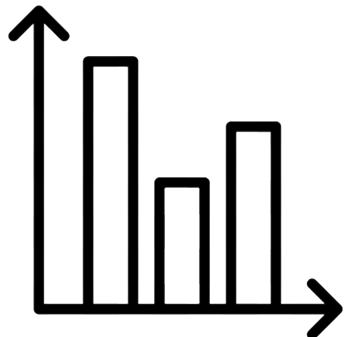
# **Three Hypotheses**

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**H1: The best chart type for a given task will differ  
between people with and without IDD**

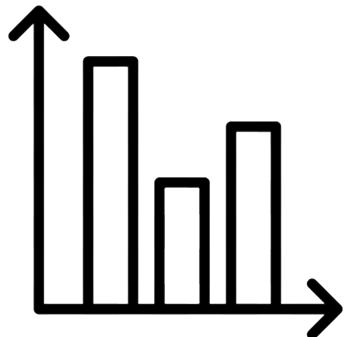
# **DataVis 101: Mapping Data to Chart Types for Best Task Performances**

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data across categories

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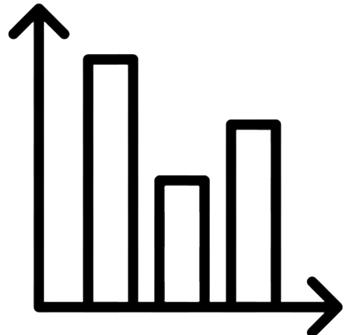


data across categories



change over time

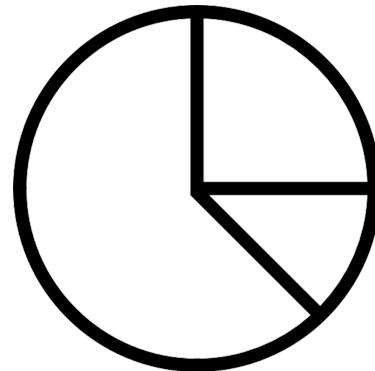
# DataVis 101: Mapping Data to Chart Types for Best Task Performances



data across categories



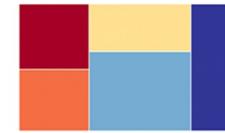
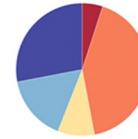
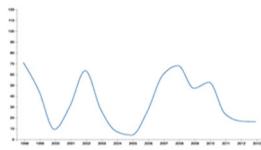
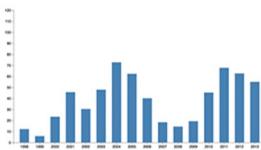
change over time



part-to-whole

# Three Hypotheses

Chart Type



# **Three Hypotheses**

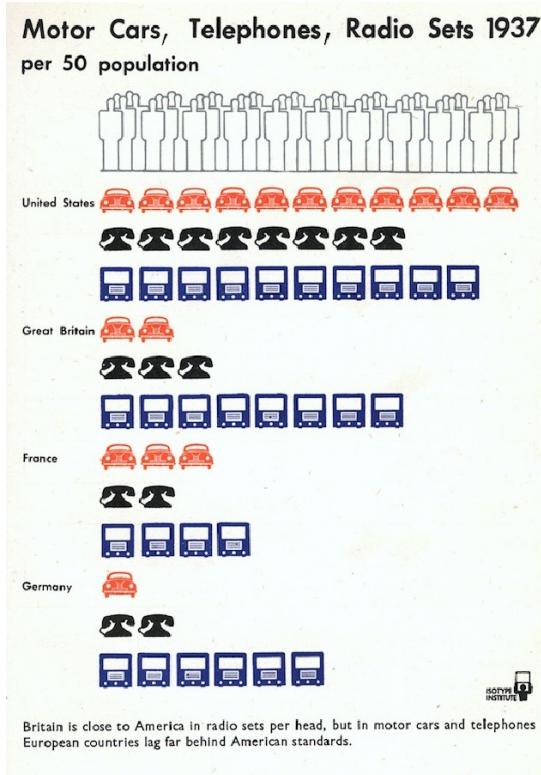
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**H1: The best chart type for a given task will differ between people with and without IDD**

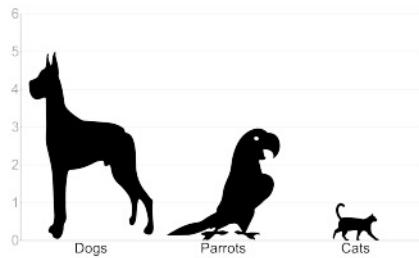
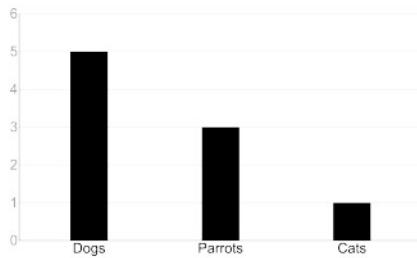
**H2: Discrete data representations will lead to more accurate performance for people with IDD**

# **DataVis 101: Isotype Visualization May Benefit Working Memory**

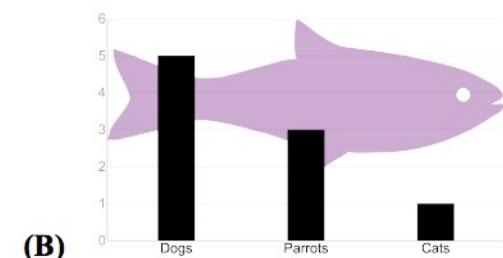
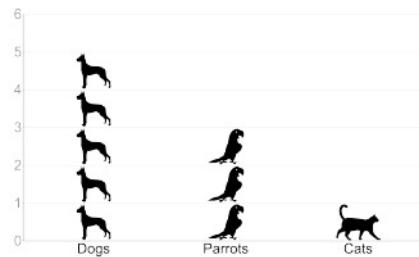
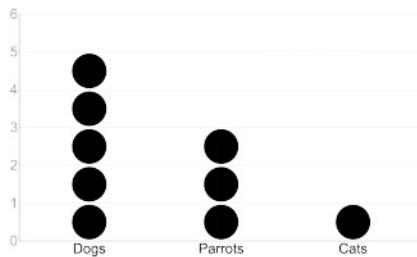
# DataVis 101: Isotype Visualization May Benefit Working Memory



# DataVis 101: Isotype Visualization May Benefit Working Memory



(A)



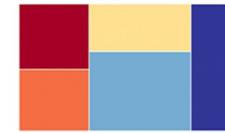
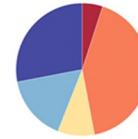
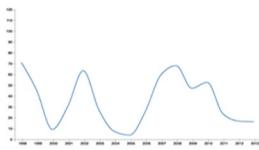
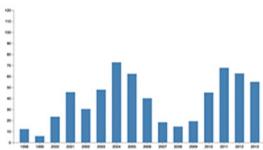
(B)



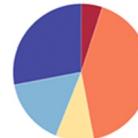
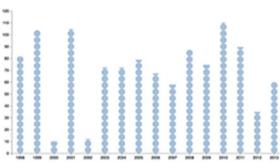
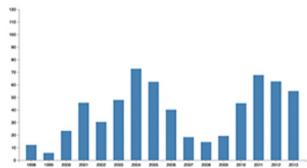
\*Haroz et al. 2015. ISOTYPE Visualization: Working Memory, Performance, and Engagement with Pictographs.

# Three Hypotheses

Chart Type



Data Continuity



# **Three Hypotheses**

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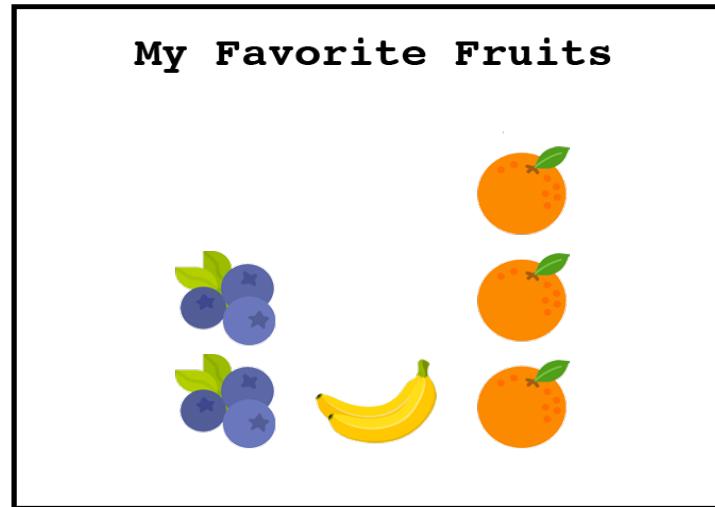
**H1: The best chart type for a given task will differ between people with and without IDD**

**H2: Discrete data representations will lead to more accurate performance for people with IDD**

**H3: Semantically meaningful chart embellishments will enhance data interpretation for people with IDD**

# **DataVis 101: Embellishments Can Connect Data to Meaning**

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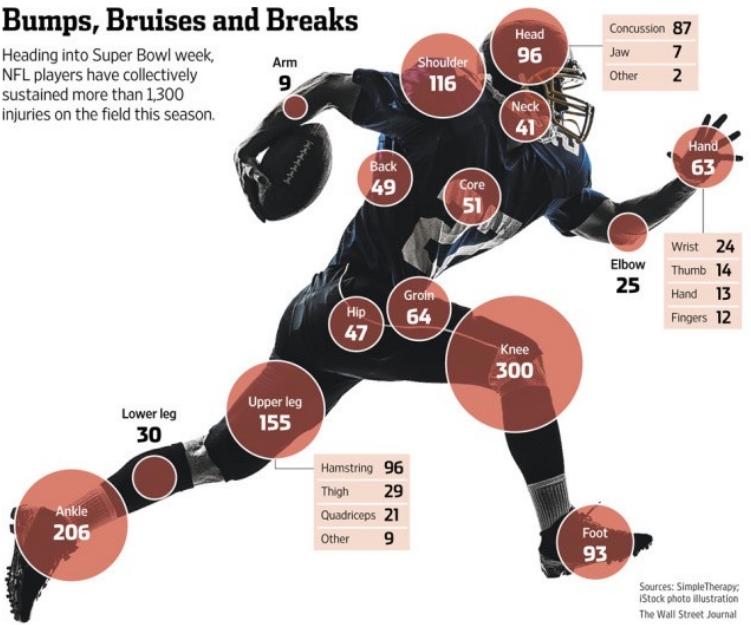


Icon

# DataVis 101: Embellishments Can Connect Data to Meaning

## Bumps, Bruises and Breaks

Heading into Super Bowl week, NFL players have collectively sustained more than 1,300 injuries on the field this season.



Beep, beep! Big cars being overtaken

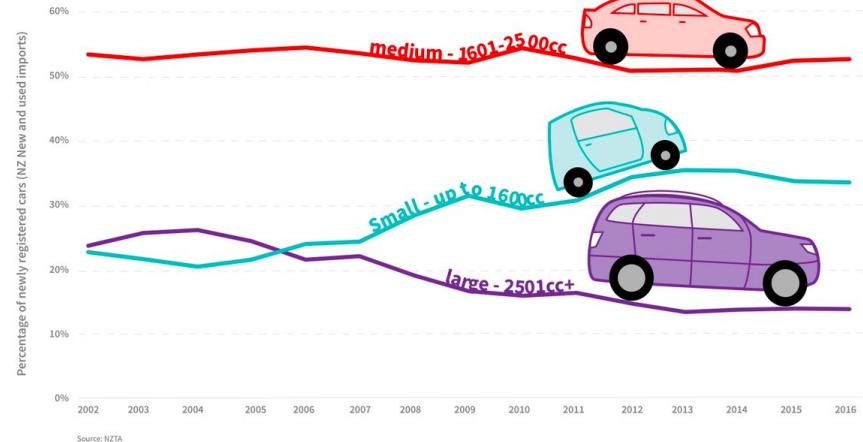
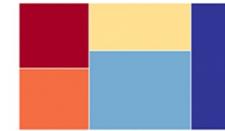
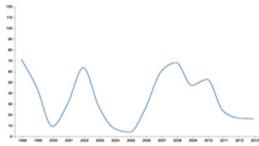
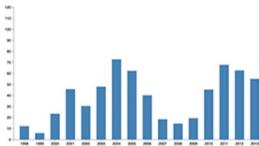


Chart Junk

# Three Hypotheses

Chart Type



Data Continuity

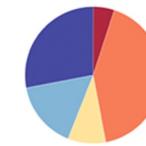
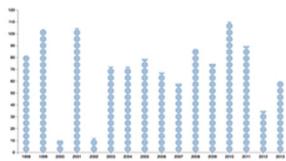
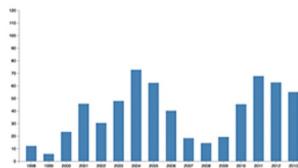
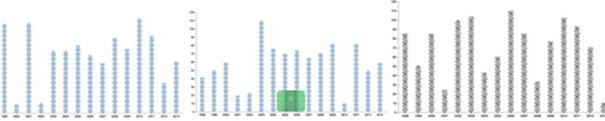
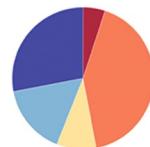


Chart  
Embellishment



# Recruitment

The poster is dark blue with white and orange text. It features stylized human icons in orange and blue at the top. The main title 'ACCESSIBLE VISUALIZATION' is in large, bold, orange letters. Below it, a subtitle in smaller blue text reads: 'We are looking for participants to join our research to design visualizations for people with Intellectual Developmental Disabilities'. A horizontal line separates this from the next section. The next section is titled 'WEB-BASED EXPERIMENT' in orange, followed by '35 - 45 MIN | 21 - 60 YEARS OLD' in blue. Another horizontal line follows. The third section is titled '\$10 GIFT CARD' in orange. Below this, contact information is provided: 'Questions? Contact: Keke.Wu@colorado.edu'. At the bottom left is a logo for 'STATE OF THE STATES IN INTELLECTUAL AND DEVELOPMENTAL DISABILITIES' featuring a map of the United States. At the bottom right is the 'VisuaLab' logo with a yellow 'CU' monogram.

**ACCESSIBLE VISUALIZATION**

We are looking for participants to join our research to design visualizations for people with Intellectual Developmental Disabilities

WEB-BASED EXPERIMENT  
35 - 45 MIN | 21 - 60 YEARS OLD

\$10 GIFT CARD

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STATE OF THE STATES  
IN INTELLECTUAL AND  
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VisuaLab

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**WEB-BASED EXPERIMENT**  
35 - 45 MIN | 21 - 60 YEARS OLD

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**\$10 GIFTCARD FOR PARTICIPATION!**

## Designing Accessible Visualization

**Do you have a intellectual or mental disability? We want your help!**

We are doing a study to learn what kinds of data visualizations (charts, graphs, etc.) help people with an intellectual or mental disability analyze financial data best and what kinds of visualizations they prefer. We are doing this in order to design more accessible visualizations that are customized for people with cognitive impairments.

**What do I need to know about the study?**

- We are looking for participants ages 21-60, with or without cognitive impairments.
- The study will take place over a Zoom video call with a researcher. You will sign up for a date and time and we will send you a link to the meeting.
- You will look at different visualizations online, answer questions, and give your opinions.
- The study can be expected to last about 45-60 minutes.
- As a thank you for your time and effort, you will receive a \$10 giftcard after the study.

**Questions? Contact:** keke.wu@colorado.edu  
or emma.petersen@colorado.edu

## How to Join a Zoom Meeting

This document will show you step by step how to join a zoom meeting using the link in your email invite and then how to begin the study. You can also watch Zoom's video on how to join a meeting here: <https://support.zoom.us/hc/en-us/articles/201362193-Joining-a-Meeting>

**How to Join a Zoom Meeting With an Email Invite:**

1. Click on the link in the email we sent you. It will be below the text "Join Zoom Meeting", as in the image below.

click here → [Join Zoom Meeting](https://cuboulder.zoom.us/j/4518530831)  
Meeting ID: 451-853-0831

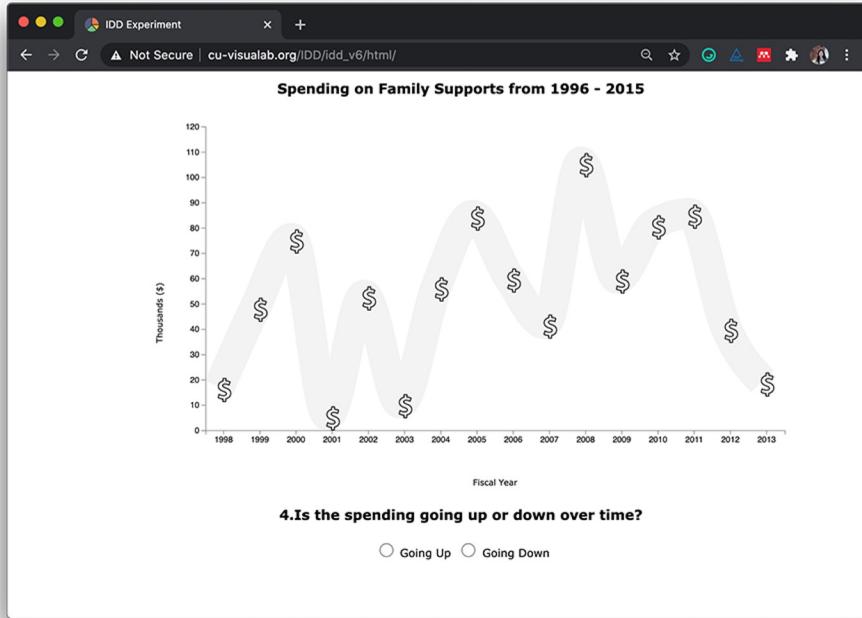
2. This will open a new tab and your web browser will prompt you to open Zoom. Press "Open Zoom". The example below is in Google Chrome, some web browsers will say something slightly different (ex. in Safari you will hit "Allow" to open Zoom).

click here → [Join Now](https://cuboulder.zoom.us/j/4518530831)

Launching...

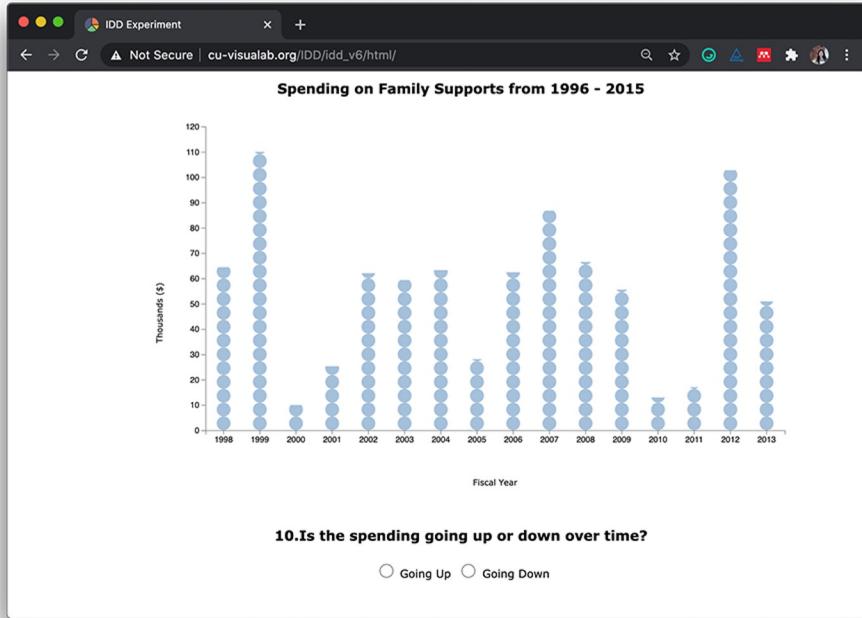
Please click Open Zoom Meetings if you see the system dialog.  
If nothing prompts from browser, click here to launch the meeting, or download & run Zoom.

# Mixed-Methods Experiment



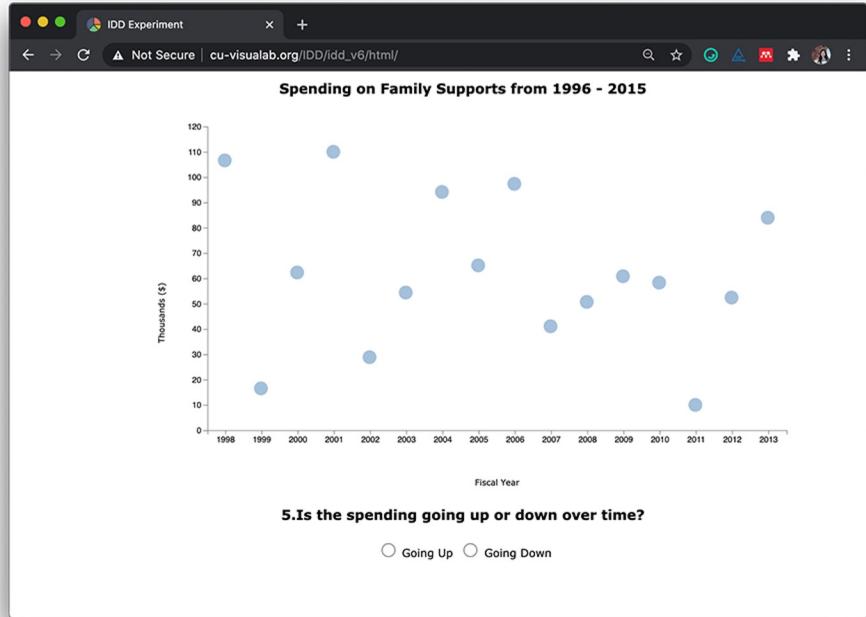
34 Participants  
with and without IDD

# Mixed-Methods Experiment



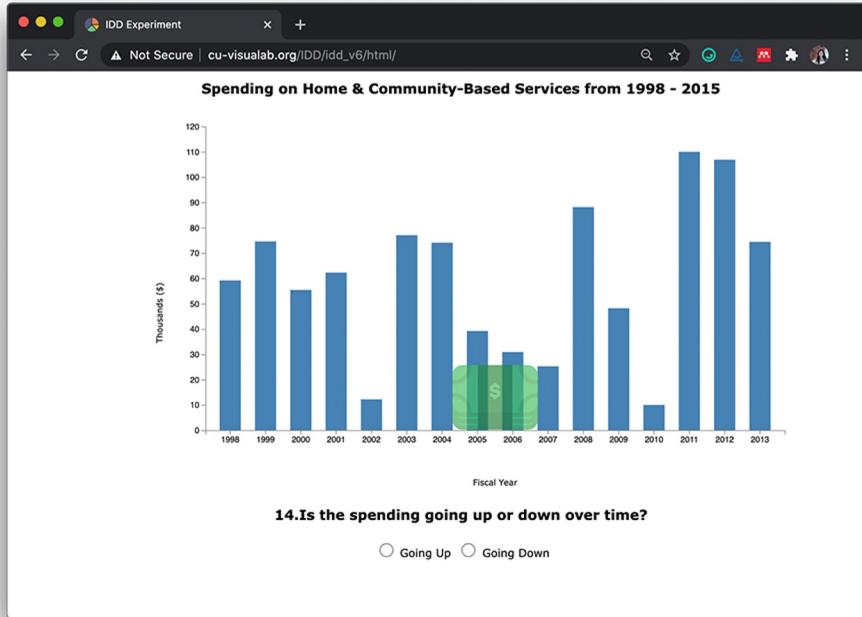
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# Mixed-Methods Experiment



**34 Participants  
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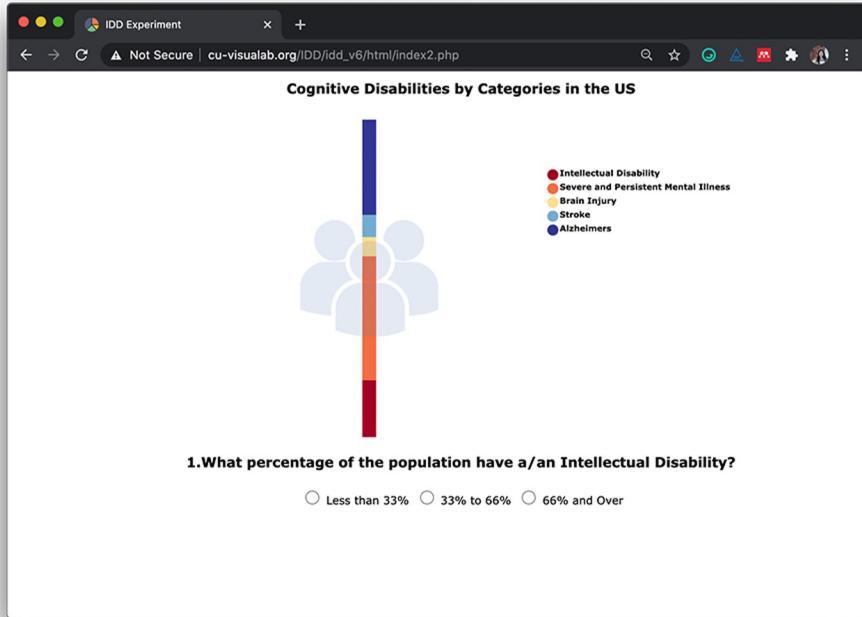
# Mixed-Methods Experiment



34 Participants  
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Time Series &  
Proportion Data

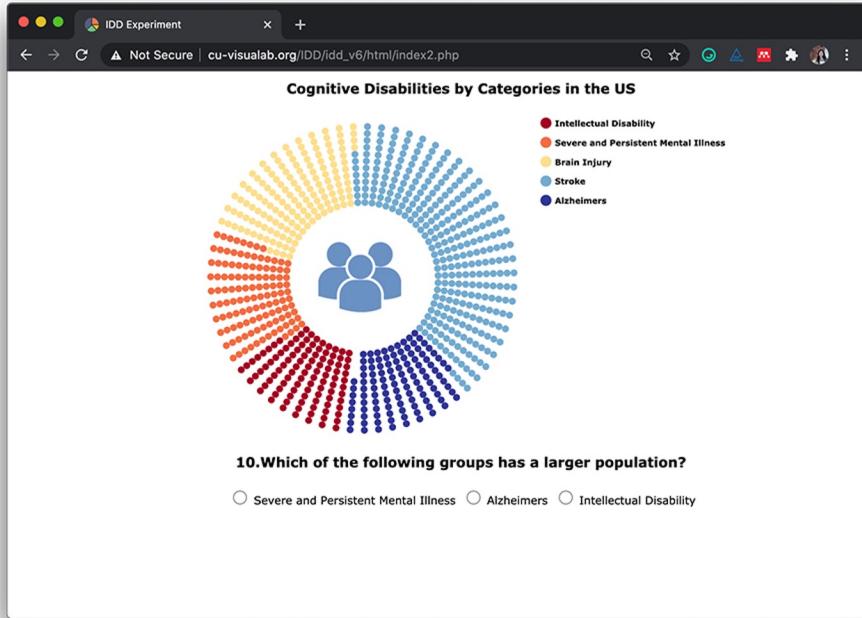
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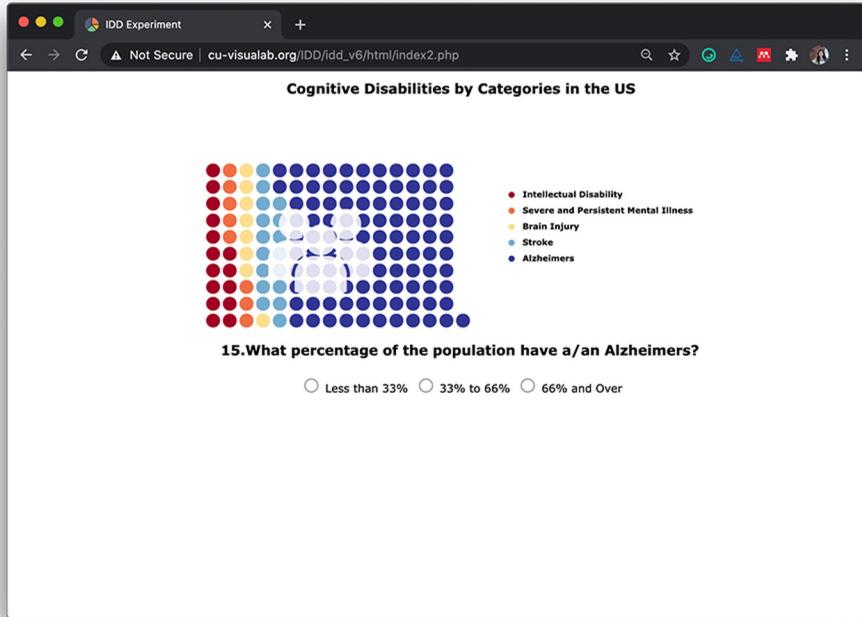


34 Participants  
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Time Series &  
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Task Performance &  
Chart Preference

# Mixed-Methods Experiment

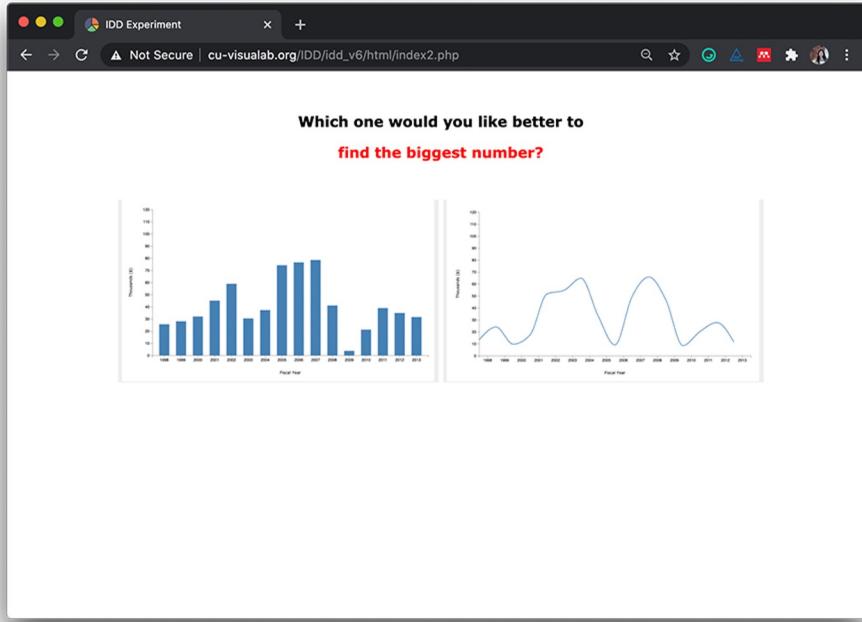


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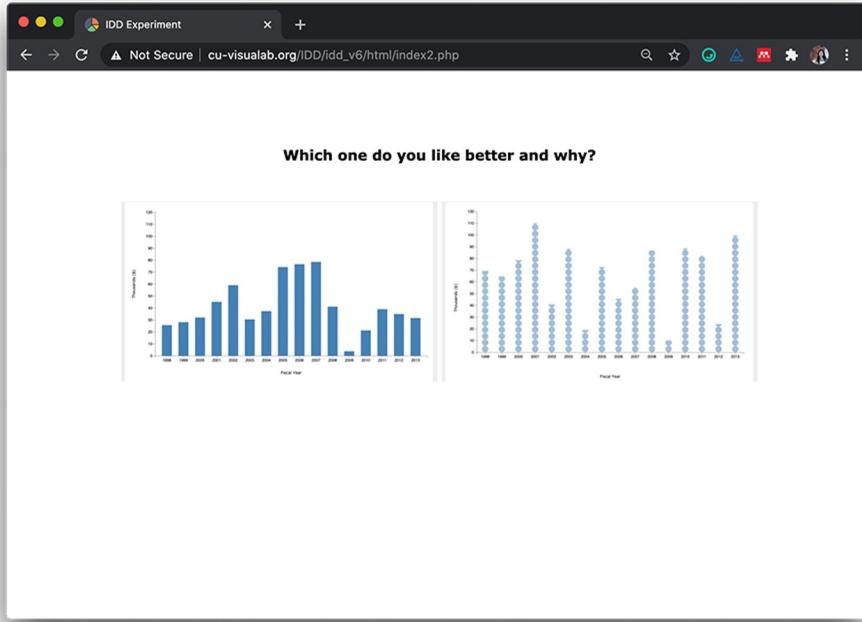


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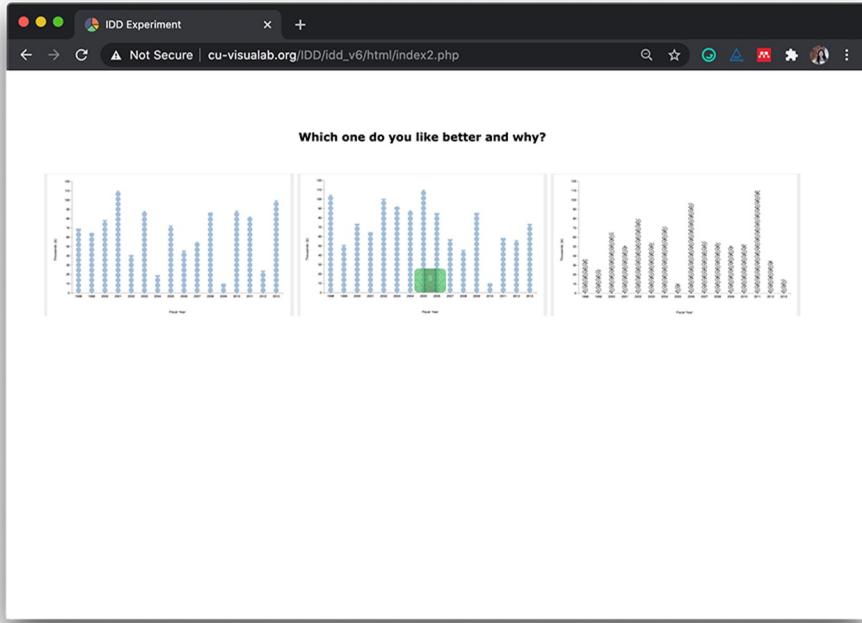


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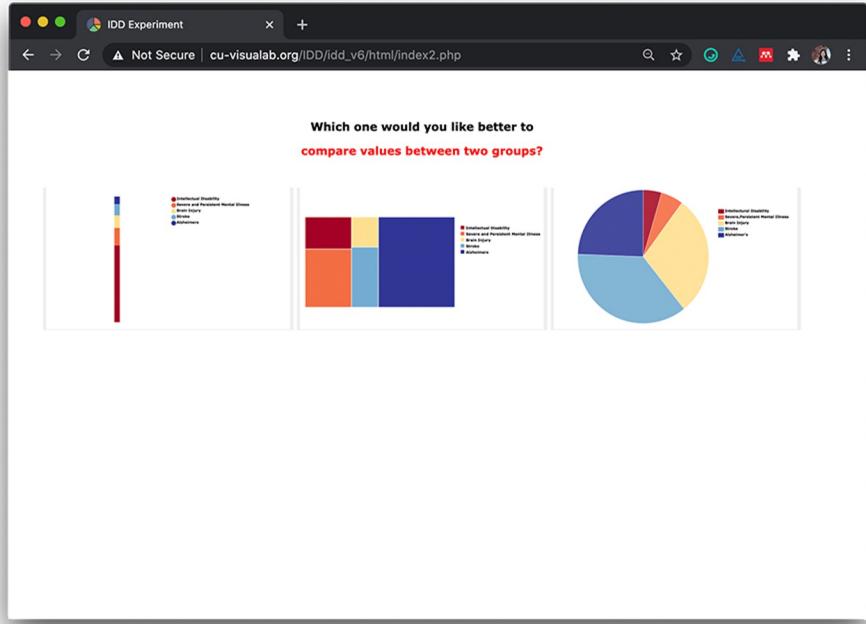


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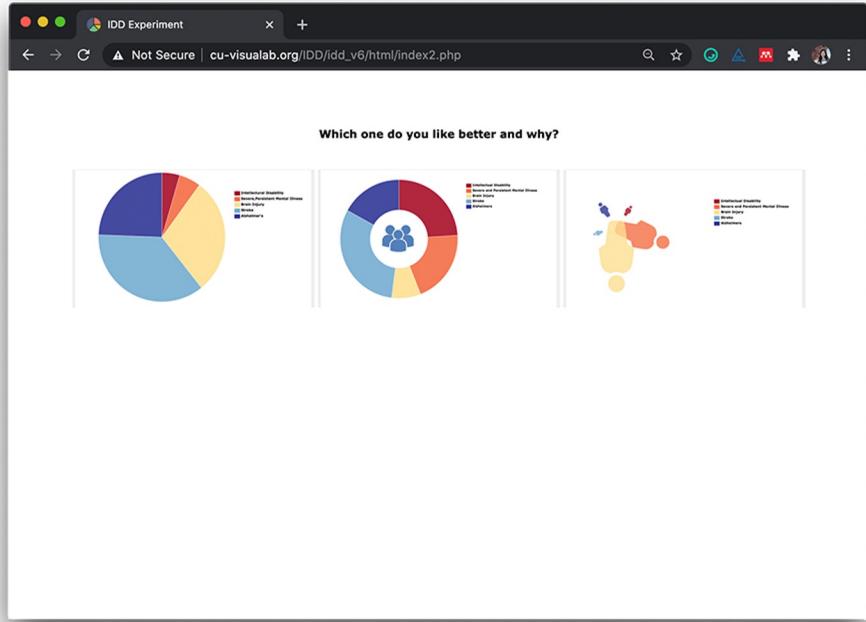


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34 Participants  
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# Four Design Guidelines

# Design Guidelines

Avoid pie charts

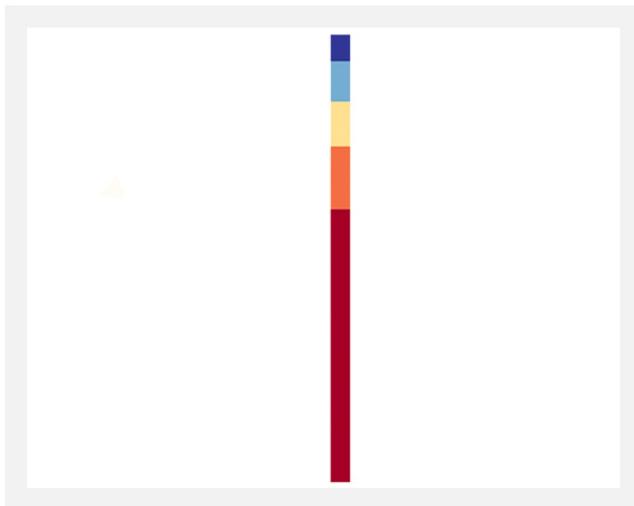
Use familiar metaphors

Manage visual complexity

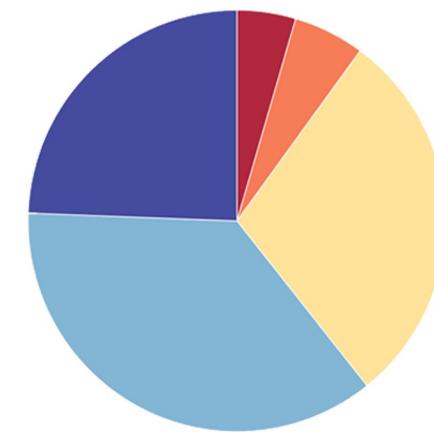
Use discrete encodings for axis-aligned representations

# Design Guidelines

## Avoid Pie Chart



Accessible



Not Accessible

# Design Guidelines

Avoid pie charts

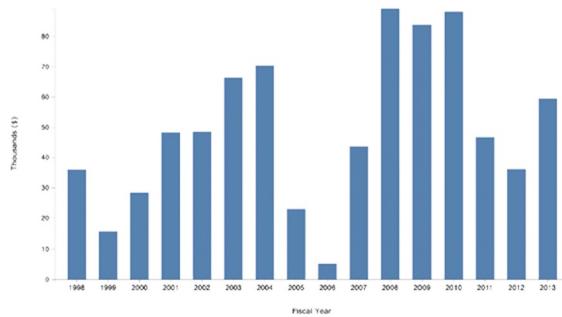
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Use discrete encodings for axis-aligned representations

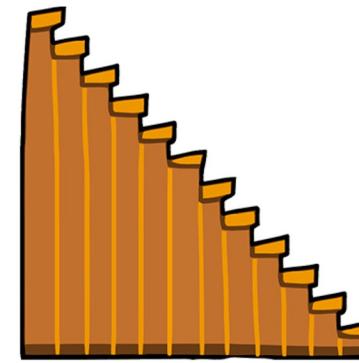
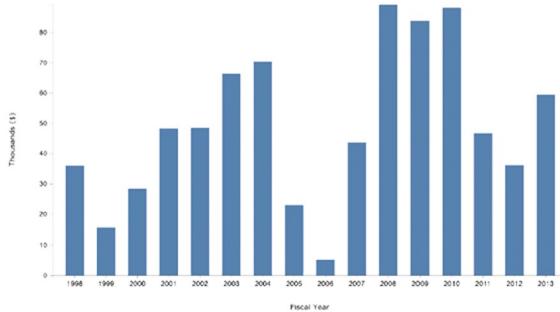
# Design Guidelines

## Use Familiar Metaphors



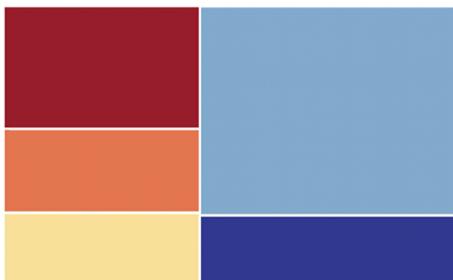
# Design Guidelines

## Use Familiar Metaphors



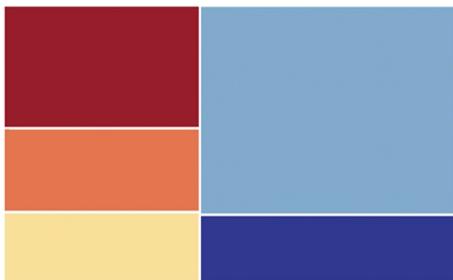
# Design Guidelines

## Use Familiar Metaphors



# Design Guidelines

## Use Familiar Metaphors



# Design Guidelines

Avoid pie charts

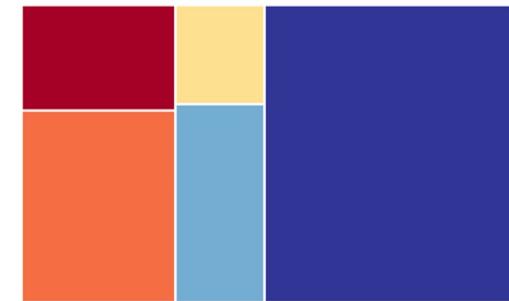
Use familiar metaphors

Manage visual complexity

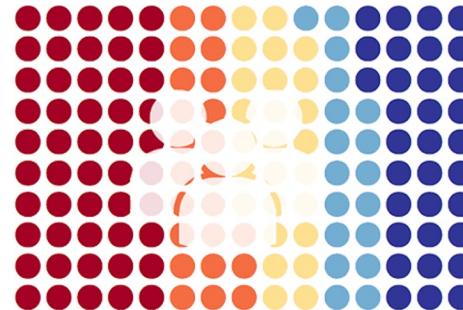
Use discrete encodings for axis-aligned representations

# Design Guidelines

## Manage Visual Complexity



Accessible



Not Accessible

# Design Guidelines

Avoid pie charts

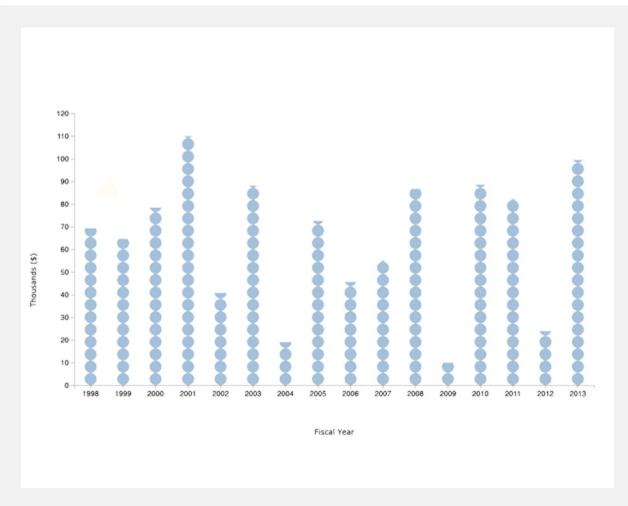
Use familiar metaphors

Manage visual complexity

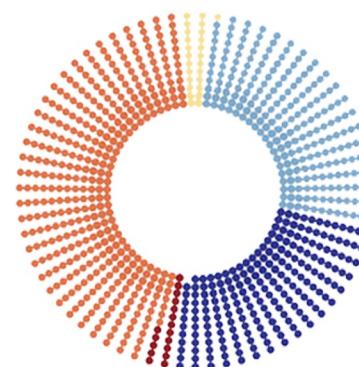
Use discrete encodings for axis-aligned representations

# Design Guidelines

Use Discrete Encodings for Axis-aligned Representations



Accessible



Not Accessible



<http://cu-visualab.org/IDD/demo/>

# Variation is the Norm.



# Creativity is a Spectrum!



# Design Guidelines

Avoid pie charts

Use familiar metaphors

Manage visual complexity

Use discrete encodings for axis-aligned representations

# Design Implications

Avoid pie charts

Use familiar metaphors

Manage visual complexity

Use discrete encodings for axis-aligned representations

# Design Implications

**Discover better ways to represent proportion**

**Use familiar metaphors**

**Manage visual complexity**

**Use discrete encodings for axis-aligned representations**

# Design Implications

**Discover better ways to represent proportion**

**Add context to the data**

**Manage visual complexity**

**Use discrete encodings for axis-aligned representations**

# Design Implications

**Discover better ways to represent proportion**

**Add context to the data**

**Understand individual differences**

**Use discrete encodings for axis-aligned representations**

# Design Implications

**Discover better ways to represent proportion**

**Add context to the data**

**Understand individual differences**

**Repurpose old charts for new use**

# What's Next?

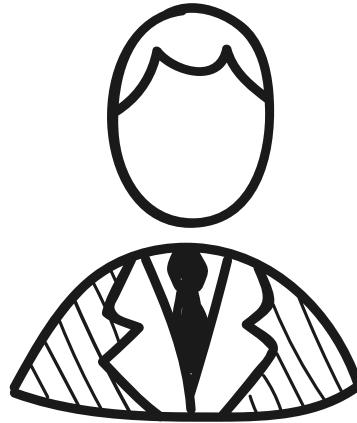




# **How do People with Intellectual and Developmental Disabilities Encounter Data and Build Visual Representations?**



**“Nothing About  
Us Without Us!”**



—SOMEONE FAMOUS

# Semi-Structured Interview

# Semi-Structured Interview

What does data mean to people with IDD?

# Semi-Structured Interview

What does data mean to people with IDD?

When & Where do they experience data ?

# Semi-Structured Interview

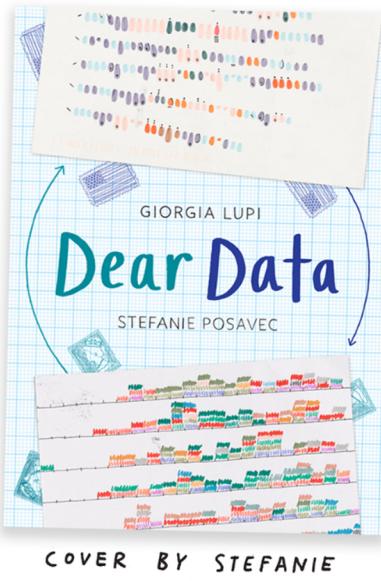
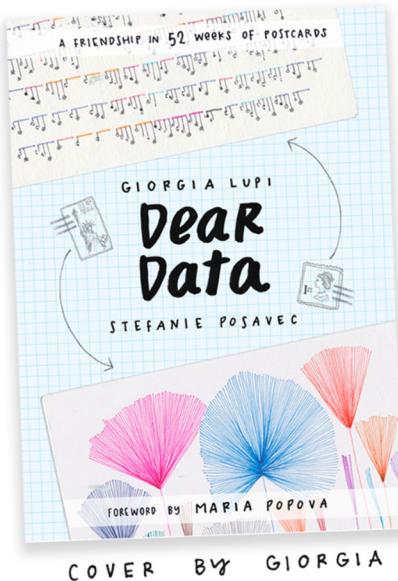
What does data mean to people with IDD?

When & Where do they experience data ?

What do they do with data?

# Participatory Design Workshop

PUBLISHED IN  
NORTH AMERICA BY



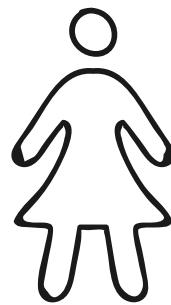
PUBLISHED IN  
THE UK BY



# Participatory Design Workshop



Data-Pal



Role-Playing

# Participatory Design Workshop

## SCHEDULE

**01** World of Objects  
Categorical Data  
(Week 1 & Week 2)

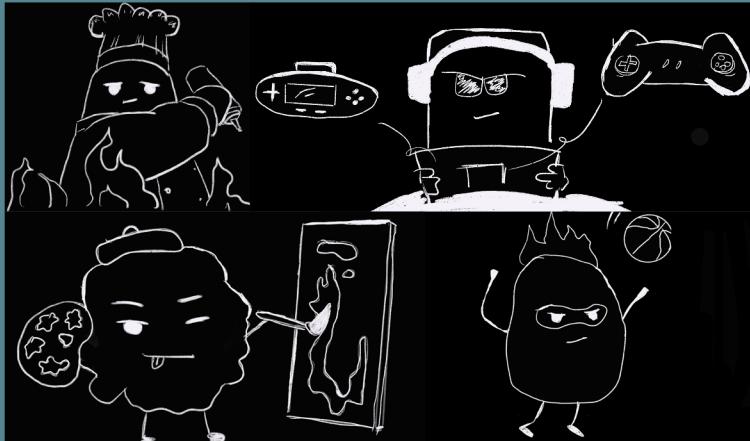
**02** Past, Present, and Future  
Time-Series Data  
(Week 3 & Week 4)

**03** Me, You, and Us  
Proportion Data  
(Week 5 & Week 6)

**04** BONUS  
We'll also meet at Week 0 (today)  
and Week 7 for a short interview!

# Participatory Design Workshop

Pick Your Favorite!



Who's your favorite alien?

Foodie Alien

Gamer Alien

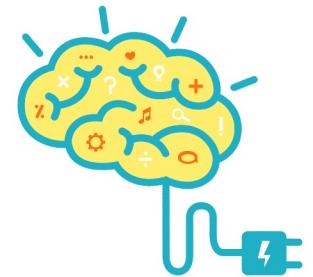
Artist Alien

Athlete Alien

# Participatory Design Workshop



How can we encourage **creativity** &  
**self-expression** through data visualization?



# THANKS!

Project Page: <https://cu-visualab.org/IDD/idd/>

Contact Me: keke.wu@colorado.edu

