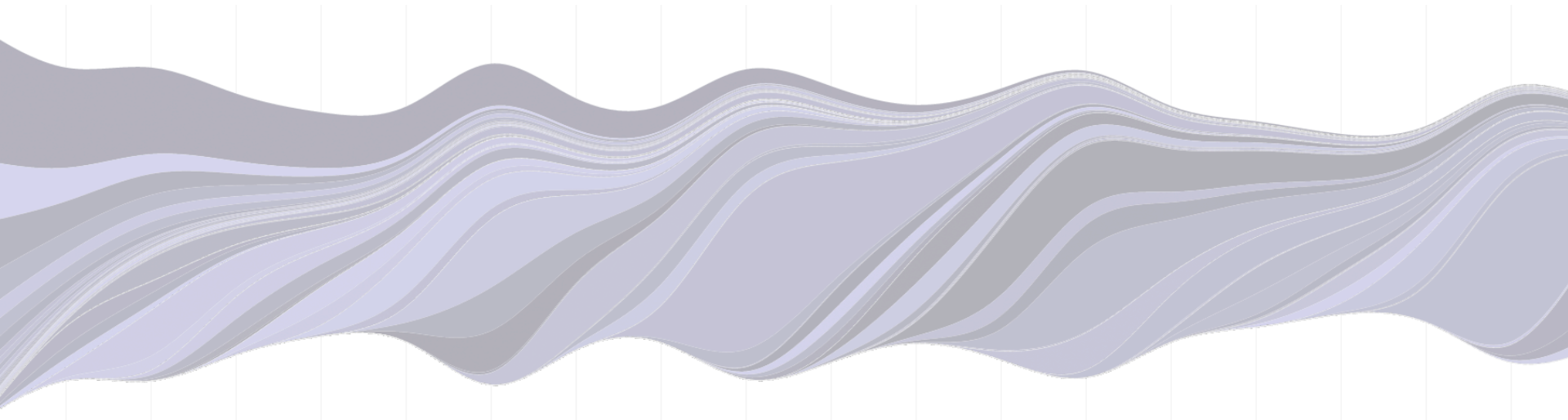
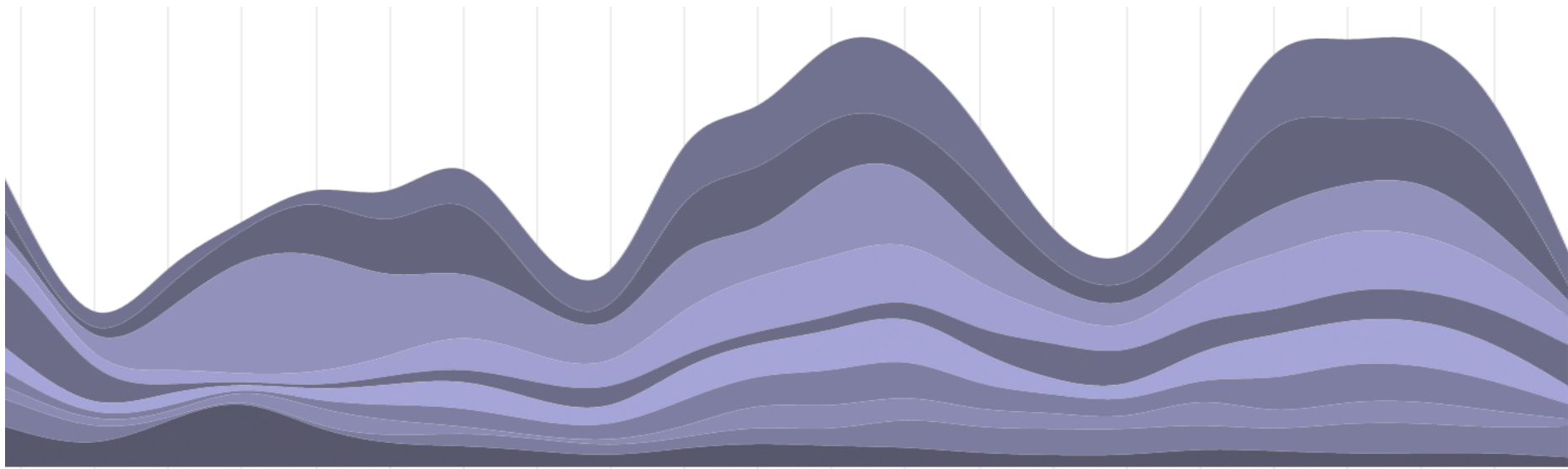


A. Thudt | J. Walny | C. Perin | F. Rajabiyazdi | L. MacDonald | R. Vardeleon | S. Greenberg | S. Carpendale

ASSESSING THE READABILITY OF STACKED GRAPHS



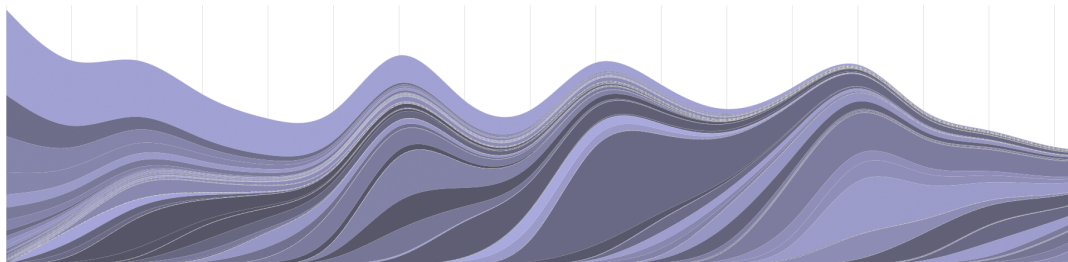
STACKED GRAPHS



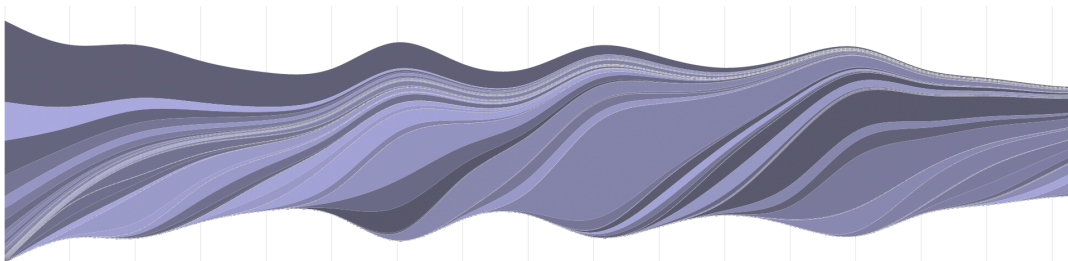
A decorative graphic element consisting of multiple overlapping, wavy lines in various shades of purple and blue, creating a sense of movement and depth. The lines are layered, with some appearing more prominent than others, and they flow horizontally across the image.

EVOLUTION OF STACKED GRAPHS

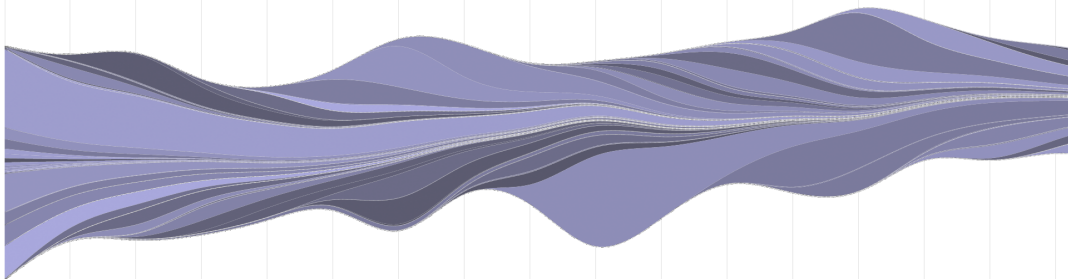
Stacked Area Chart



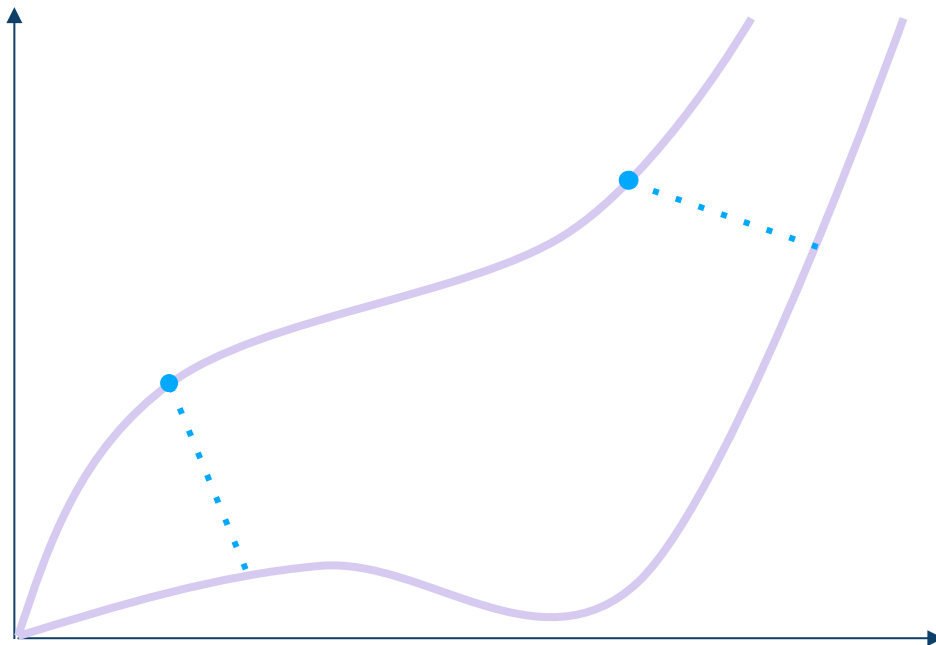
Themeriver



Streamgraph

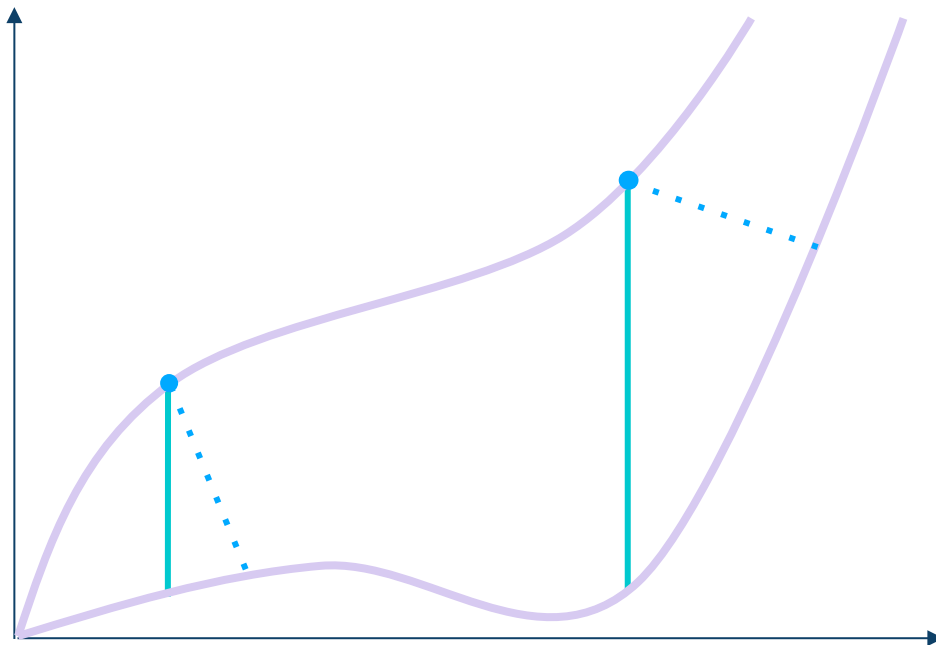


READABILITY



W. S. Cleveland and R. McGill. Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. *Journal of the American Statistical Association*, 79(387):531–554, 1984.

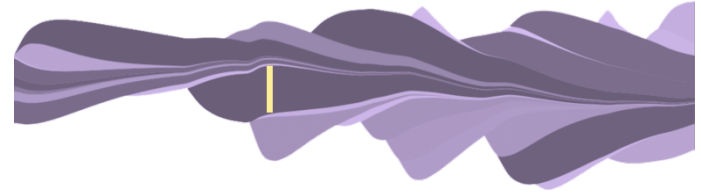
READABILITY



W. S. Cleveland and R. McGill. Graphical Perception: Theory, Experimentation, and Application to the Development of Graphical Methods. *Journal of the American Statistical Association*, 79(387):531–554, 1984.

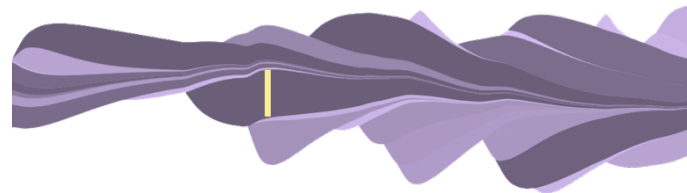
INFORMATION LEVELS

Elementary

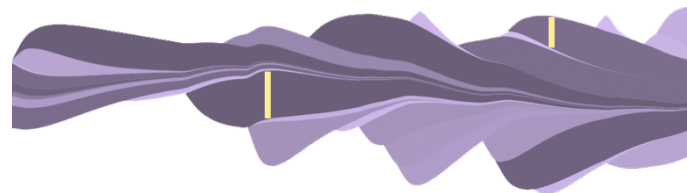


INFORMATION LEVELS

Elementary

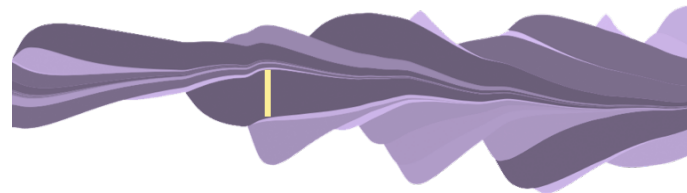


Intermediate

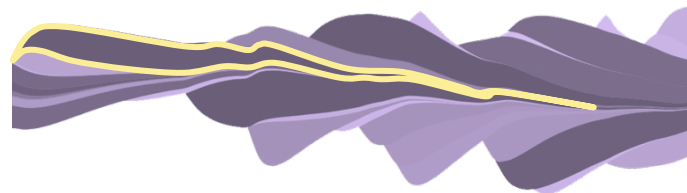


INFORMATION LEVELS

Elementary

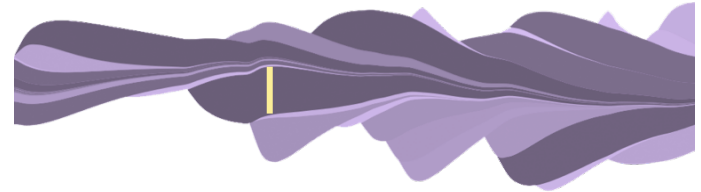


Intermediate



INFORMATION LEVELS

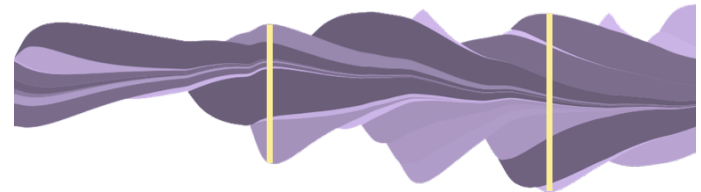
Elementary



Intermediate

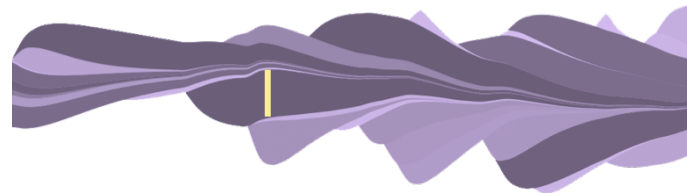


Global

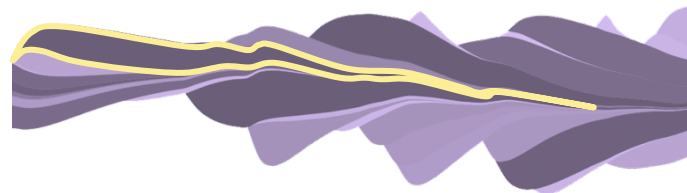


INFORMATION LEVELS

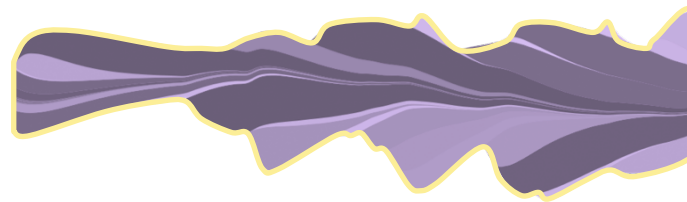
Elementary



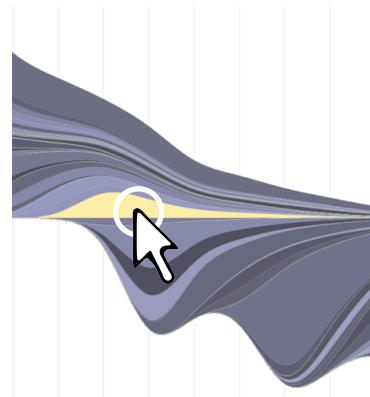
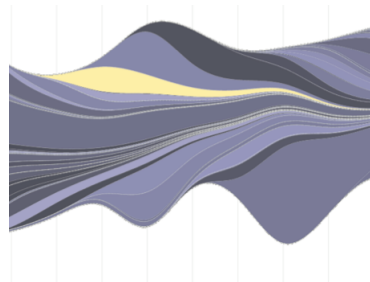
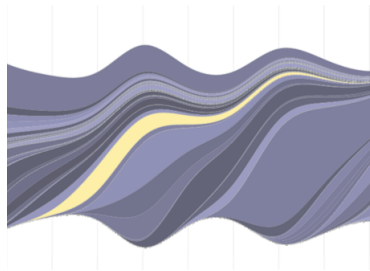
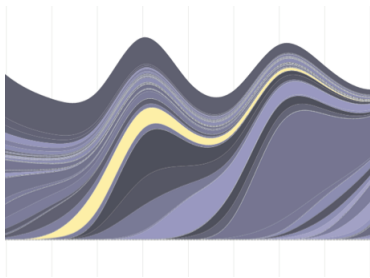
Intermediate



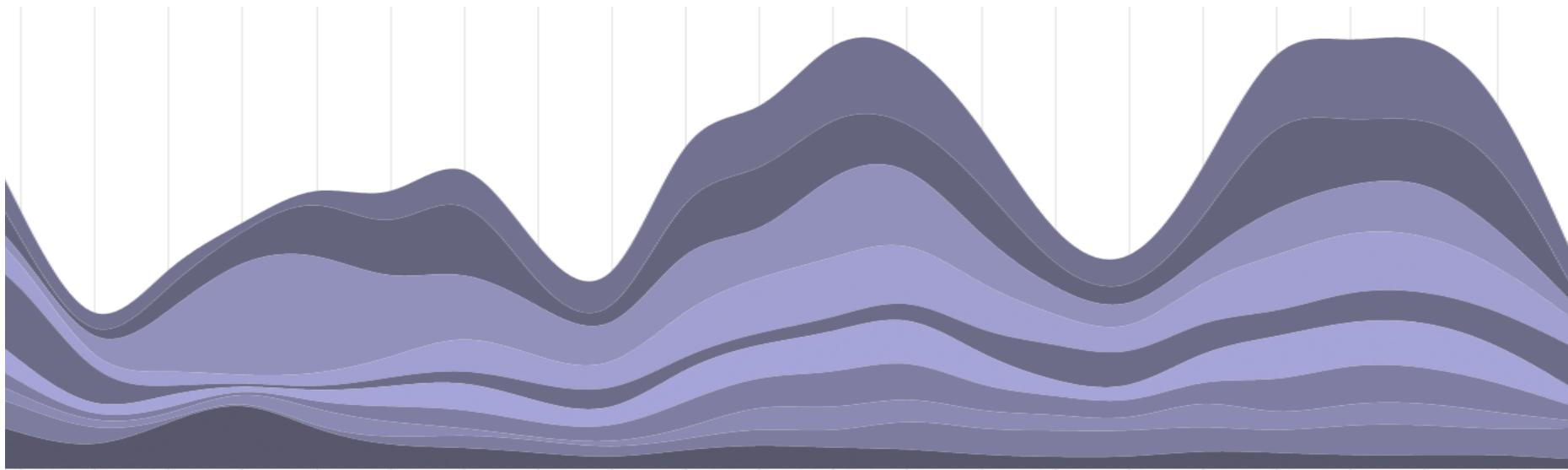
Global



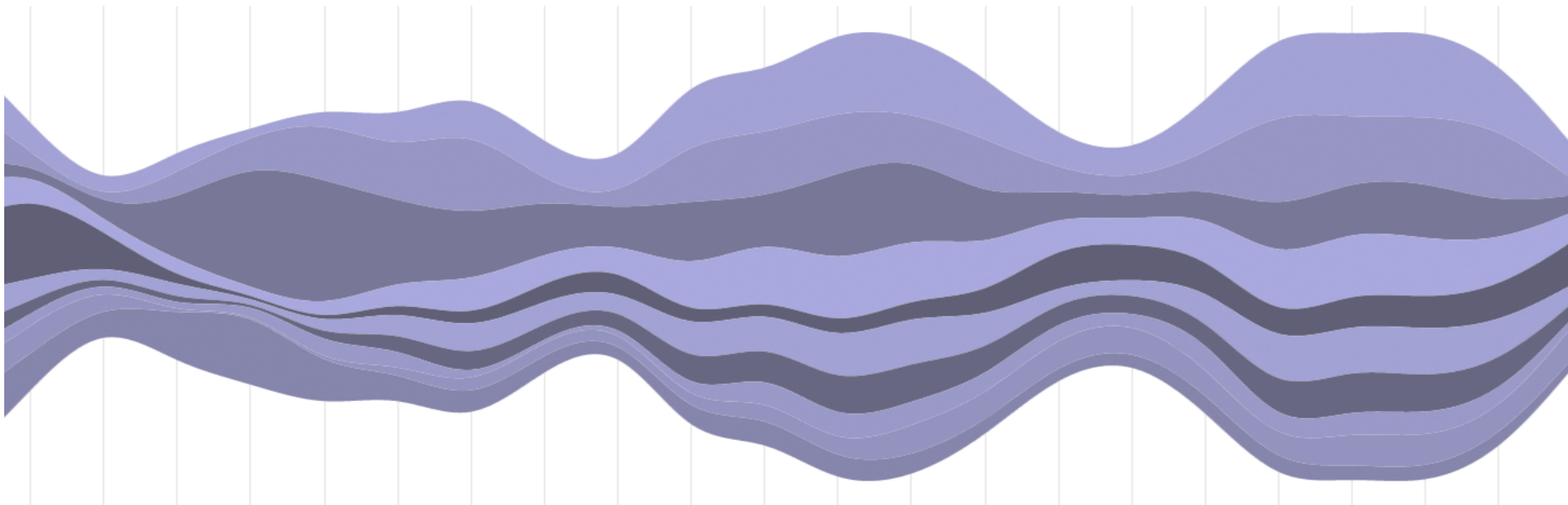
CONDITIONS



STACKED AREA CHART (STACK)

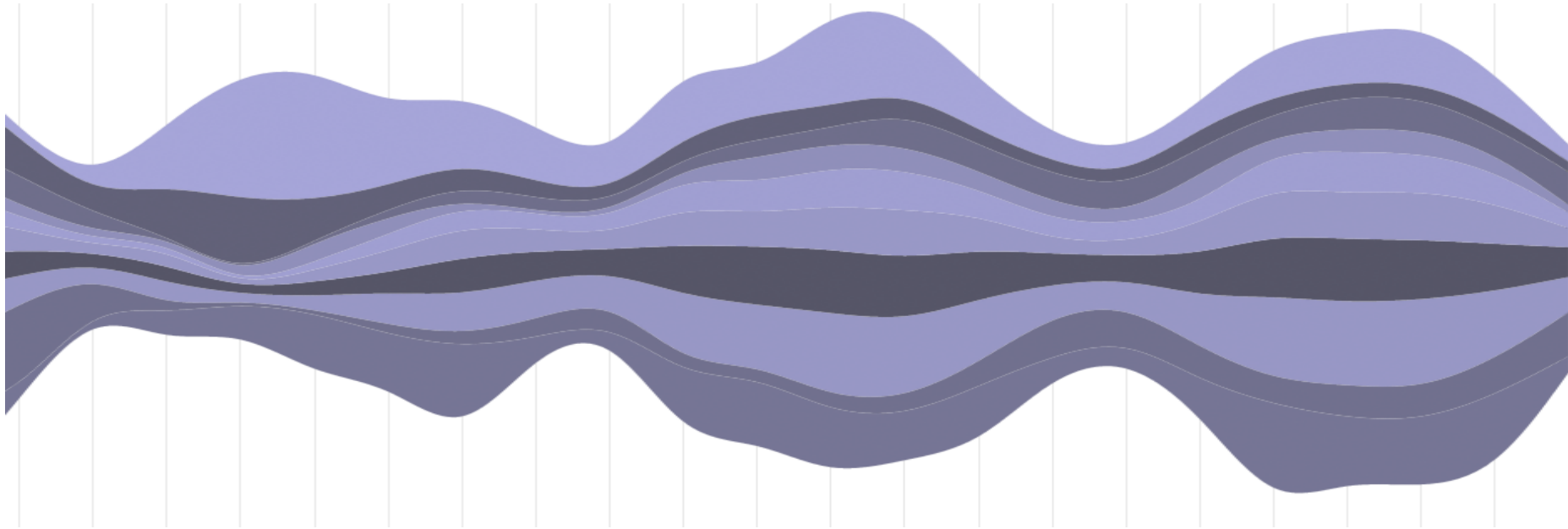


THEMERIVER (THEME)

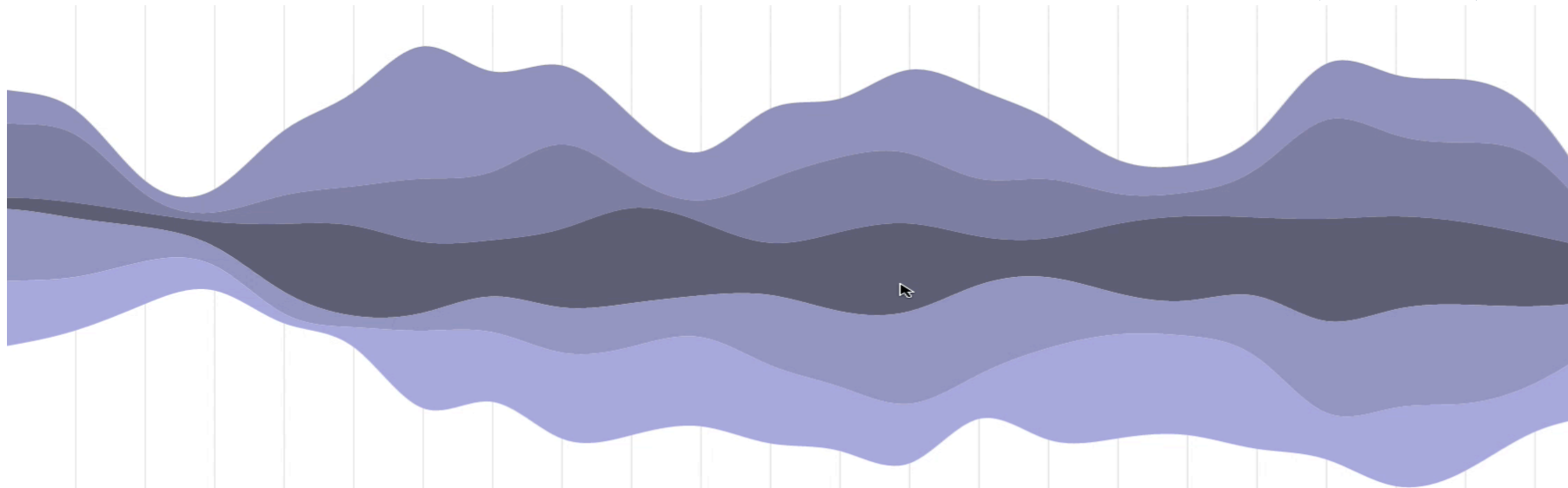


S. Havre, B. Hetzler, and L. Nowell. *ThemeRiver: visualizing theme changes over time*.
IEEE Symposium on Information Visualization, INFOVIS' 00, 2000.

STREAMGRAPH (STREAM)



INTERACTIVE STACKED GRAPH (INT)



DATASETS



Random | 30 time-series | 30 time-points

311 Calls in NYC (Calls) | 10 time-series | 35 time-points

Box Office Revenue Dataset (Movies) | 300 time-series | 20 time-points

TASKS

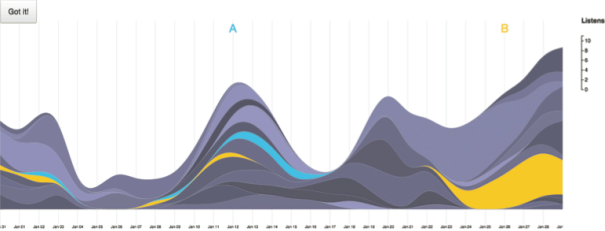
The following graph represents a music listening history. Each stream shows the number of listens for one artist over time.

Which is larger: the number of listens of Artist 1 at A or Artist 2 at B?

☐ A

☐ B

Answer: Listens

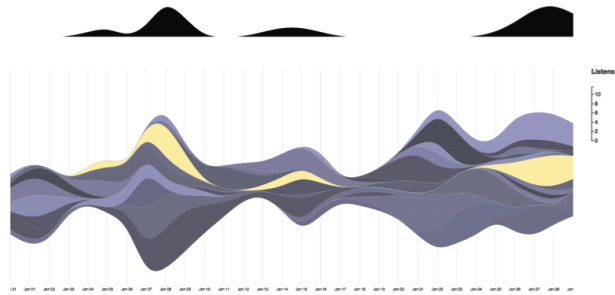


The following graph represents a music listening history. Each stream shows the number of listens for one artist over time.

This area chart represents the number of listens for one artist. In the graph below, which stream represents the same artist?

Click on a stream to select it!

Got It!



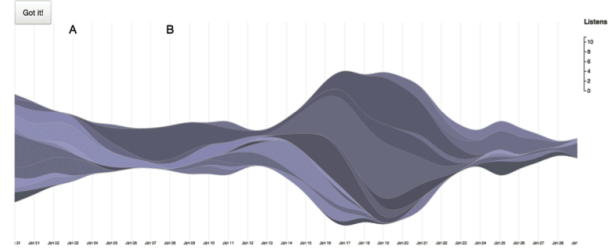
The following graph represents a music listening history. Each stream shows the number of listens for one artist over time.

Is the combined number of listens for all artists larger at A or B?

☐ A

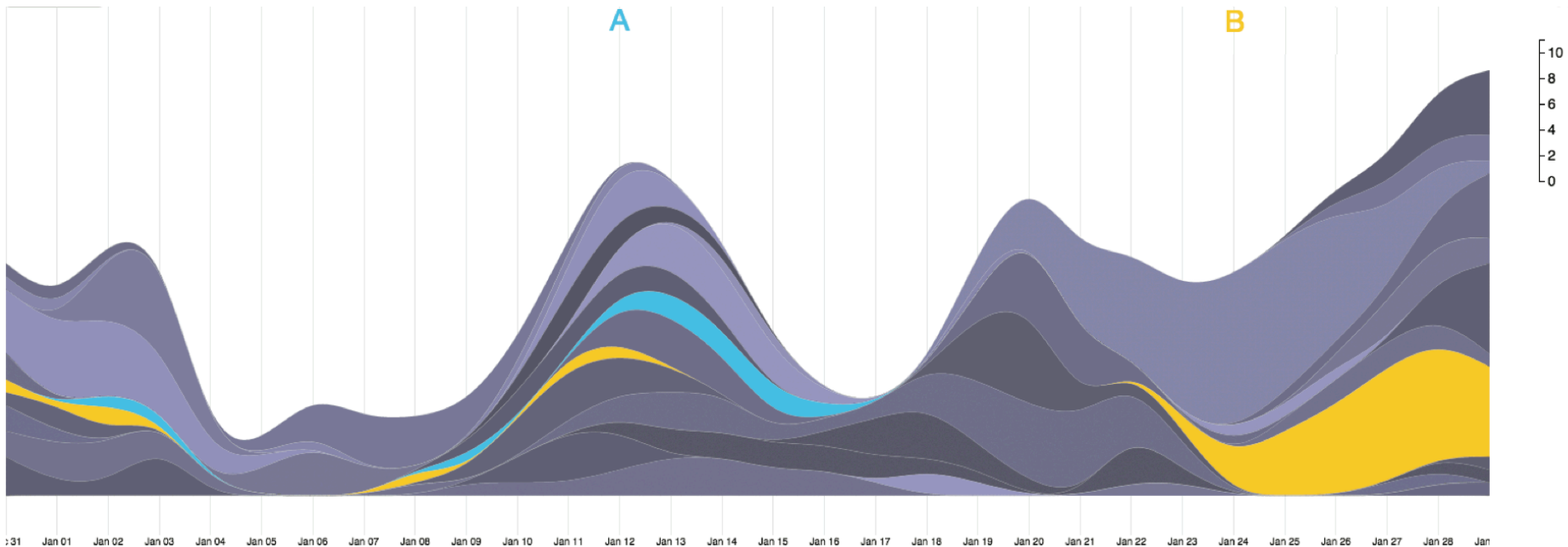
☐ B

Answer: Listens



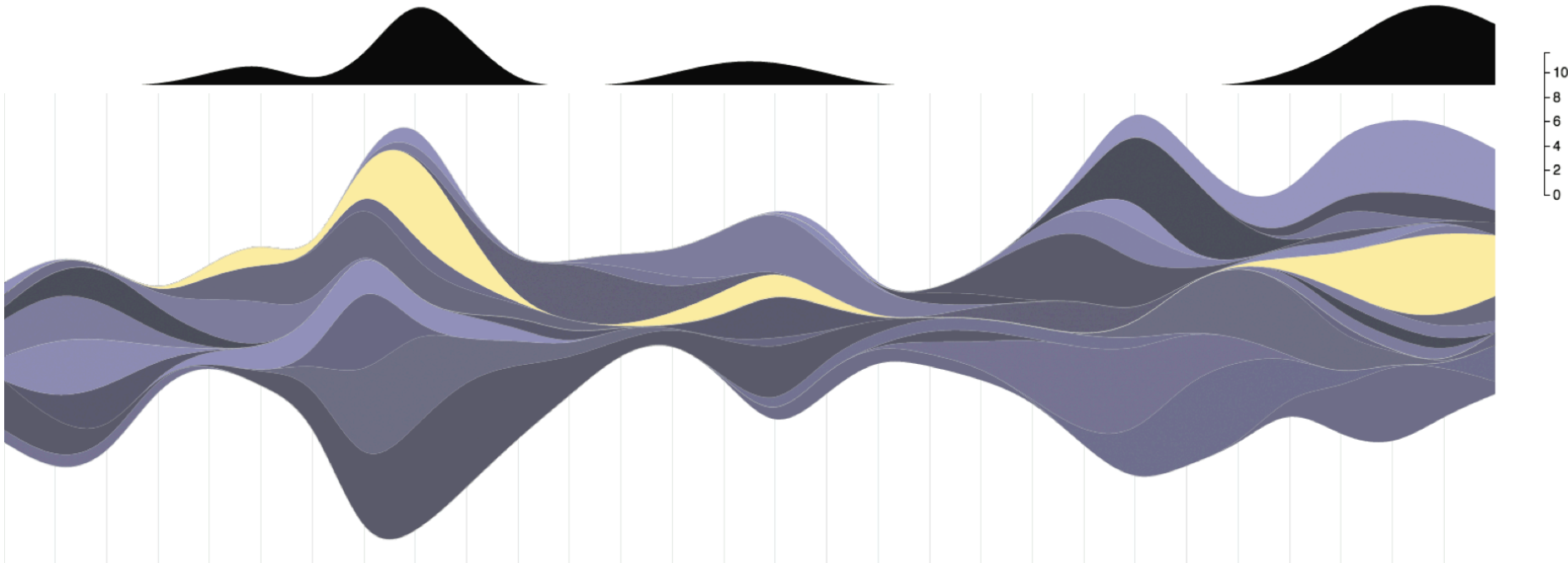
I. INDIVIDUAL DISCRIMINATION

Which is larger: the value of the blue time-series at A or the value of the yellow time-series at B?



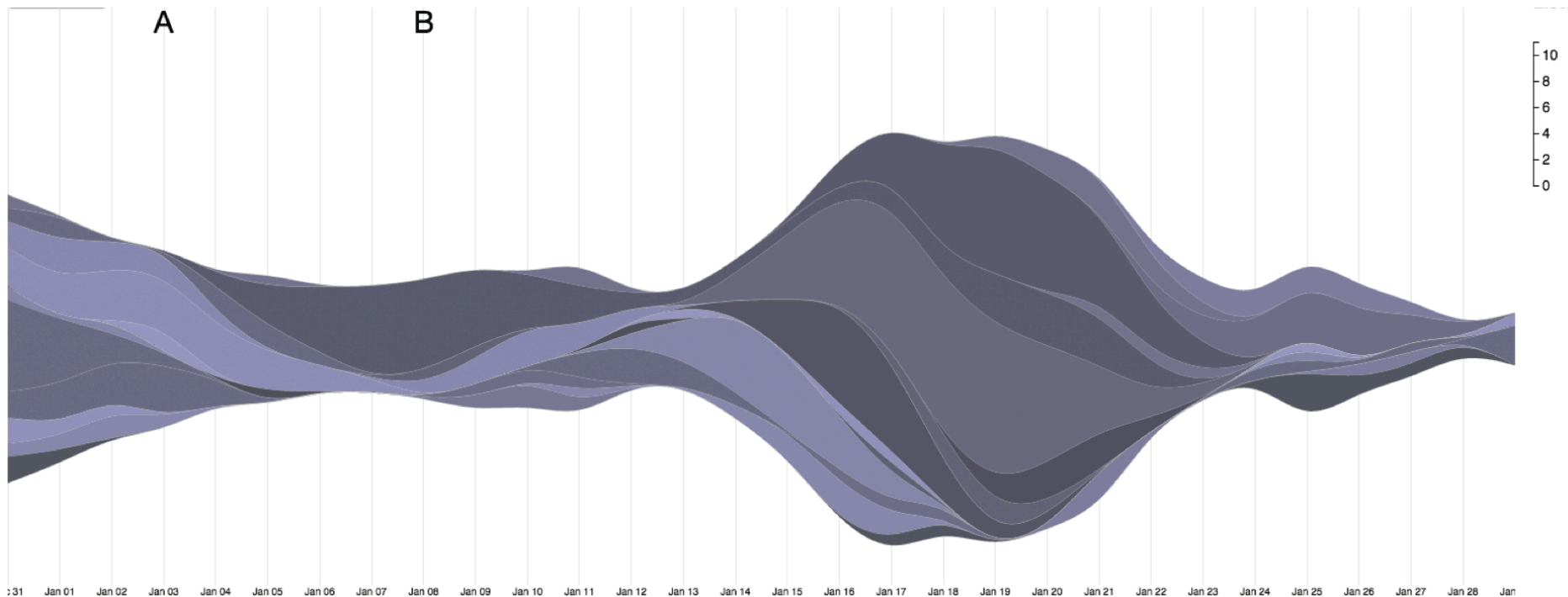
II. STREAM COMPARISON

The following area chart represents [time-series data]. In the graph below, which stream represents the same [time-series]?



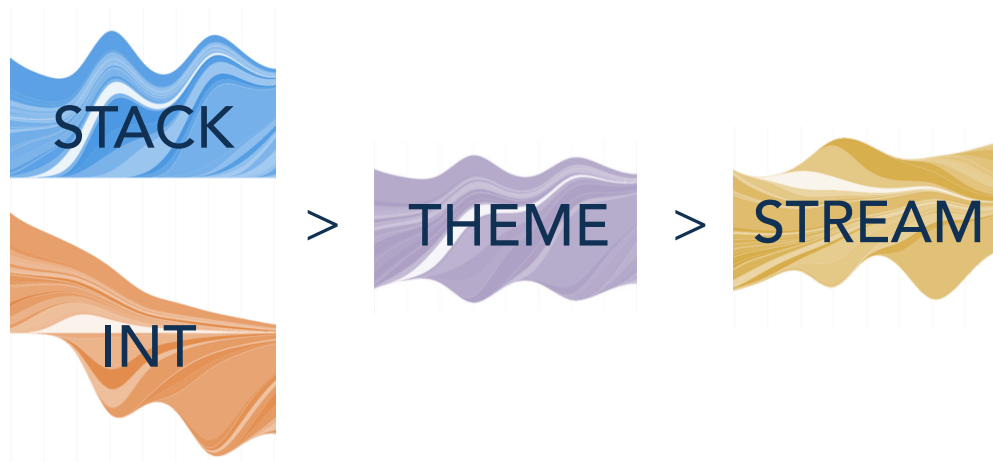
III. AGGREGATE DISCRIMINATION

Is the combined value of all time-series larger at A or at B?



HYPOTHESES

H1: Correctness for *Aggregated Discrimination (III)*:

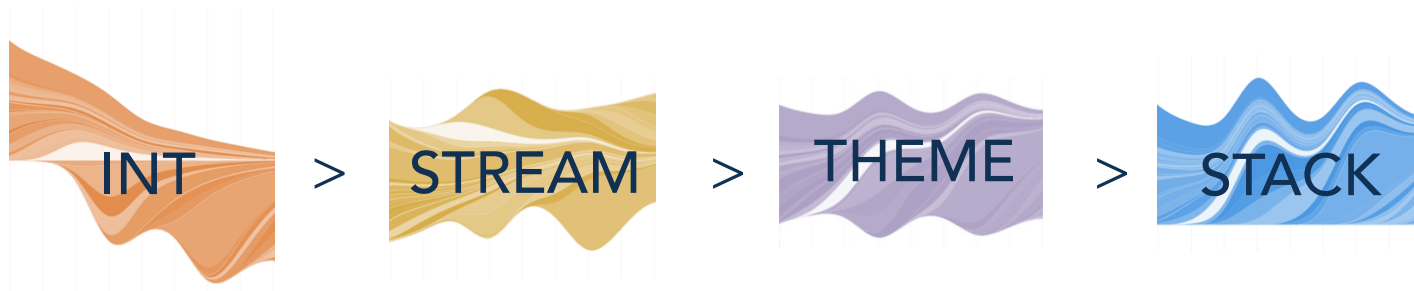


More Correct

Less Correct

HYPOTHESES

H2: Correctness for *Individual Discrimination (I)* and *Stream Comparison (II)*:



More Correct

Less Correct

HYPOTHESES

H3: Completion Time for *all tasks*:



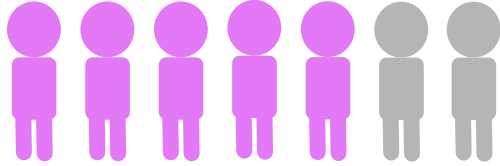
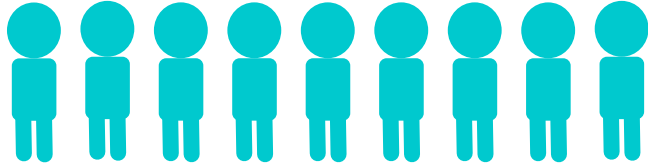
>



Faster

Slower

16 PARTICIPANTS

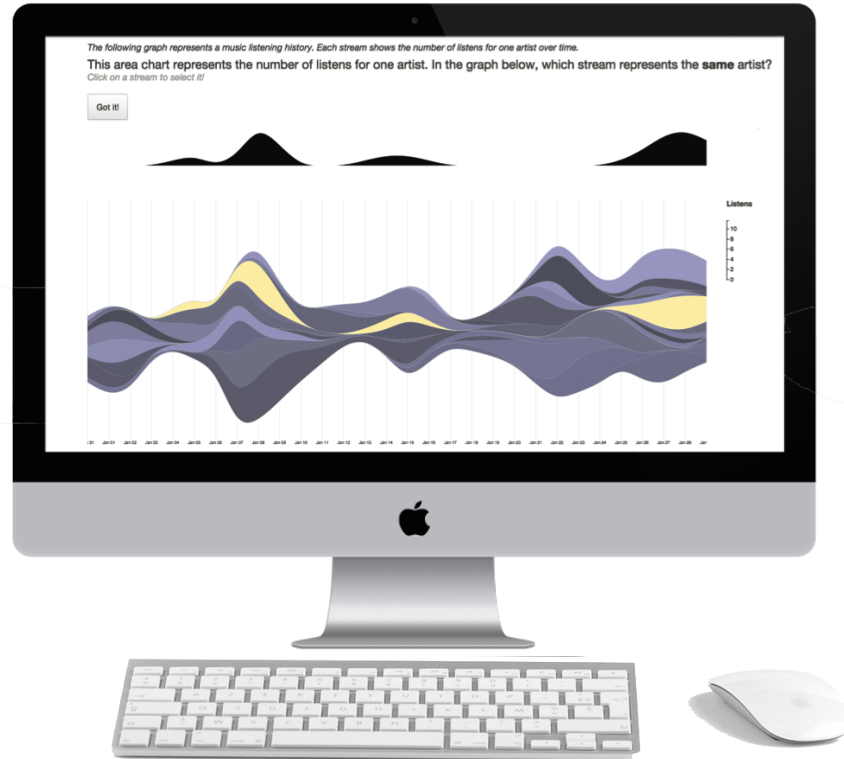


9 male, 5 female, 2 did not specify

18–65 years

various occupations

STUDY SETUP



STUDY DESIGN

within-subjects design

balanced 4x4 Latin square

training with all tasks for each condition

$4 \text{ cond} \times 3 \text{ tasks} \times 3 \text{ datasets} = 36 \text{ trials}$

DATA

Condition: SM

Round: 0

SM_SC_0: Shape Comparison

Correct Answer: Stream7
Answer Time: 12.083
Answer: Stream7
SM_A_D_0: Aggregate Discrimination

Correct Answer: A
Answer Time: 18.216
Answer: B
SM_I_D_0: Individual Discrimination

Correct Answer: B
Answer Time: 3.86
Answer: B
SM_A_E_0: Aggregate Estimation

Correct Answer: 200
Answer Time: 10.673
Answer: 100
SM_I_E_0: Individual Estimation

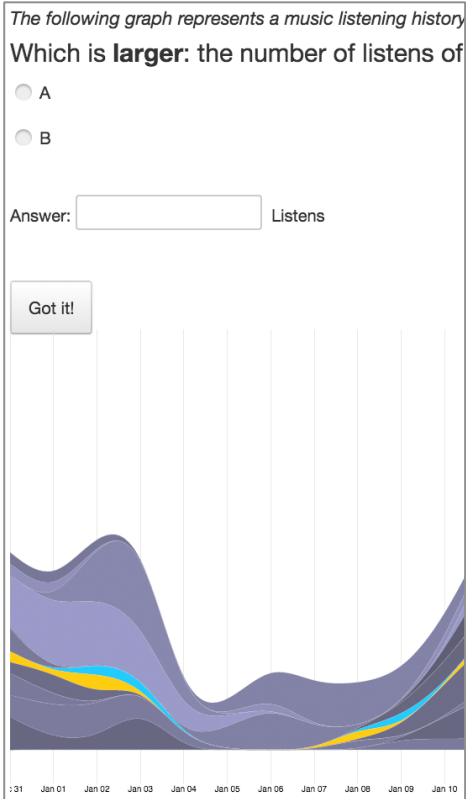
Correct Answer: 200
Answer Time: 28.348
Answer: 100
SM_0,12.083,Stream7,18.216,B,3.86,B,10.673,100,28.348

Round: 1

Answer: 100
SM_SC_1: Shape Comparison

Correct Answer: Stream5
Answer Time: 8.75
Answer: Stream5
SM_A_D_1: Aggregate Discrimination

Correct Answer: B
Answer Time: 7.65



Please indicate approximately **how often** you use the following technology choice:

Technology never a few times a year, or so spradical

Computers	1	2
Internet	1	2
Visualizations	1	2

Demographic Information

This information is collected for demographic purposes only. All questions are optional.

Age: ☐ 18-25 ☐ 26-35 ☐ 36-45 ☐ 46-55 ☐ 56-65 ☐ 66+

Gender: ☐ Male ☐ Female

Please indicate the **highest** level of education you have **completed**

☐ High school or equivalent ☐ Master's degree

☐ Vocational/technical school (2 year) ☐ Doctorate

EFFECT SIZES



strong & large effect



strong & small effect



EFFECT SIZES



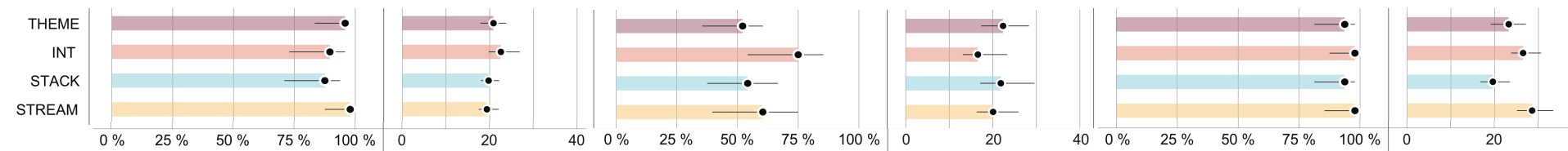
weak & large effect



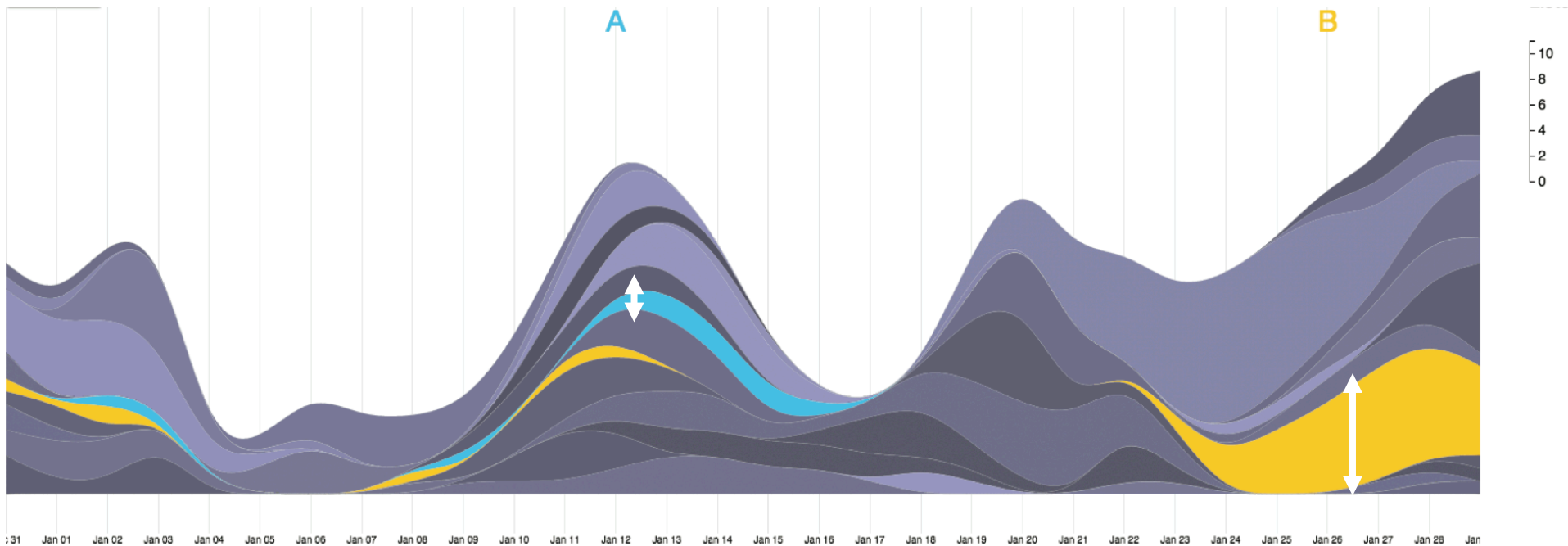
weak & small effect



RESULTS



INDIVIDUAL DISCRIMINATION



INDIVIDUAL DISCRIMINATION

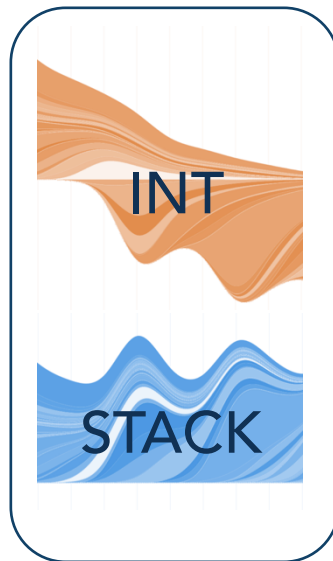
✓ Correctness



More Correct

Strong & small effect

>



Less Correct

INDIVIDUAL DISCRIMINATION



Completion Time



Faster

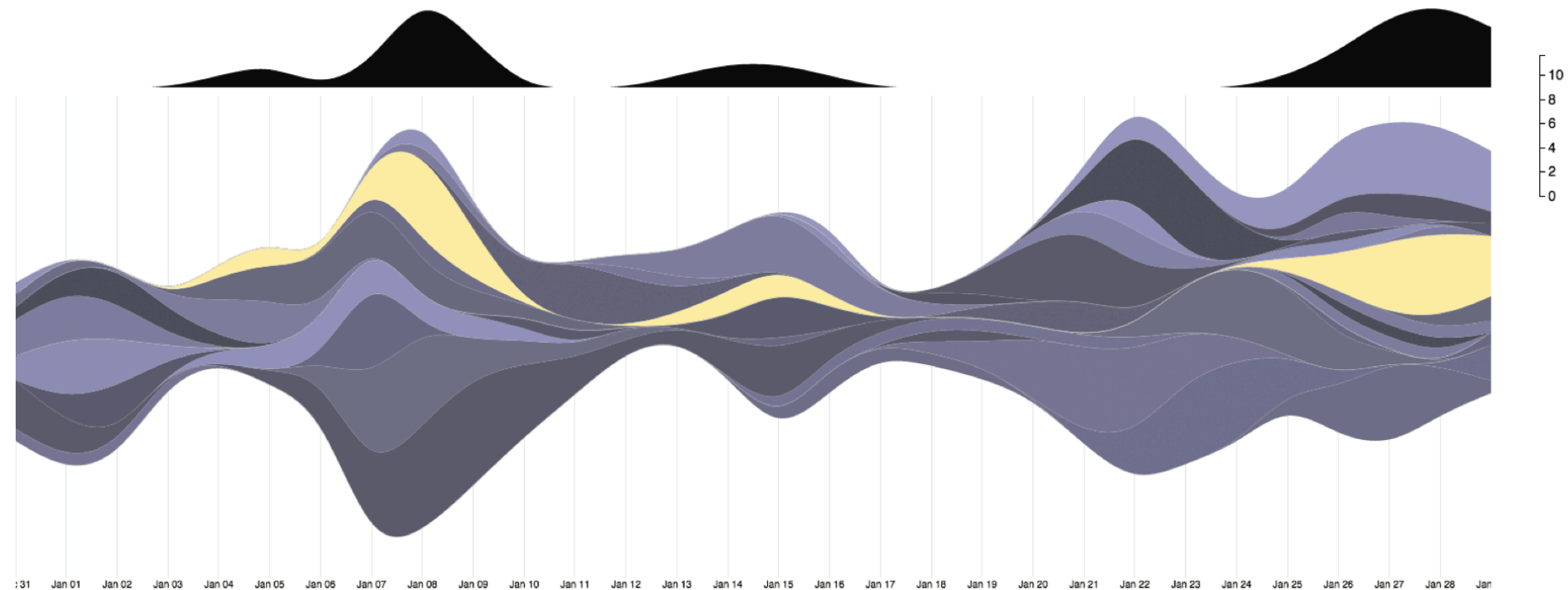
Strong & small effect

>



Slower

STREAM COMPARISON



STREAM COMPARISON

 Correctness



Strong & small effect

>

Strong & small effect

>

Weak & large effect

≥



More Correct

Less Correct

STREAM COMPARISON

 Completion Time



Strong & small effect

$>$

Weak & small effect

\geq

Weak & small effect

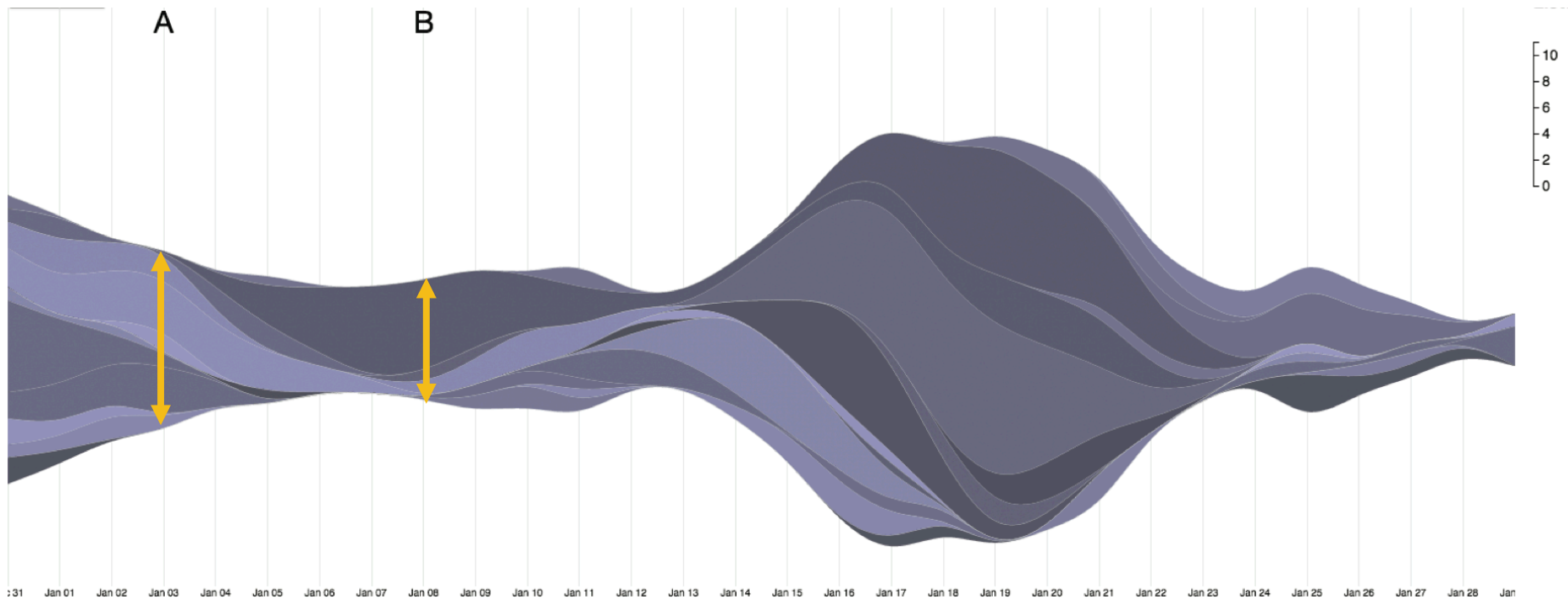
\geq



Faster

Slower

AGGREGATE DISCRIMINATION



AGGREGATE DISCRIMINATION

✓ Correctness



Strong & small effect
>



More Correct

Less Correct

AGGREGATE DISCRIMINATION

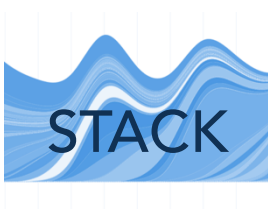
✓ Correctness



Strong & small effect
>



Strong & small effect
>



More Correct

Less Correct

AGGREGATE DISCRIMINATION

✓ Correctness



\approx 100% Correctness

AGGREGATE DISCRIMINATION

 Completion Time



Strong & small effect

>



Faster

Slower

AGGREGATE DISCRIMINATION



Completion Time



Strong & small effect

>



Strong & large effect

>



>

Strong & small effect



Faster

Slower

AGGREGATE DISCRIMINATION

 Completion Time



Strong & large effect



Strong & large effect

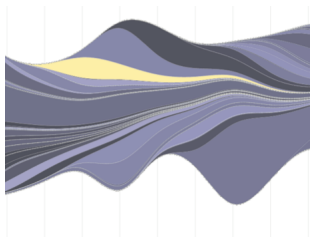


Faster

Slower

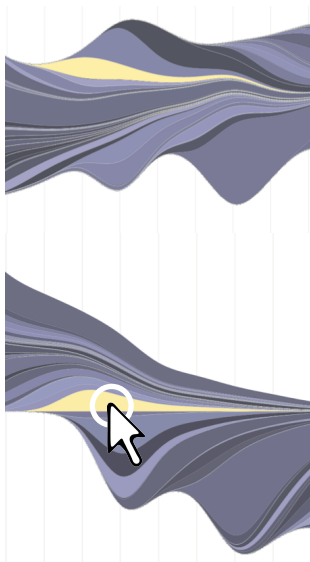
IMPLICATIONS

WHEN TO USE WHICH STACKED GRAPH?



STREAM for elementary and global level tasks with static graph

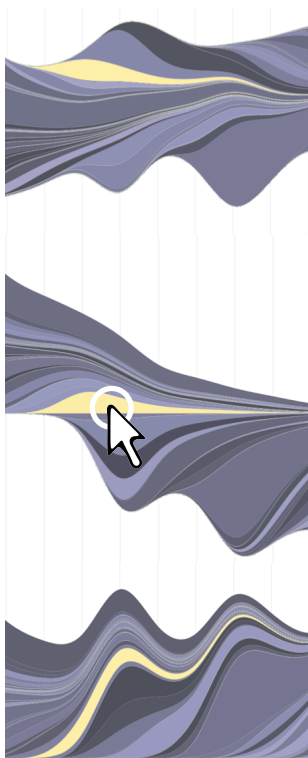
WHEN TO USE WHICH STACKED GRAPH?



STREAM for elementary and global level tasks with static graph

INT for intermediate and global level tasks

WHEN TO USE WHICH STACKED GRAPH?



STREAM for elementary and global level tasks with static graph

INT for intermediate and global level tasks

STACK did not provide advantage, but perceived as pleasing and easy to read

OTHER IMPLICATIONS

Theoretical Models

can work to predict perceptual advantages
do not show extent of advantages

OTHER IMPLICATIONS

Theoretical Models

- can work to predict perceptual advantages
- do not show extent of advantages

Interaction

- can be used for mitigating perceptual difficulties
- avoid increasing memory load



A. Thudt | J. Walny | C. Perin | F. Rajabiyazdi | L. MacDonald | R. Vardeleon | S. Greenberg | S. Carpendale

THANK YOU!

Project Page: <http://j.mp/stackedgraphs>

