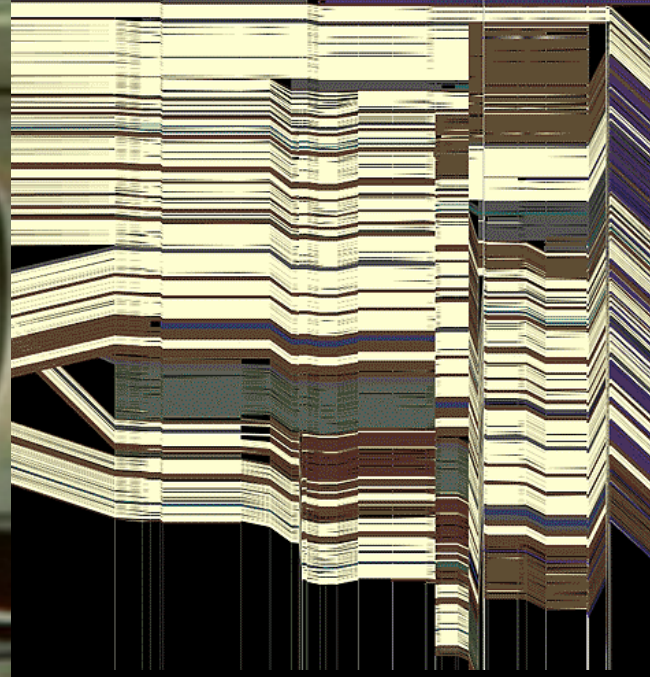
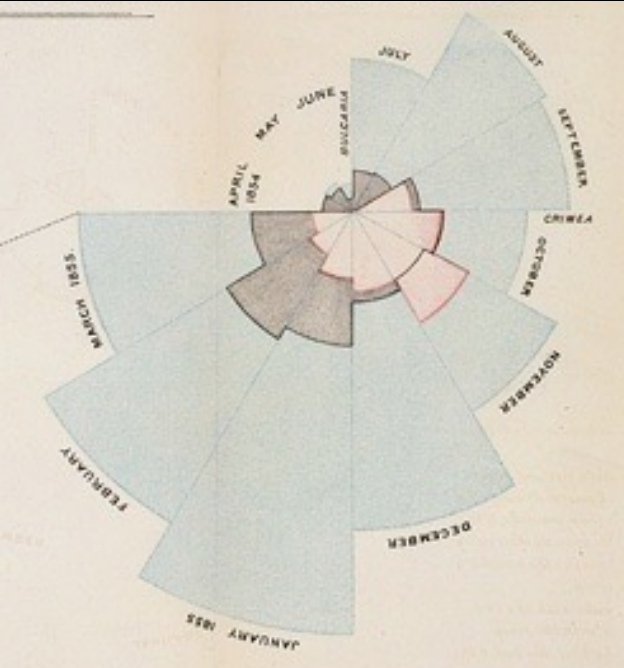


CSE 512 - Data Visualization

Animation



Jeffrey Heer University of Washington

Why Use Motion?

Visual variable to encode data

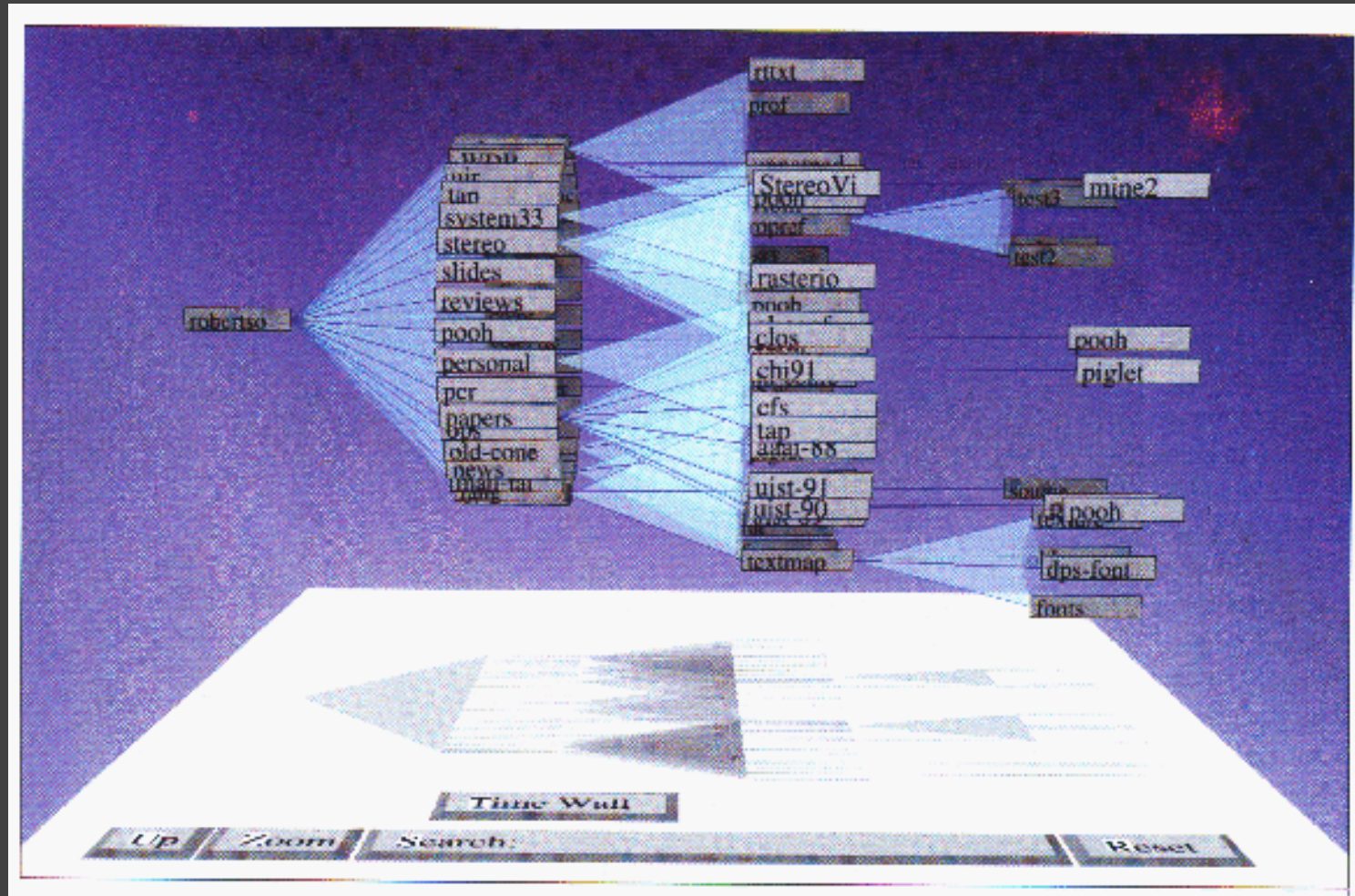
Direct attention

Understand system dynamics

Understand state transition

Increase engagement

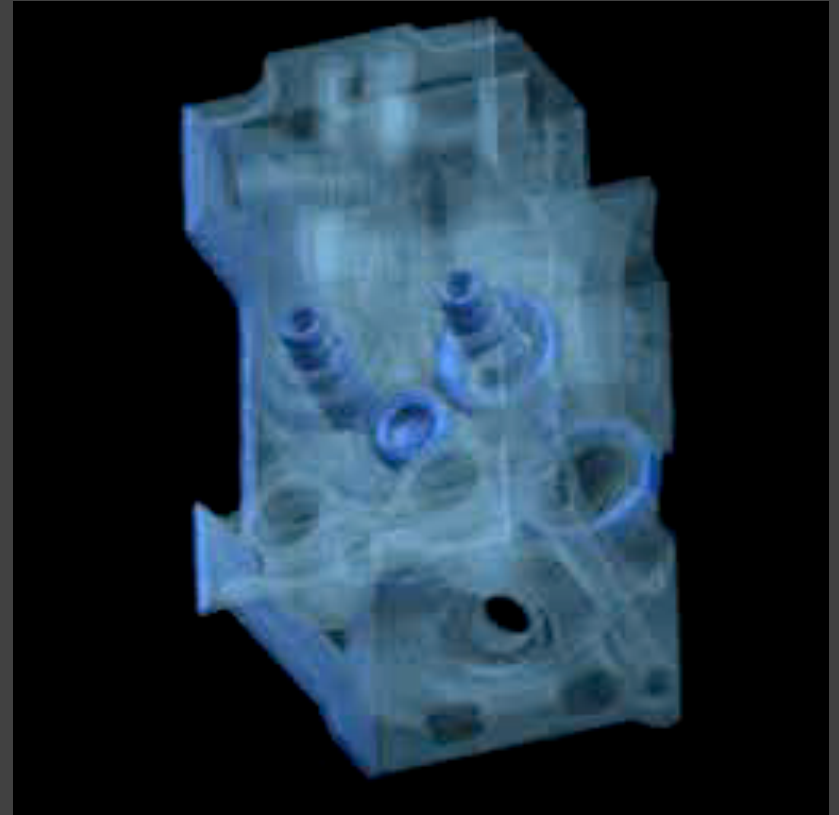
Cone Trees [Robertson 91]



[Video](#)

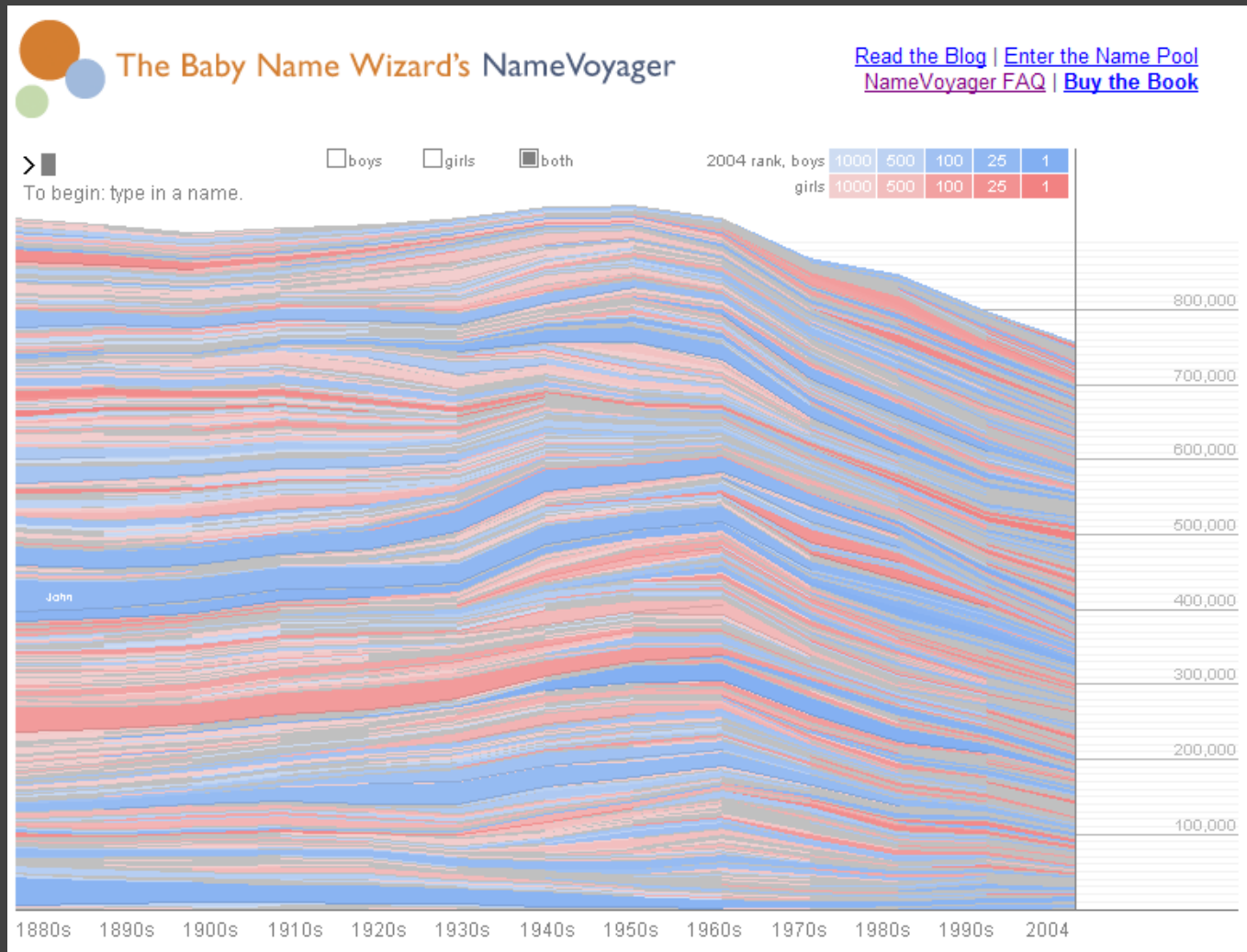


Volume Rendering [Lacroute 95]



Video

NameVoyager [Wattenberg 04]



<http://www.babynamewizard.com/namevoyager/Inv0105.html>

Topics

Motion perception

Principles for animation

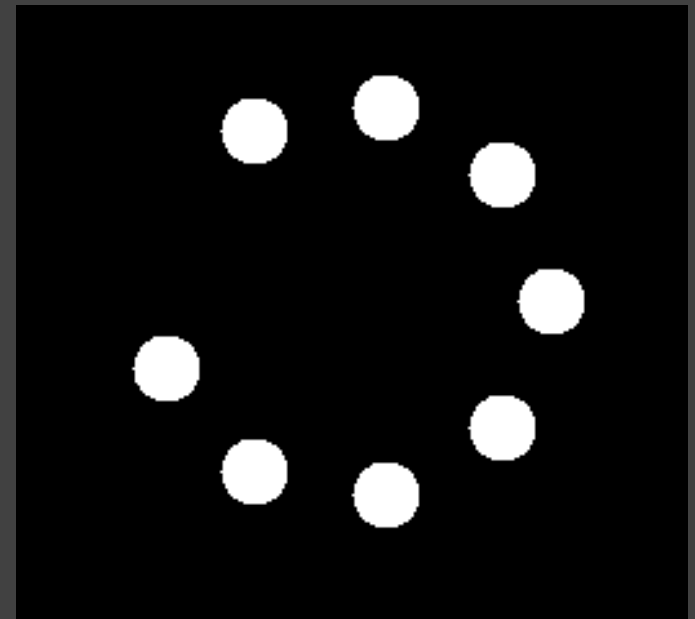
Animated transitions in visualizations

Motion Perception

Perceiving Animation

Under what conditions does a sequence of static images give rise to motion perception?

Smooth motion perceived
at ~ 10 frames/sec (100 ms).



<http://www1.psych.purdue.edu/Magniphi/PhilsNotBeta/phi2.html>

Motion as Visual Cue

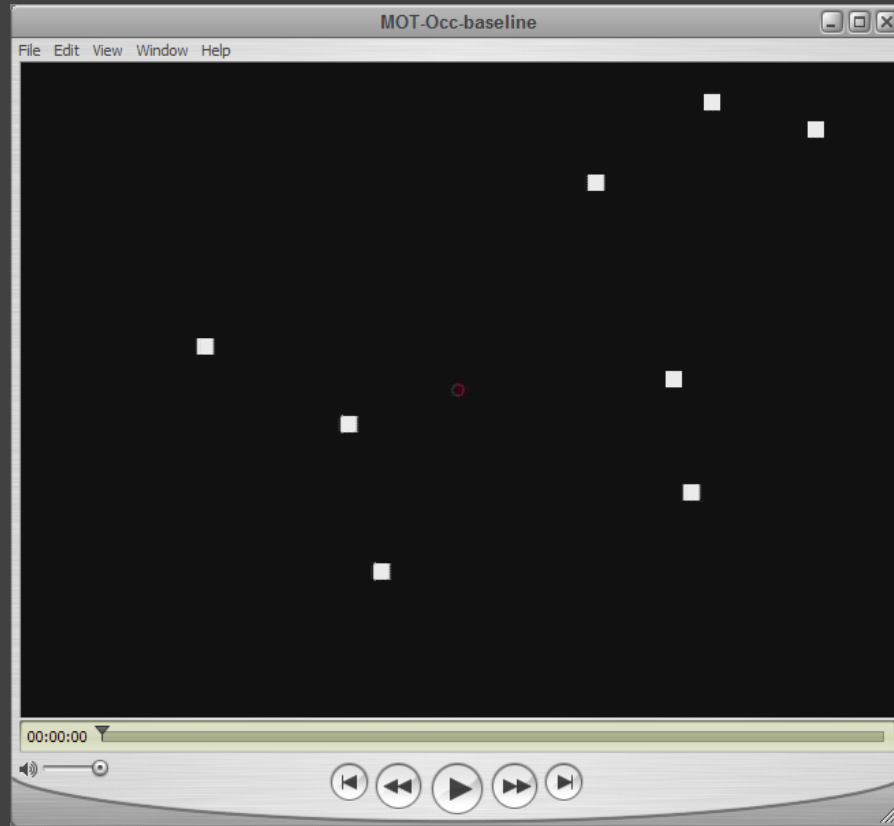
Pre-attentive, stronger than color, shape, ...

More sensitive to motion at periphery

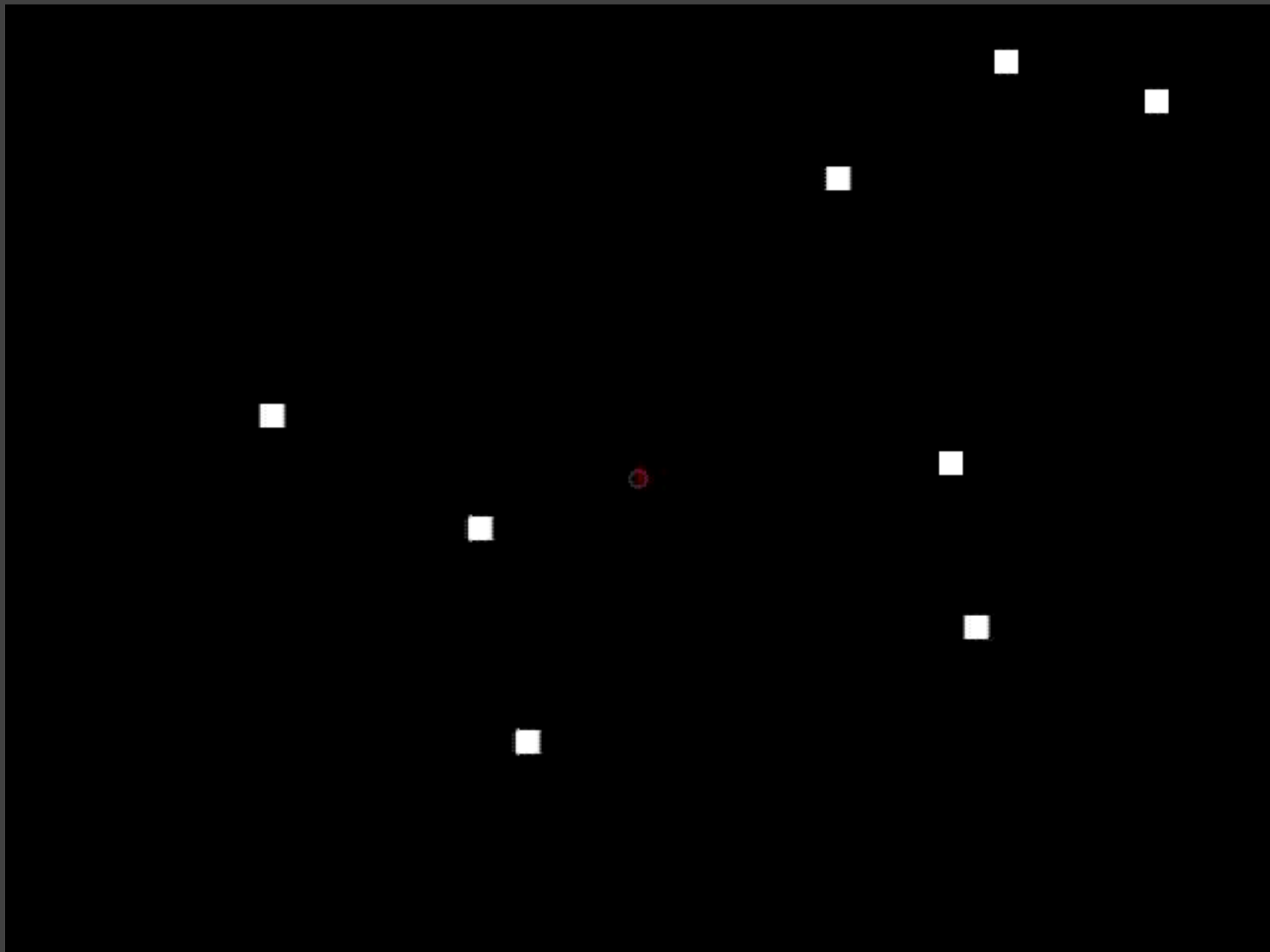
Similar motions perceived as a group

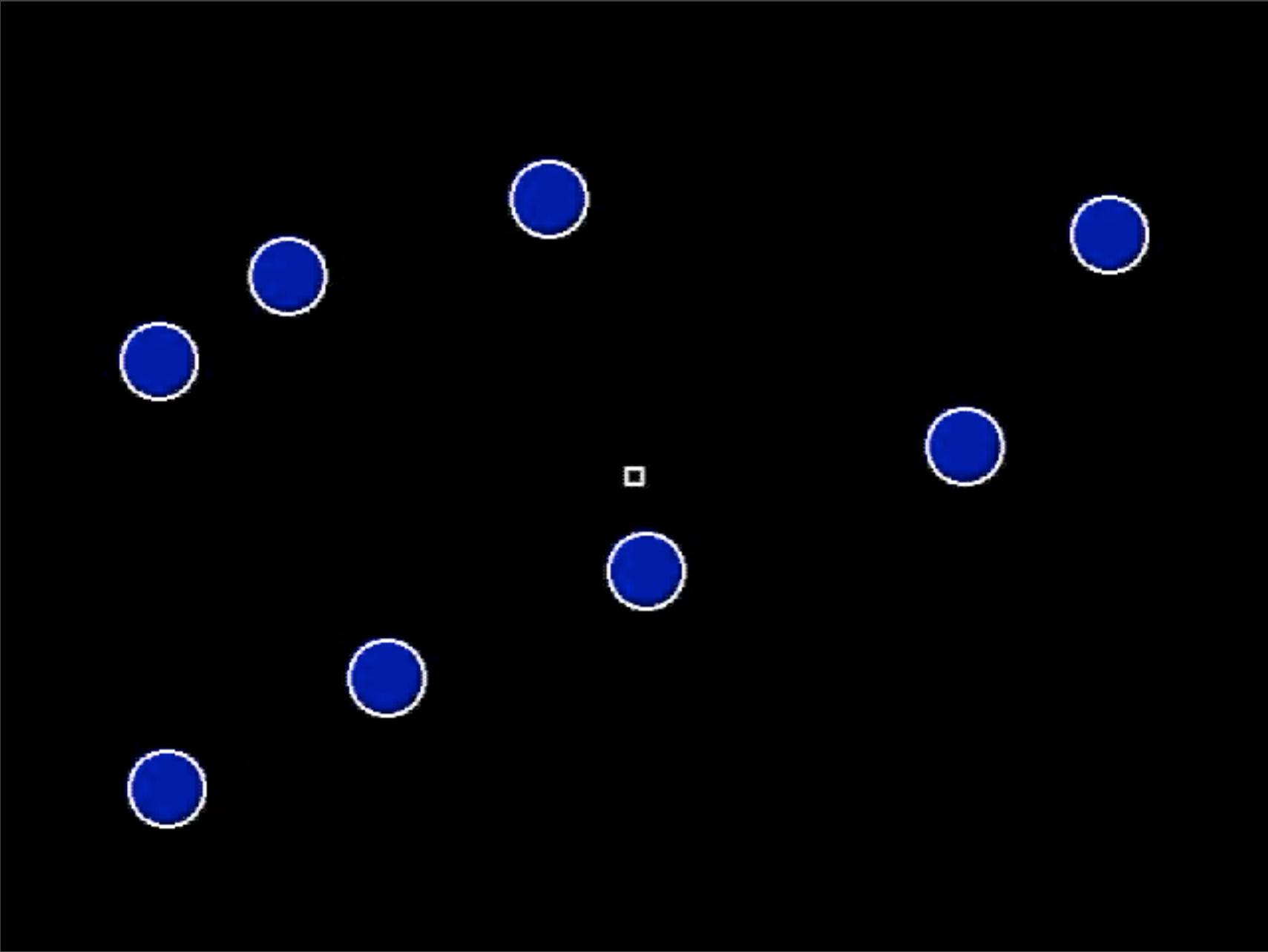
Motion parallax provide 3D cue (like stereopsis)

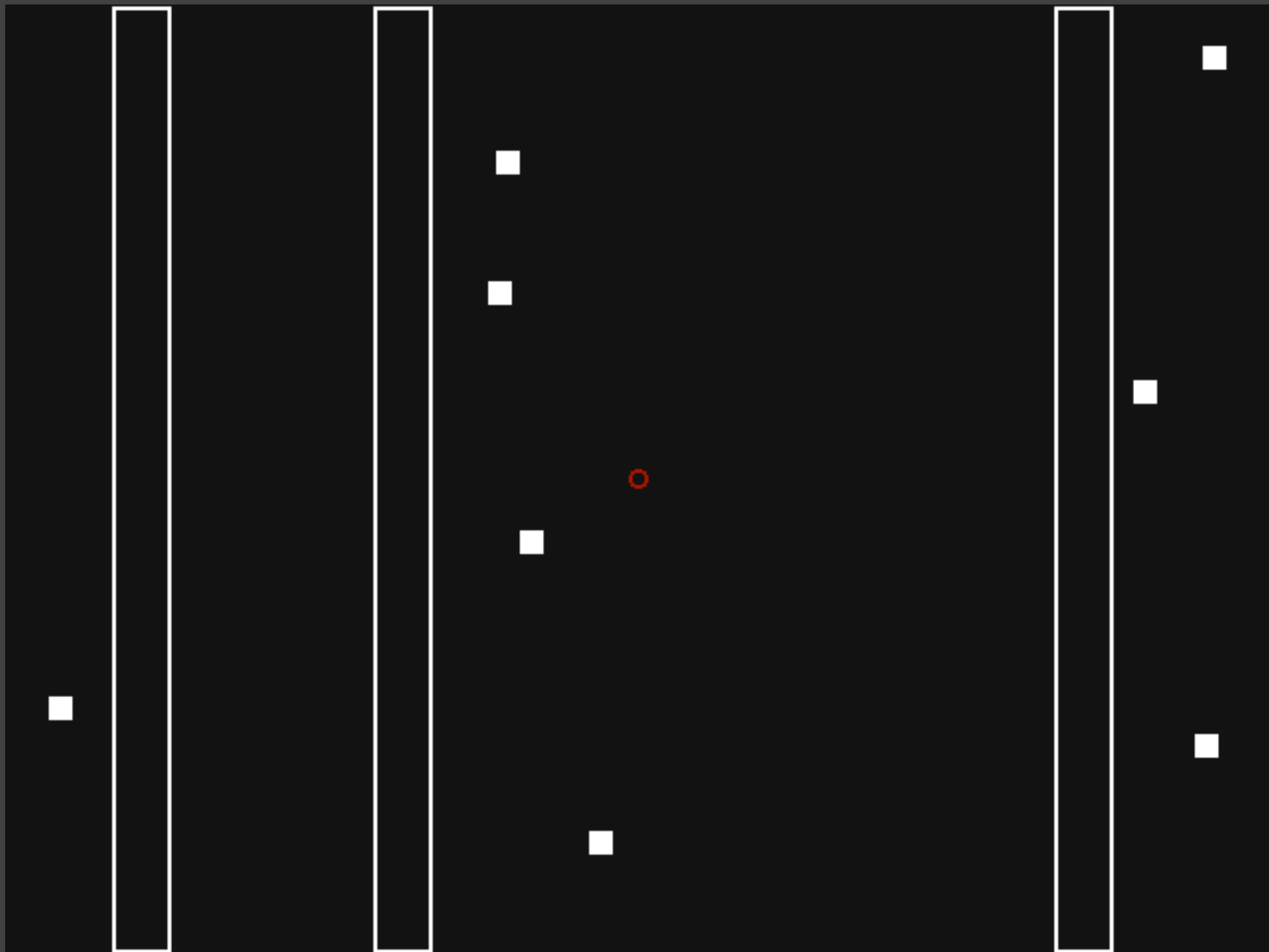
Tracking Multiple Targets

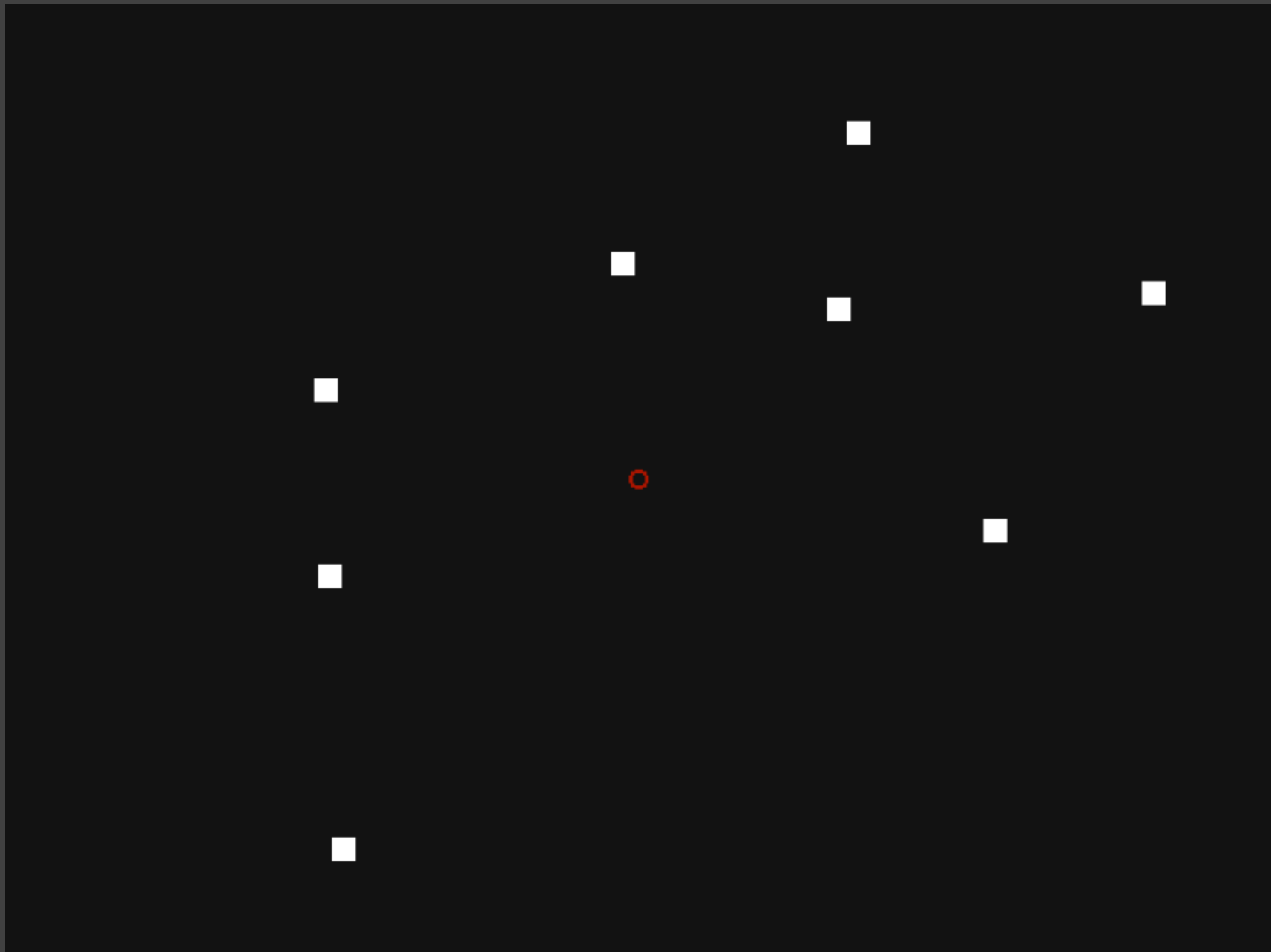


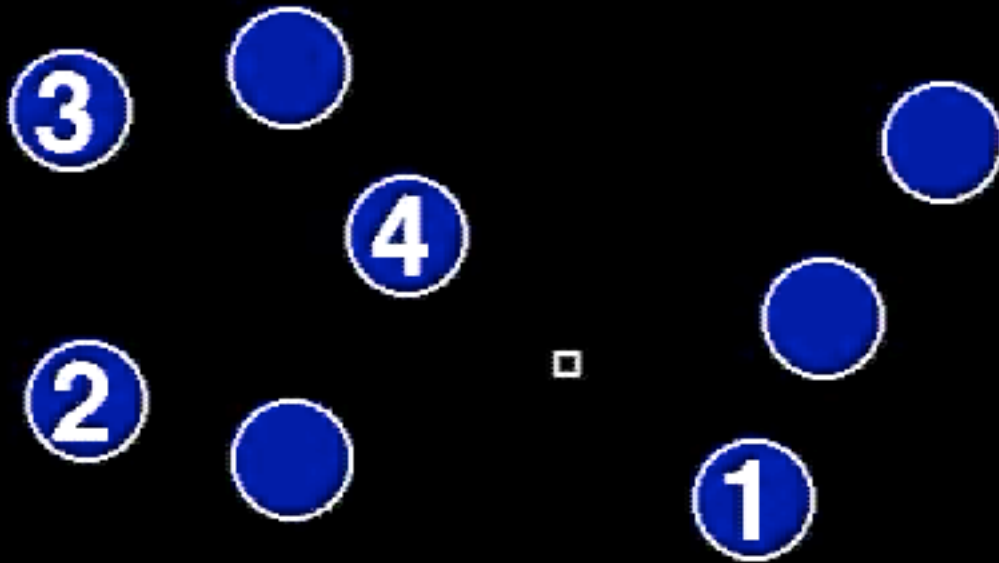
How many dots can we simultaneously track?



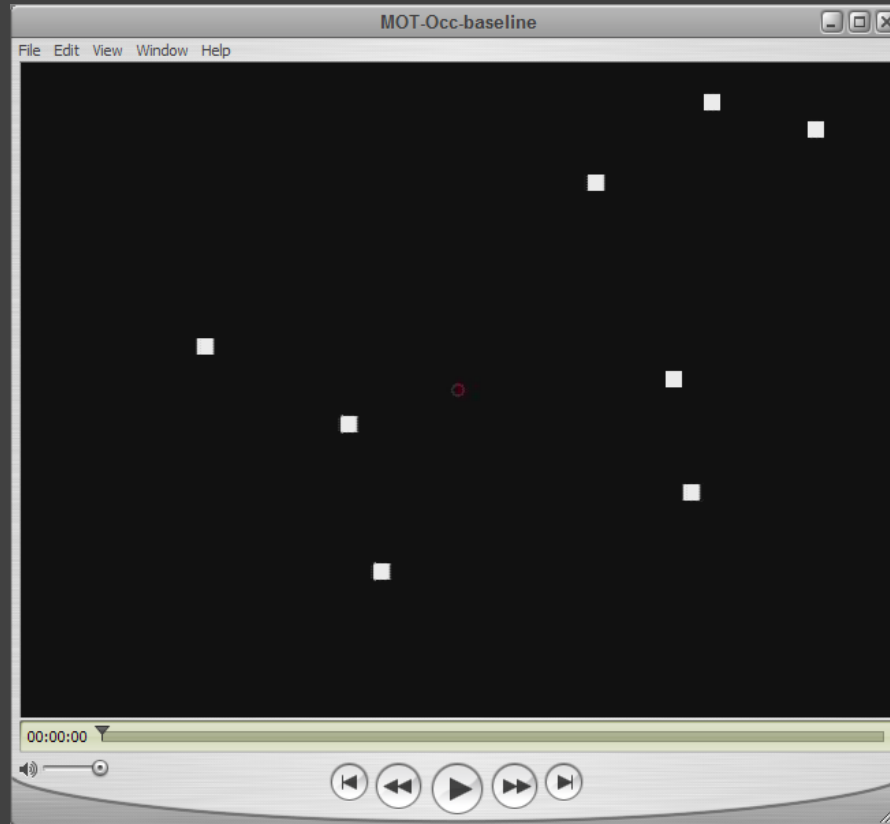








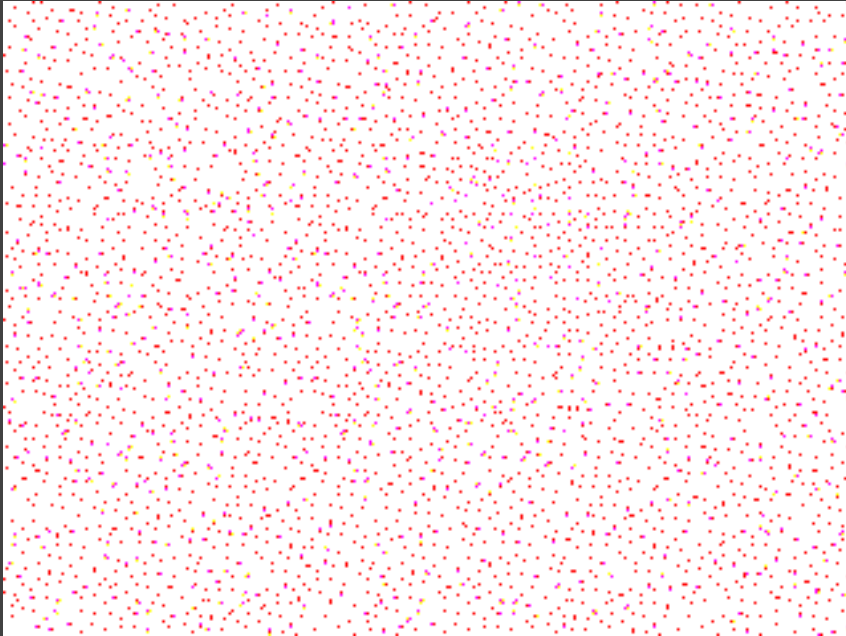
Tracking Multiple Targets



How many dots can we simultaneously track?

~4-6. Difficulty increases sig. at 6. [Yantis 92, Pylyshn 88, Cavanagh 05]

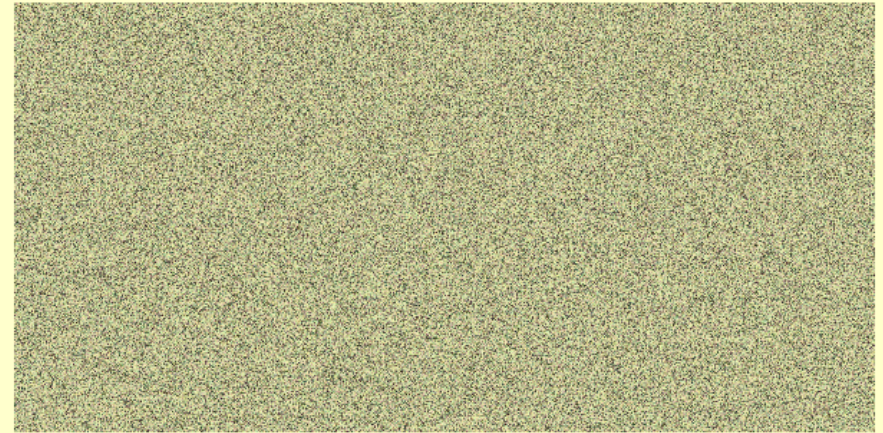
Segment by Common Fate



<http://dragon.uml.edu/psych/commfate.html>

Sand Shrimp

These camouflaged creatures are shy and prefer to hide.
They reveal themselves only when they feel a nudge.

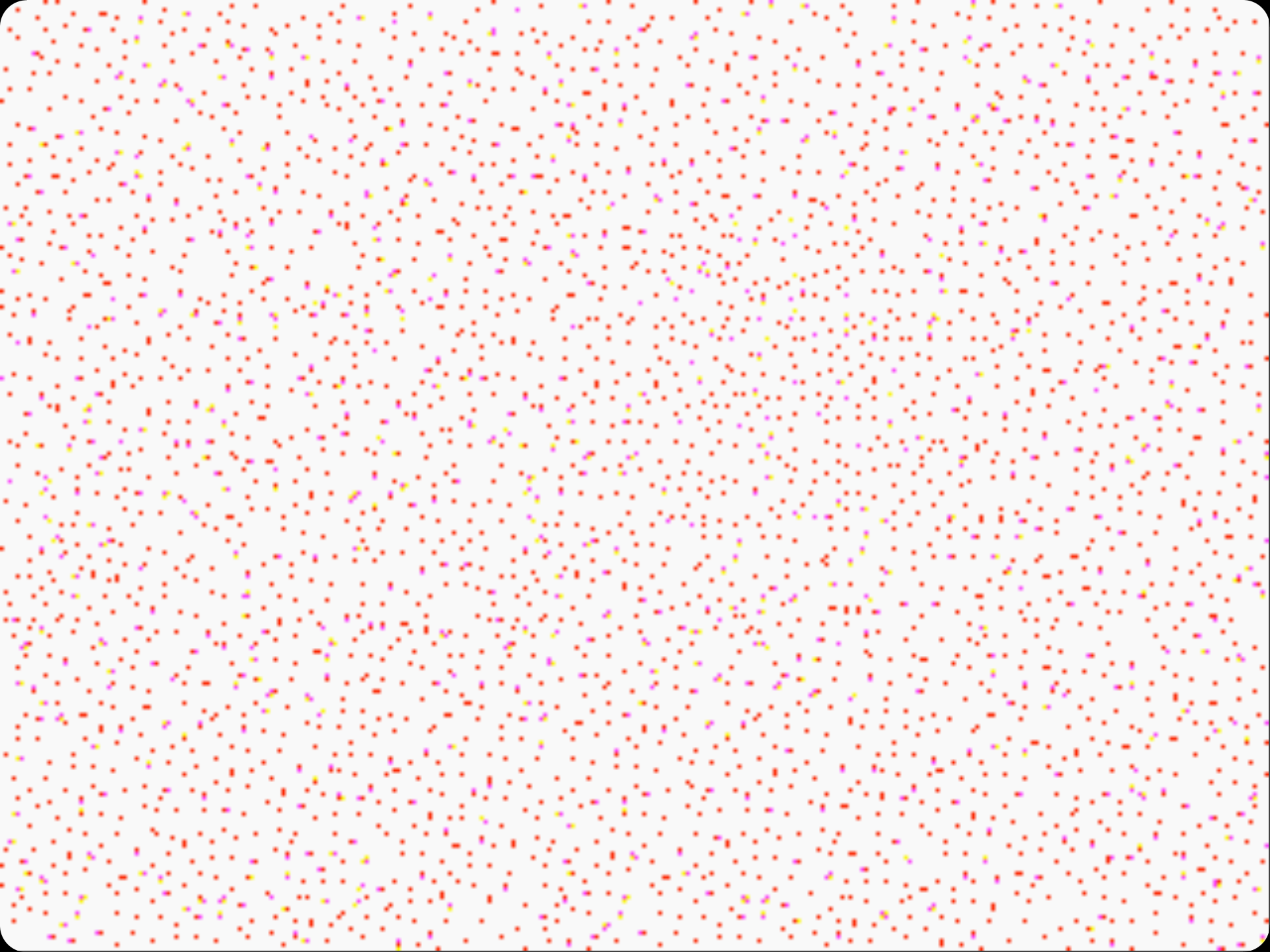


singlecell: July 2001

by Martin Wattenberg, New York

See also: [The Shape of Song](#) - [Apartment](#) - [Map of the Market](#)

<http://www.singlecell.org/july/index.html>



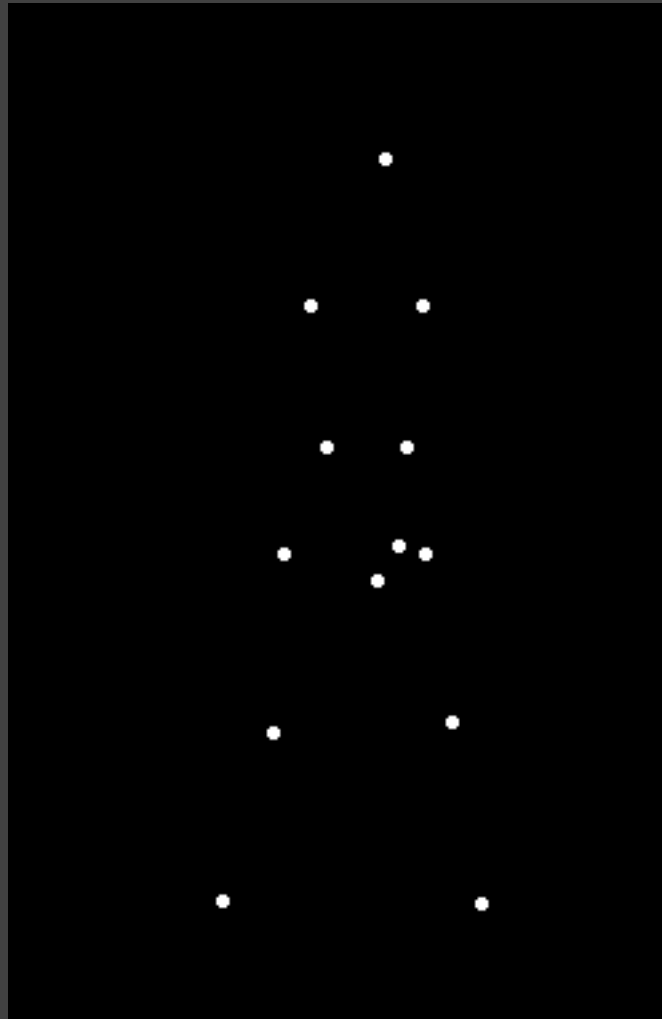
Grouped Dots Count as 1 Object



Dots moving together are grouped

<http://coe.sdsu.edu/eet/articles/visualperc1/start.htm>

Grouping of Biological Motion



[Johansson 73]

http://www.lifesci.sussex.ac.uk/home/George_Mather/Motion/WALK.MOV

Motions Show Transitions

See change from one state to next



start

Motions Show Transitions

See change from one state to next



end

Motions Show Transitions

See change from one state to next



start

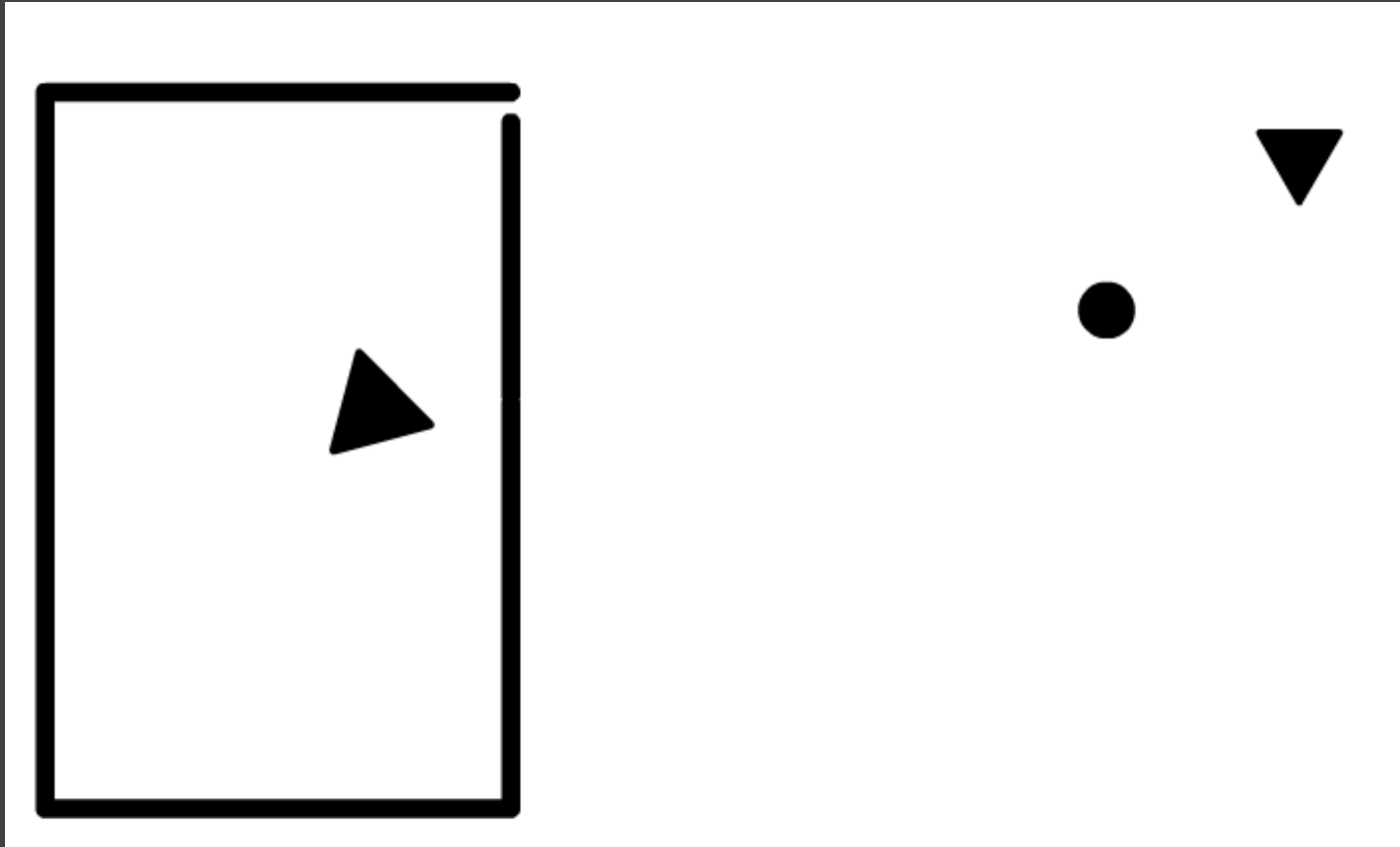
end

Shows transition better, but

Still may be too fast, or too slow

Too many objects may move at once

Constructing Narratives



http://anthropomorphism.org/img/Heider_Flash.swf

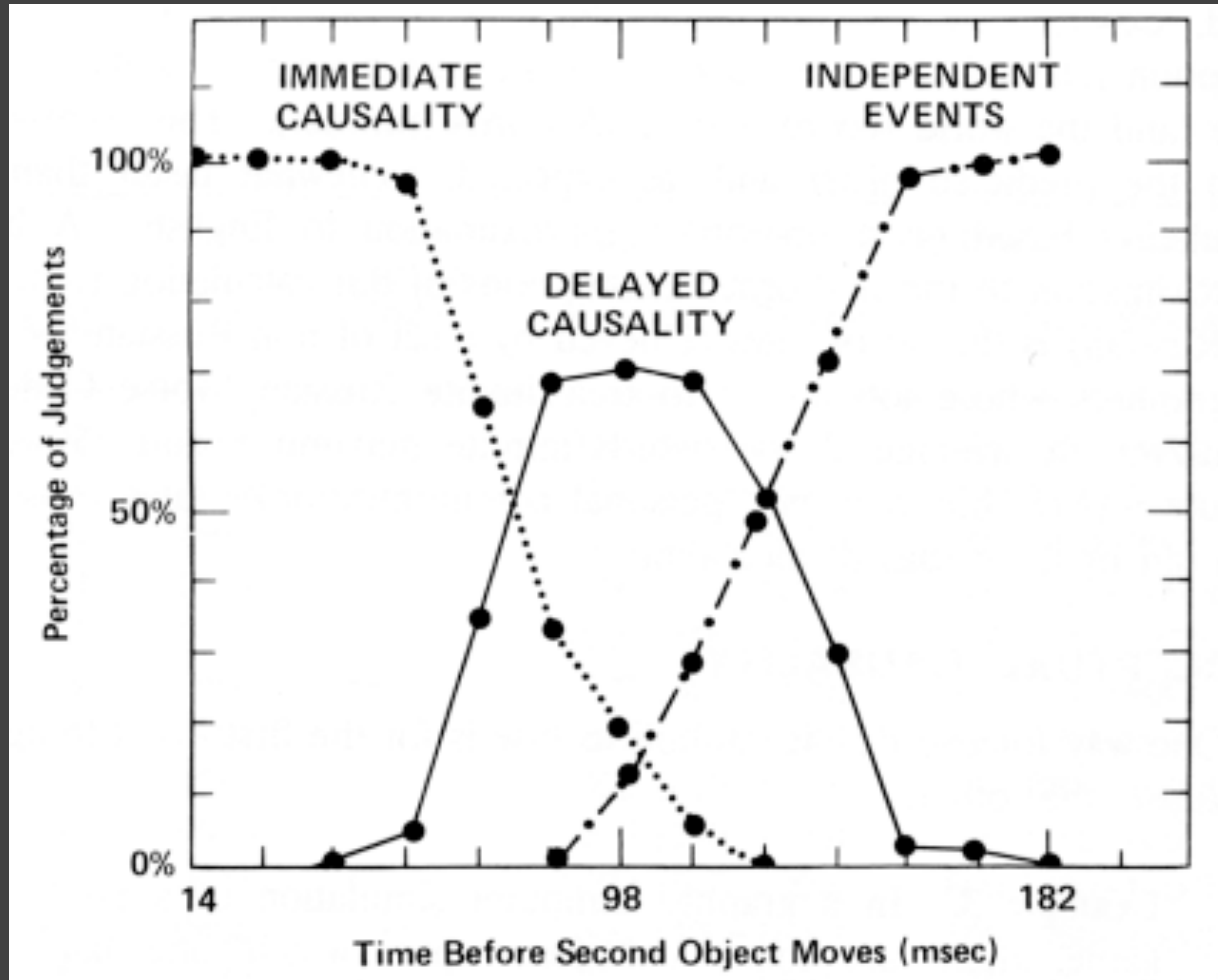
Attribution of Causality [Michotte 46]

Michotte demonstration 1. What do you see? Most observers report that "the **red ball hit** the **blue ball**." The **blue ball** moved "**because** the **red ball** hit it." Thus, the **red ball** is perceived to "**cause**" the **blue ball** to move, even though the balls are nothing more than color disks on your screen that move according to a programme.



<http://cogweb.ucla.edu/Discourse/Narrative/michotte-demo.swf>

Attribution of Causality [Michotte 46]



[Reprint from Ware 04]

Animation

Helps?

Hurts?

Attention

direct attention

distraction

Constancy

change tracking

false relations

Causality

cause and effect

false agency

Engagement

increase interest

"chart junk"

Calibration

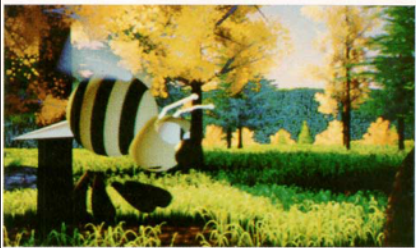
too slow: boring

too fast: errors



Animation Principles

Principles for Animation



Character Animation

(Johnston & Thomas '81, Lasseter '87)

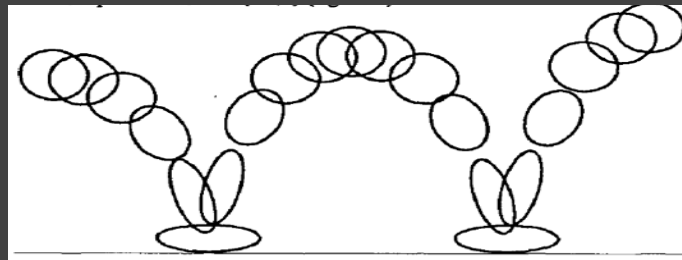
Squash and stretch

Exaggeration

Anticipation, Follow-through

Staging, Overlapping Action

Slow-in / Slow-out

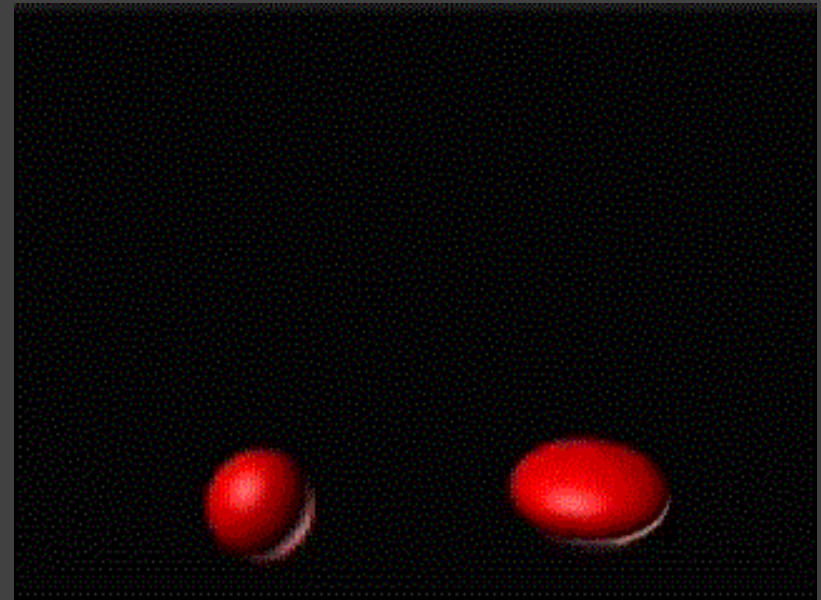
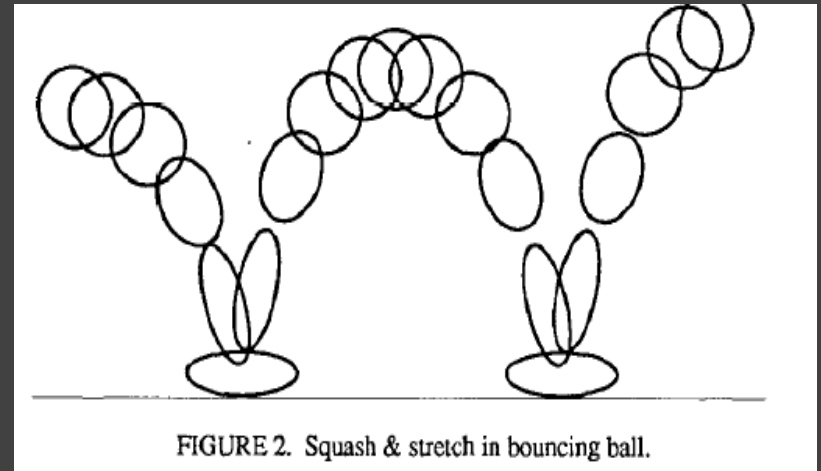


Squash & Stretch

Defines rigidity of material

Should maintain constant volume

Smooths fast motion, similar to motion blur



Staging

Clear presentation of one idea at a time

Highlight important actions

Lead viewers' eyes to the action

Motion in still scene, stillness in busy scene

Motion clearest at silhouette



Anticipation

Show preparation for an action



Follow-Through

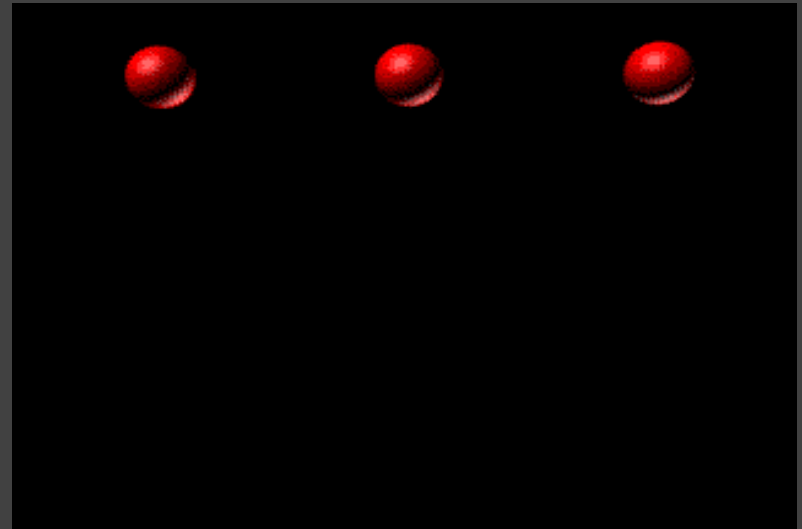
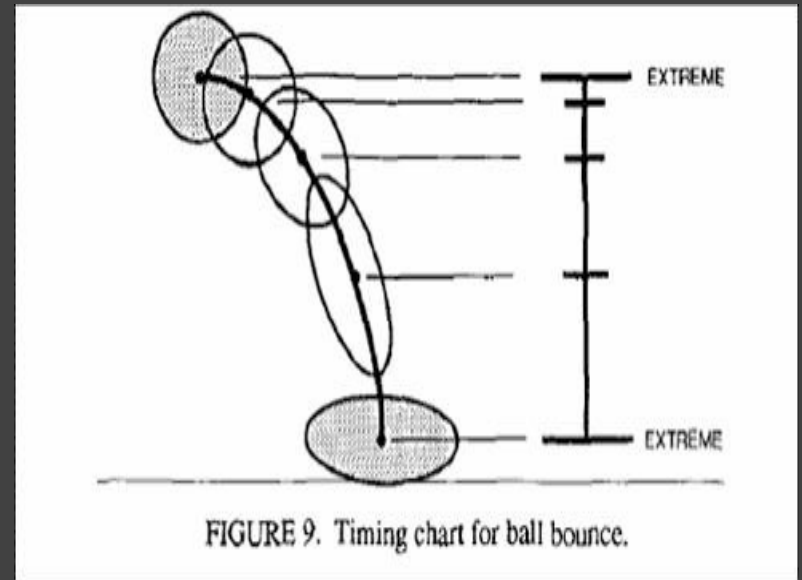
Emphasize termination of action



Slow-In, Slow-Out

Space in-betweens to provide slow-in and out

Linear interpolation is less pleasing



Example: Andre and Wally B.



Example: Andre and Wally B.



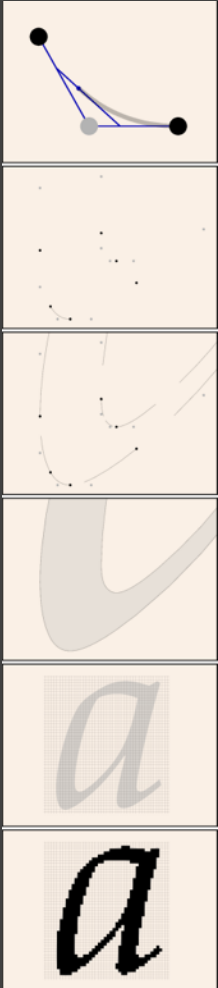
Example: Andre and Wally B.



Example: Andre and Wally B.



Principles for Animation



Animated Presentations

(Zongker & Salesin '03)

Make all movement meaningful

Avoid squash-and-stretch, exaggeration

Use anticipation and staging

Do one thing at a time

Principles for Animation

Congruence

Expressiveness

The structure and content of the external representation should correspond to the desired structure and content of the internal representation.

Apprehension

Effectiveness

The structure and content of the external representation should be readily and accurately perceived and comprehended.

[from Tversky 02]

Problems with Animation [Tversky]

Difficult to estimate paths and trajectories

Motion is fleeting and transient

Cannot simultaneously attend to multiple motions

Parse motion into events, actions and behaviors

Misunderstanding and wrongly inferring causality

Anthropomorphizing physical motion may cause confusion or lead to incorrect conclusions

Administrivia

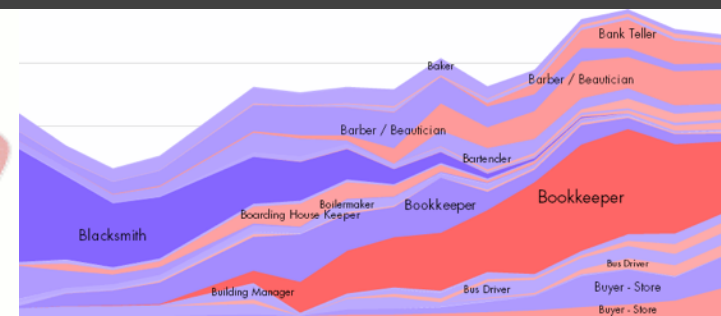
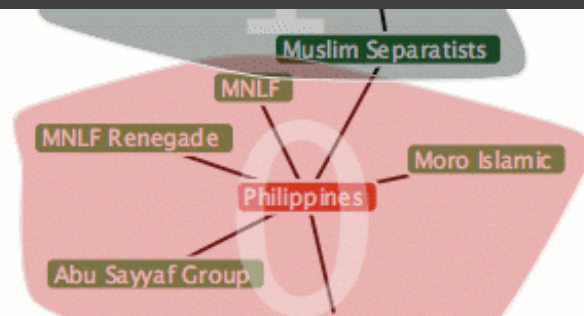
A3: Interactive Visualization

Create an interactive visualization application. Choose a data domain and an appropriate visualization technique.

1. Choose a data set and storyboard your interface
2. Implement the interface using tools of your choice
3. Submit your application and produce a final write-up

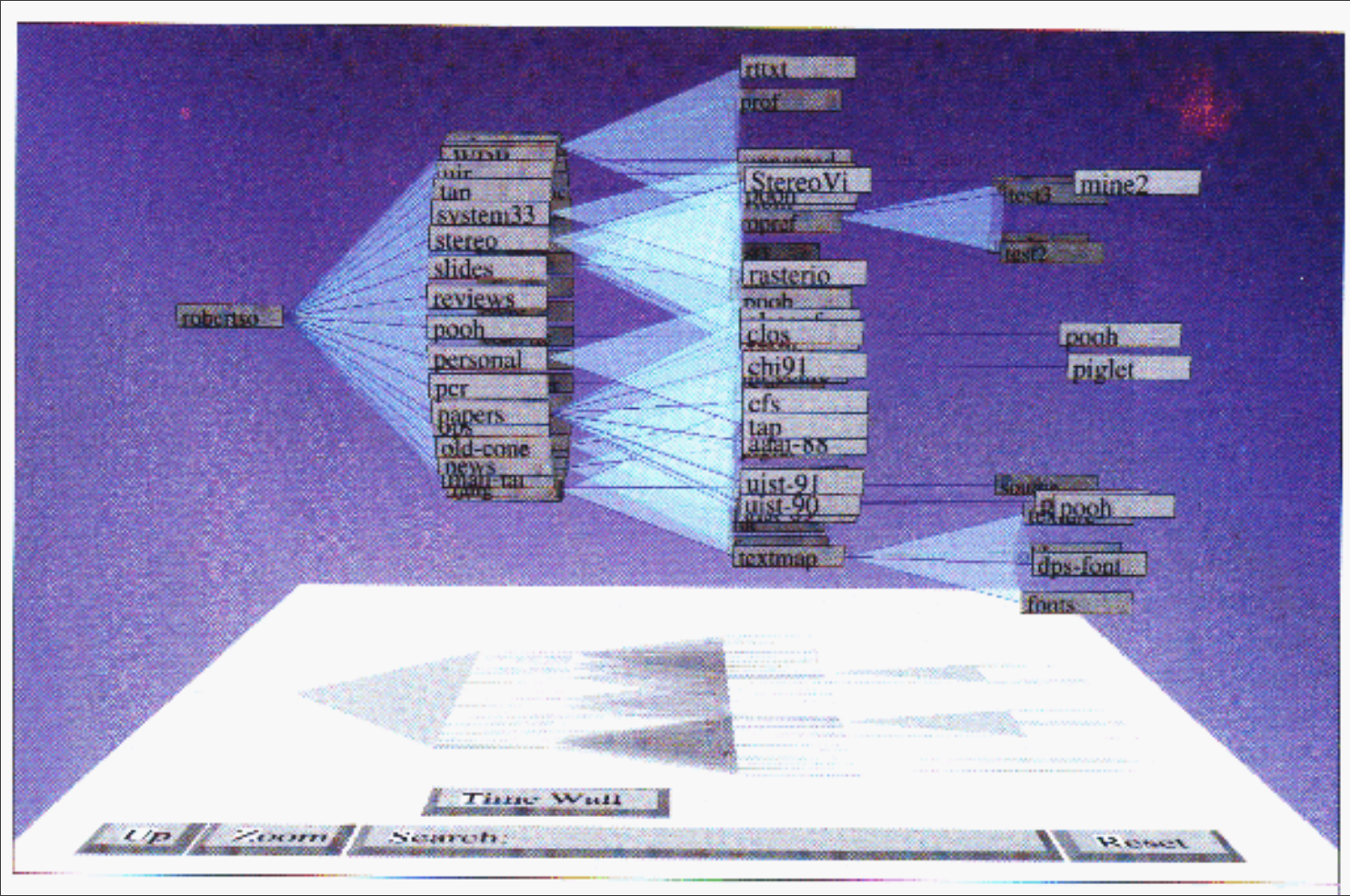
You should work in groups of 2-3.

Due by 5pm on **Monday, May 2**



Animated Transitions

Cone Trees [Robertson 91]



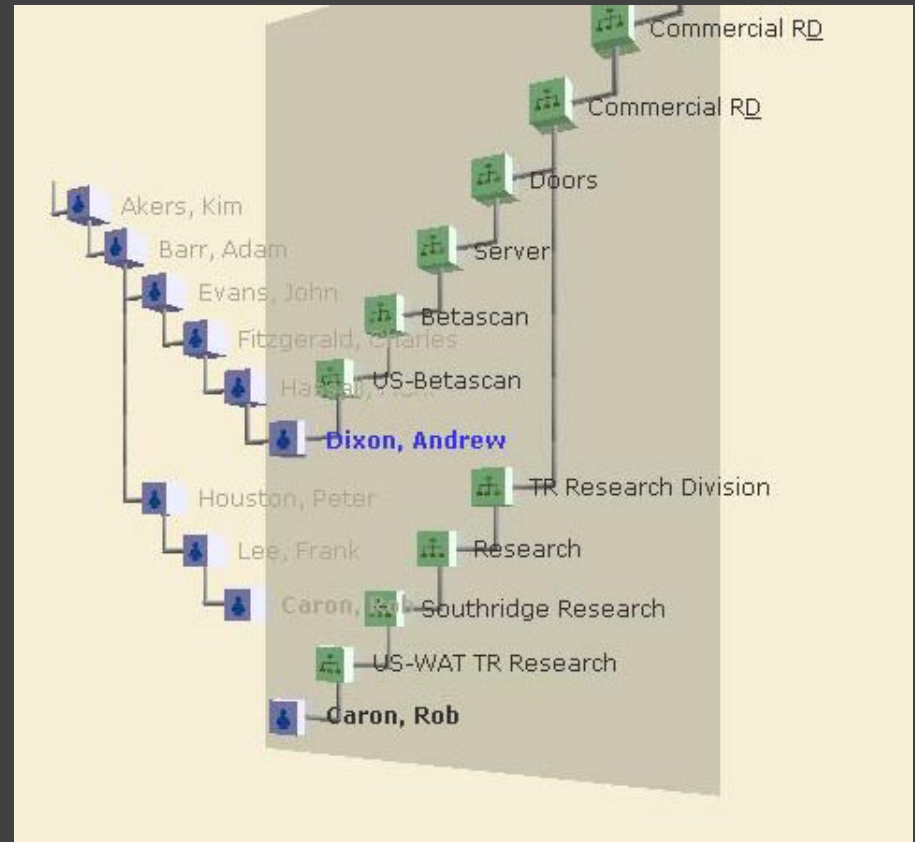
Polyarchies [Robertson 02]

Animate pivots across intersecting hierarchies.

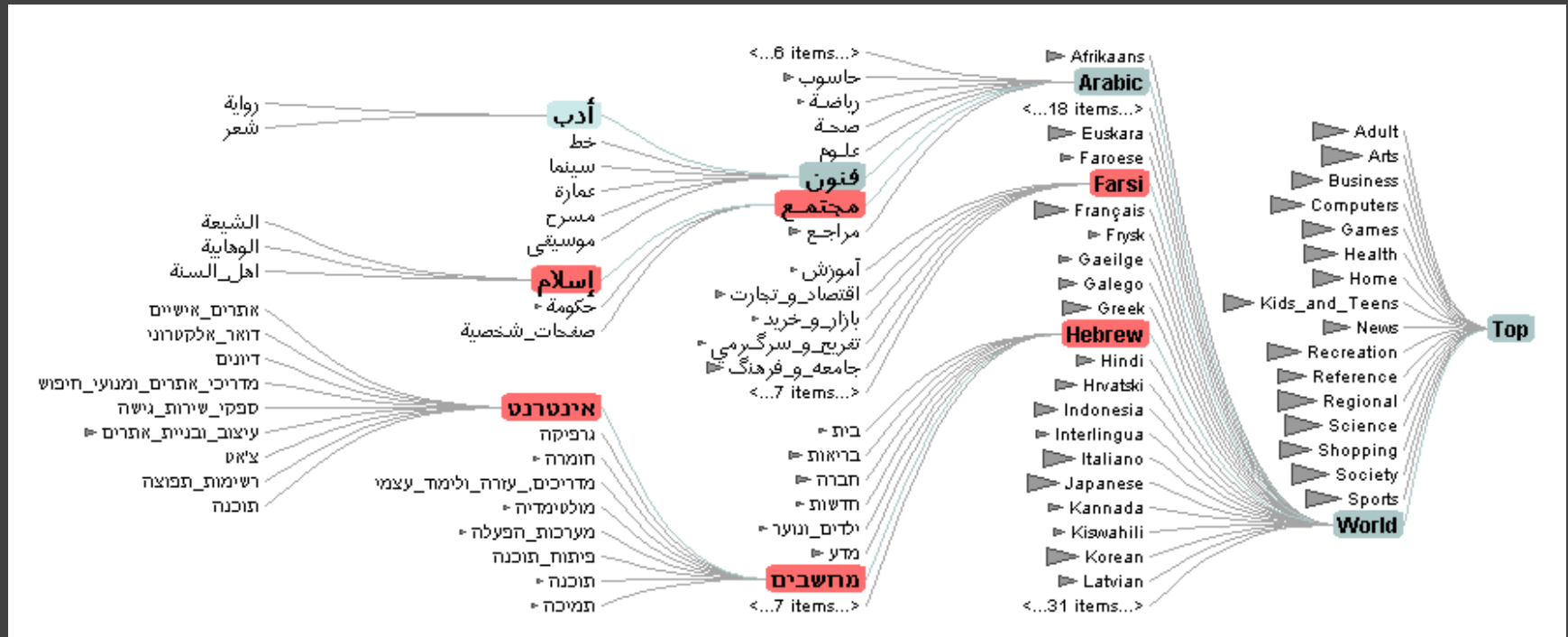
Tested a number of animation parameters.

Best duration: ~1 sec

Rotational movement degraded performance, translation preferred.

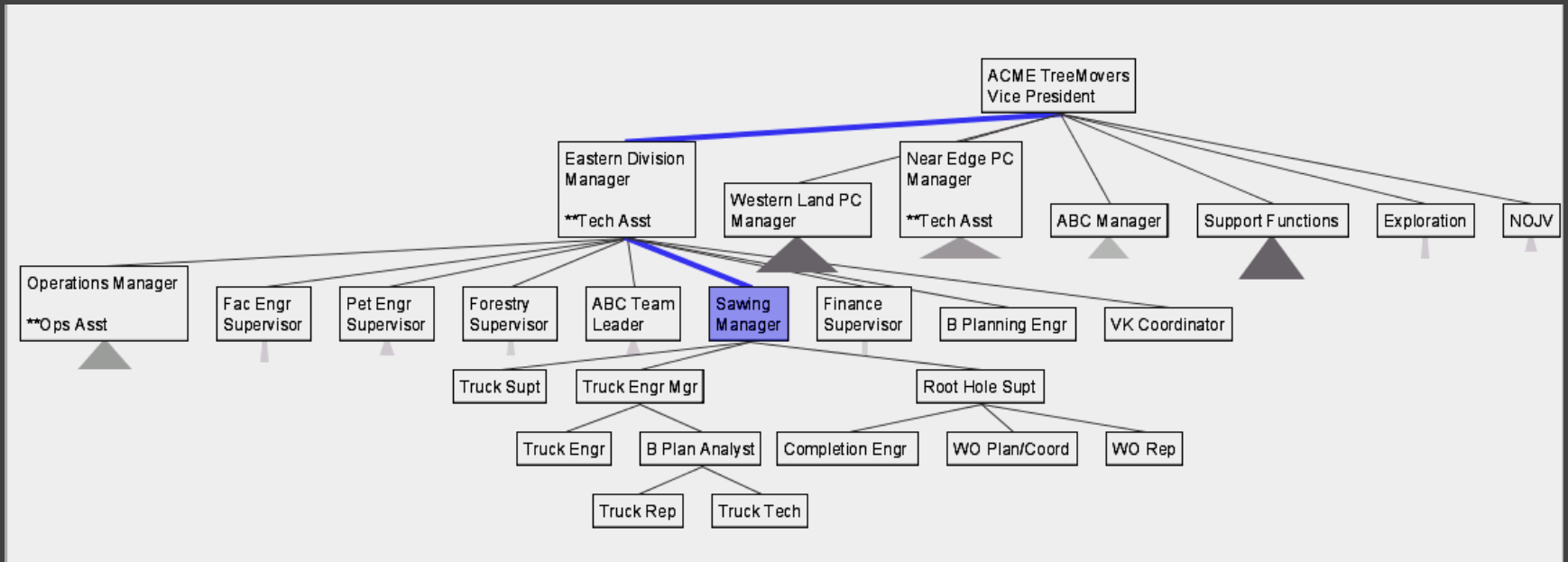


Degree-of-Interest Trees [Heer 04]



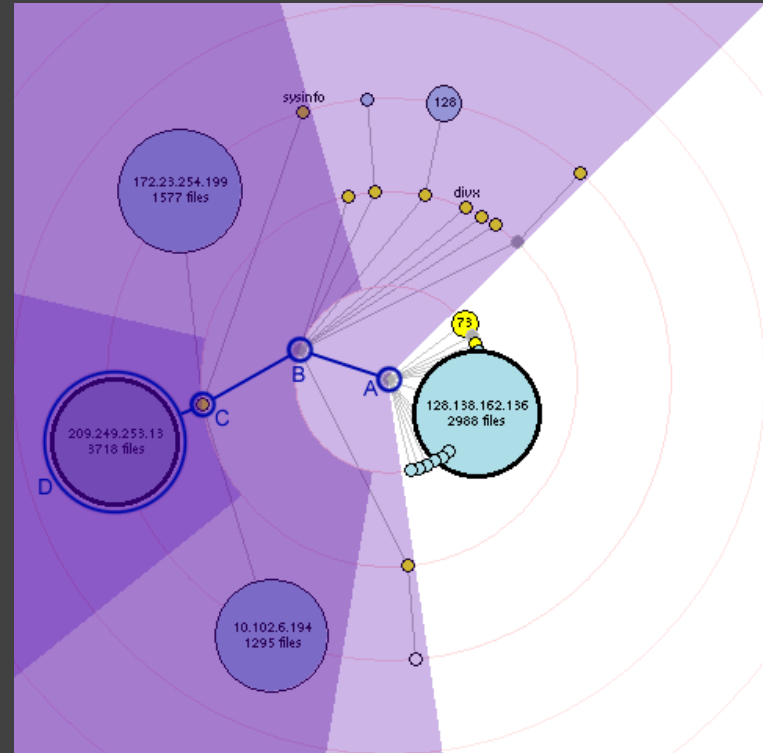
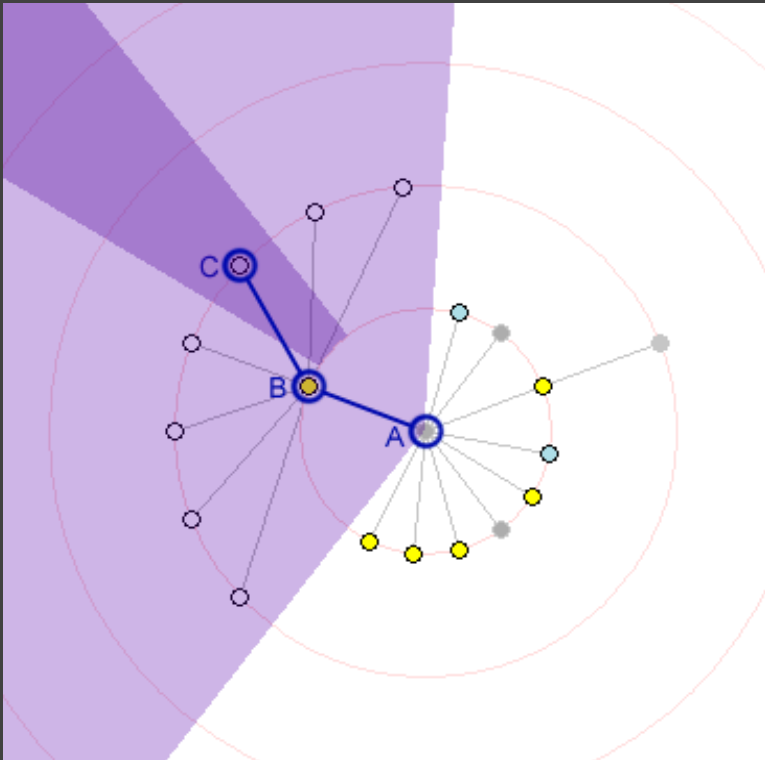
Animation of expanding/collapsing branches

Space Tree [Grosjean 04]



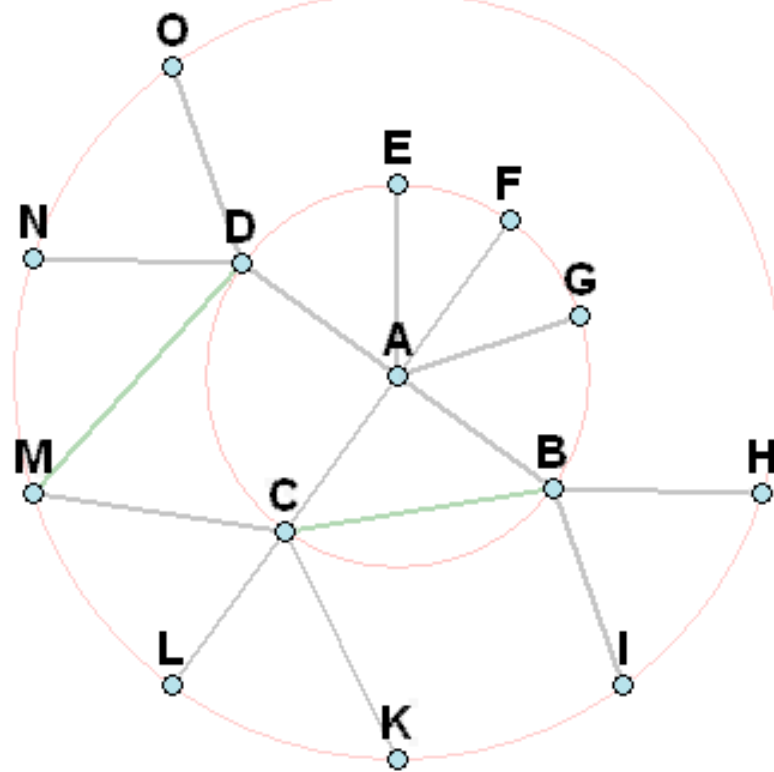
Break animated transitions into discrete stages

Radial Graph Layout



Optimize animation to aid comprehension

<http://people.ischool.berkeley.edu/~rachna/gtv/>



Animation in Radial Graph Layout

Help maintain context of nodes and general orientation of user during refocus.

Transition Paths

Linear interpolation of polar coordinates

Node moves in an arc, not straight lines

Moves along circle if not changing levels

When changing levels, spirals to next ring

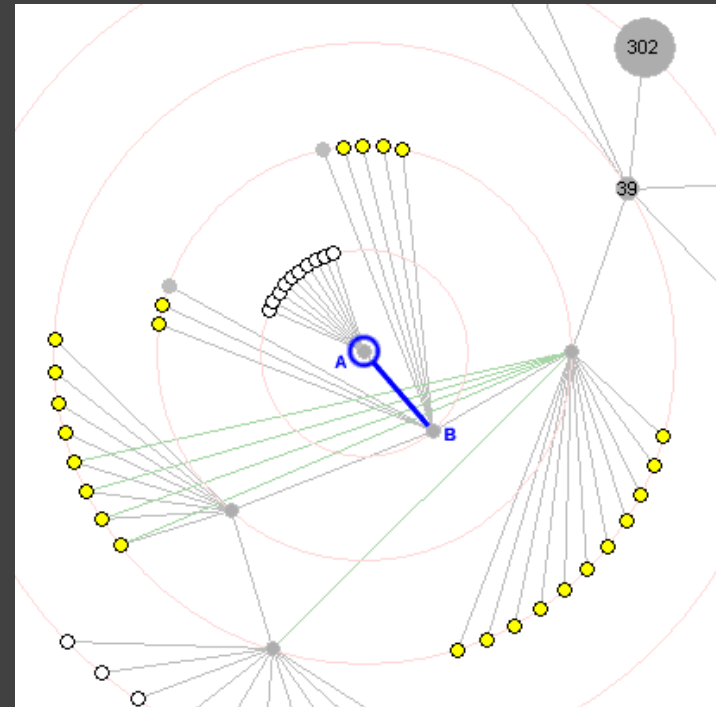
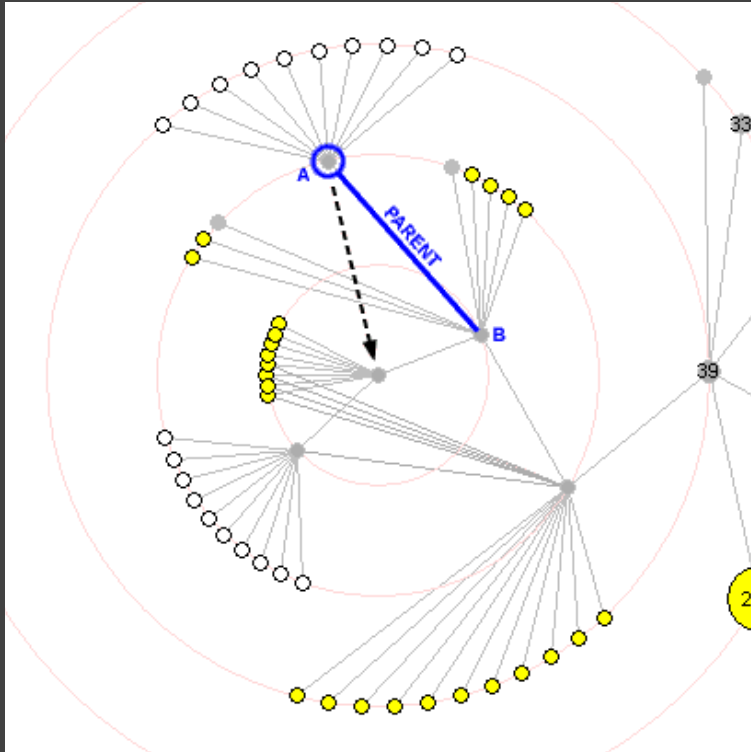
Animation in Radial Graph Layout

Transition constraints

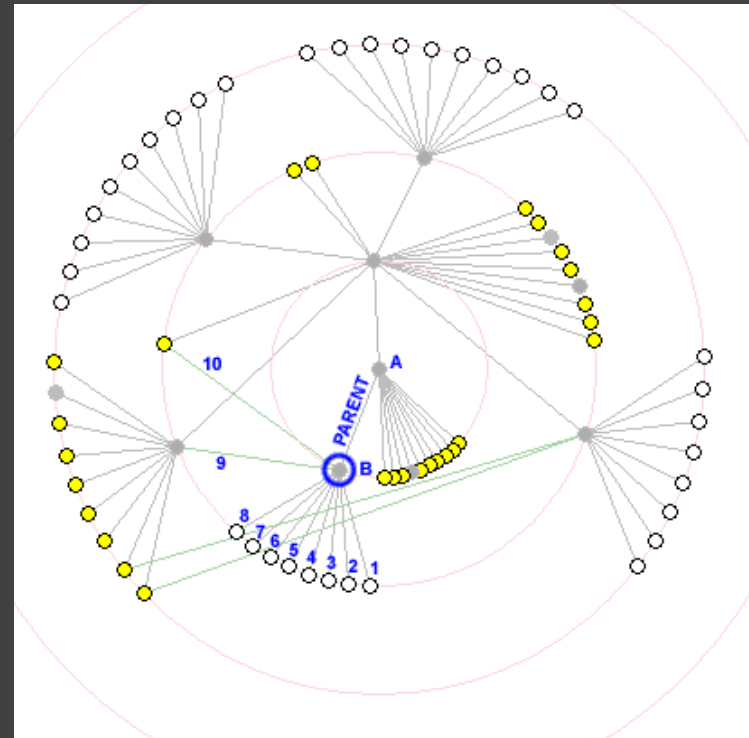
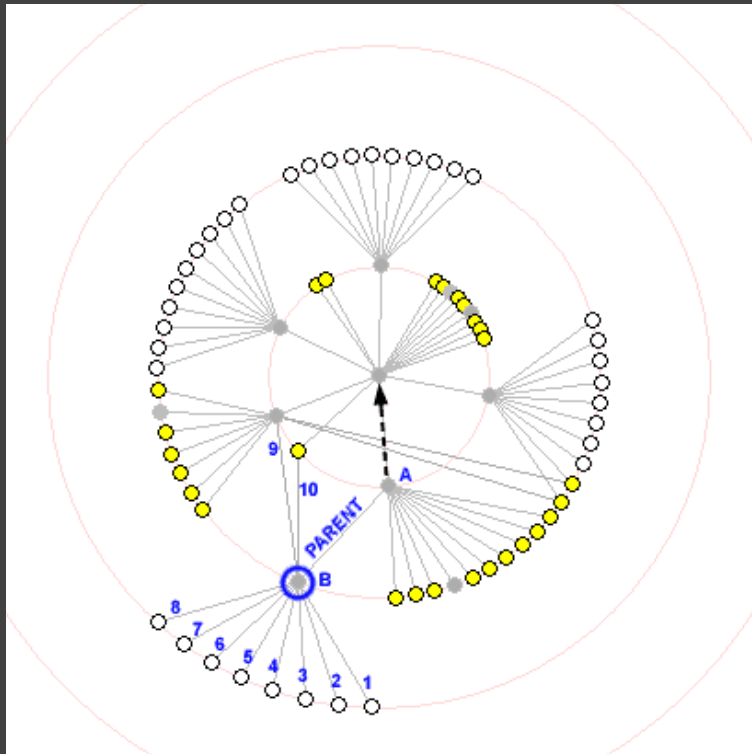
Minimize rotational travel (move former parent away from new focus in same orientation)

Avoid cross-over of edges

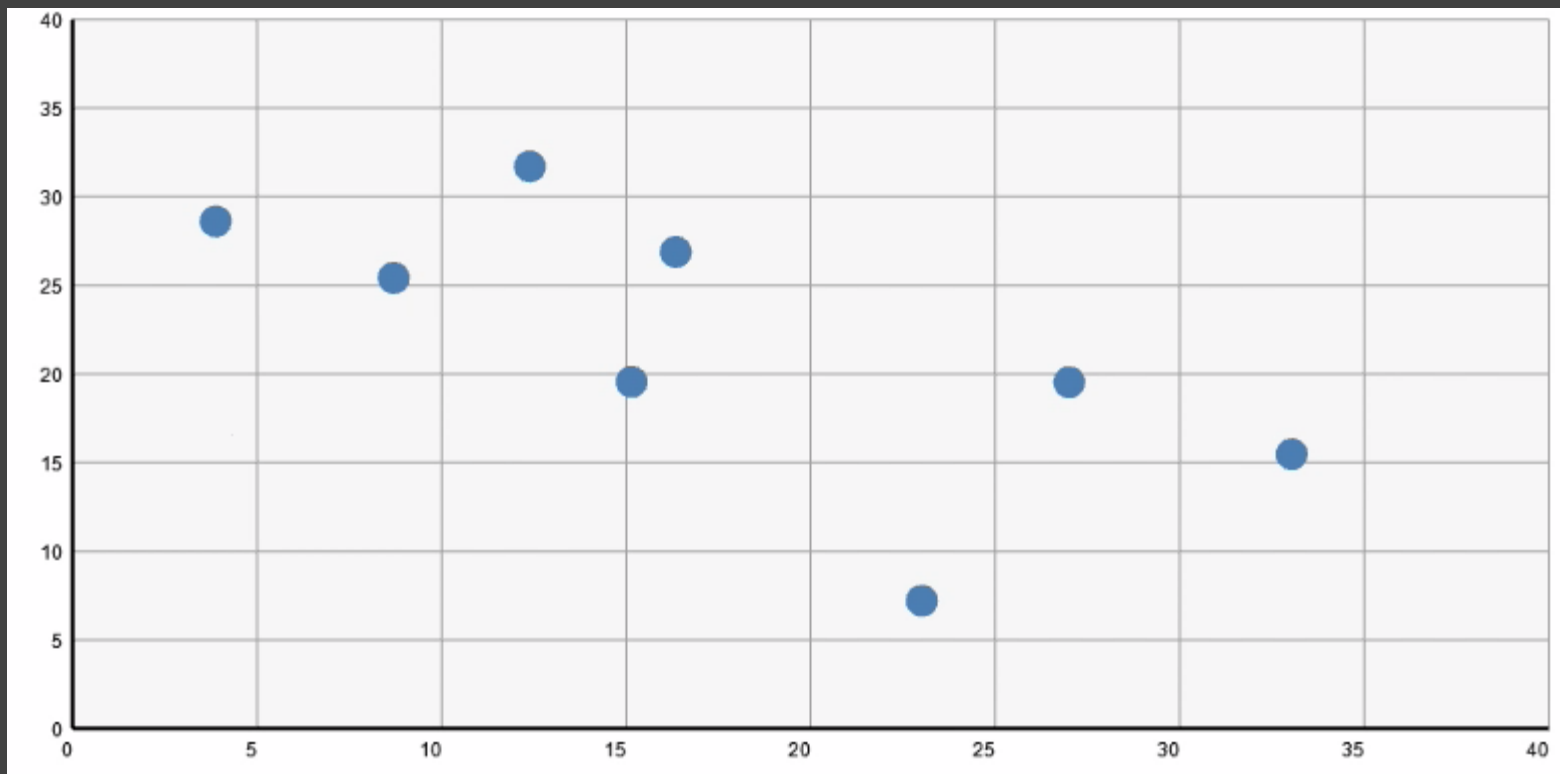
Retain Edge Orientation



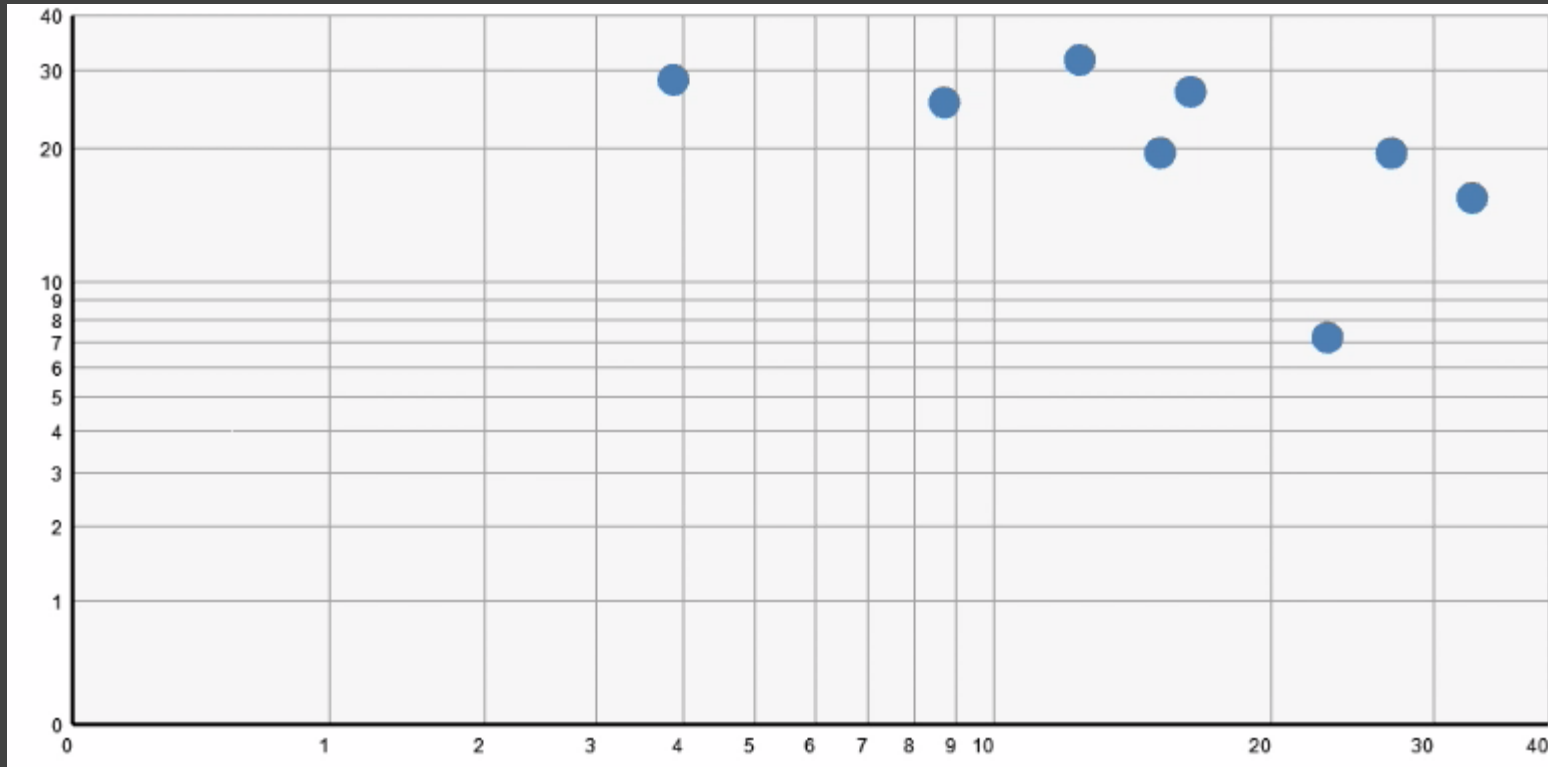
Retain Neighbor Order

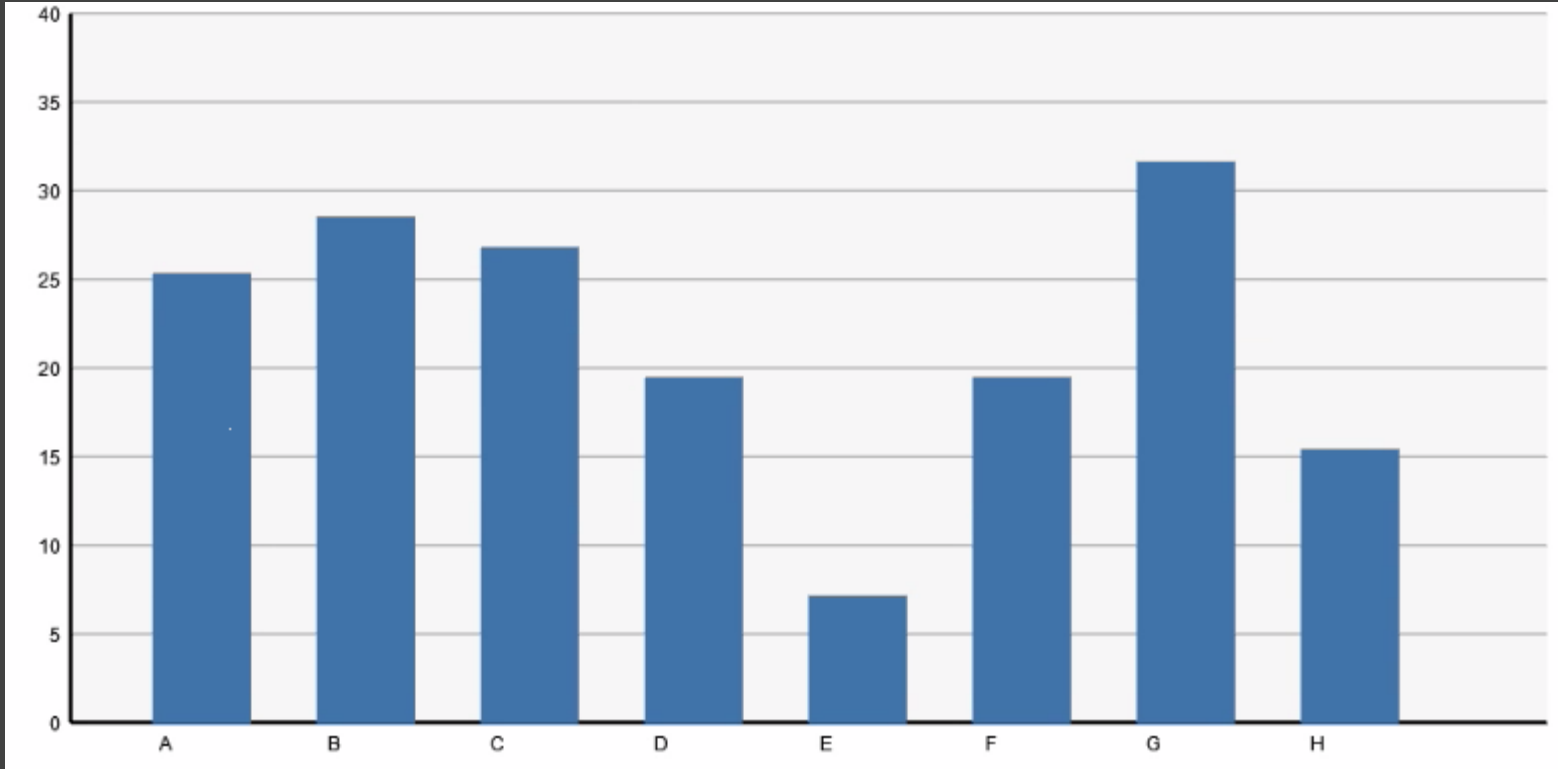


Animated Transitions in Statistical Graphics

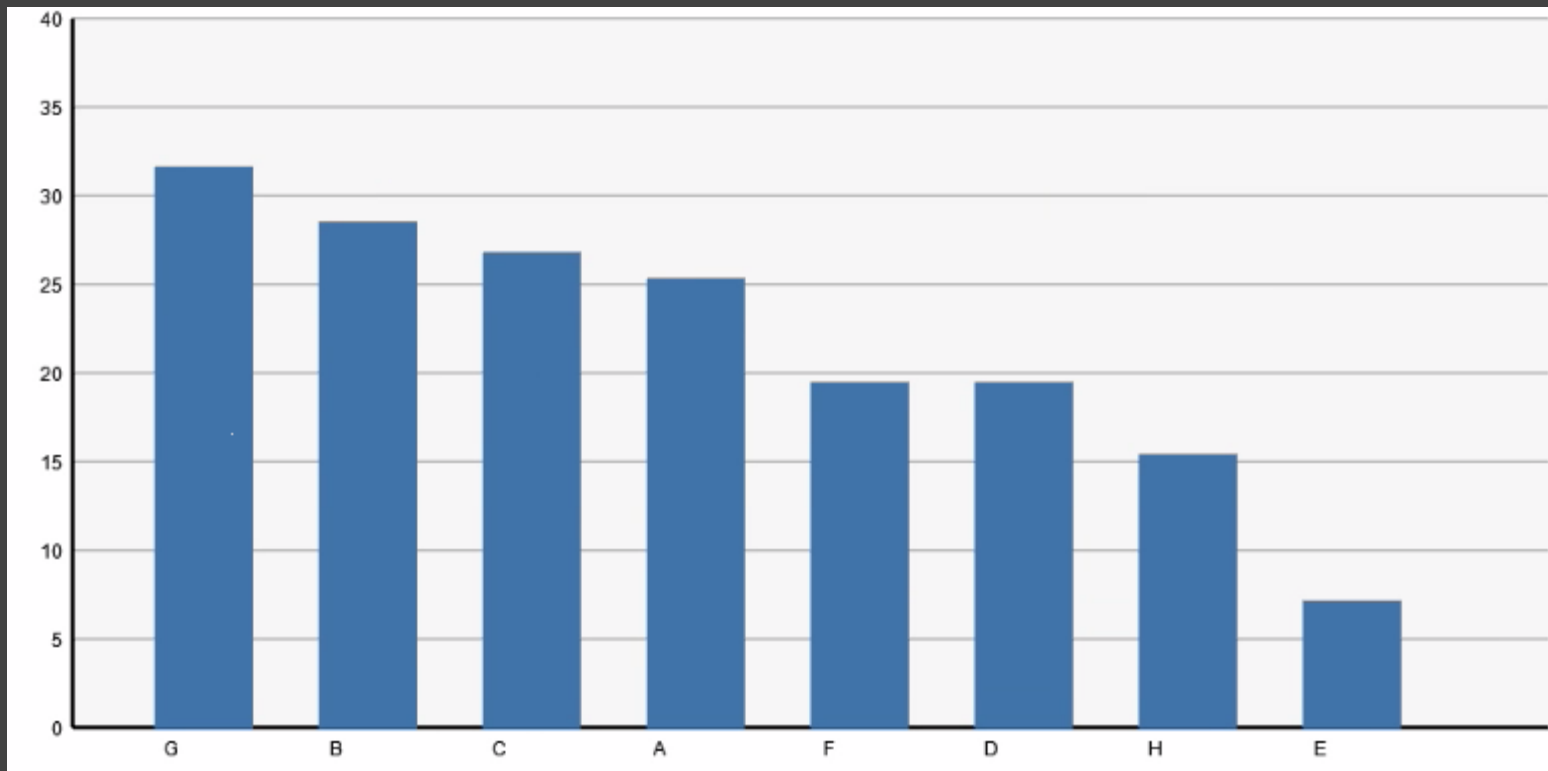


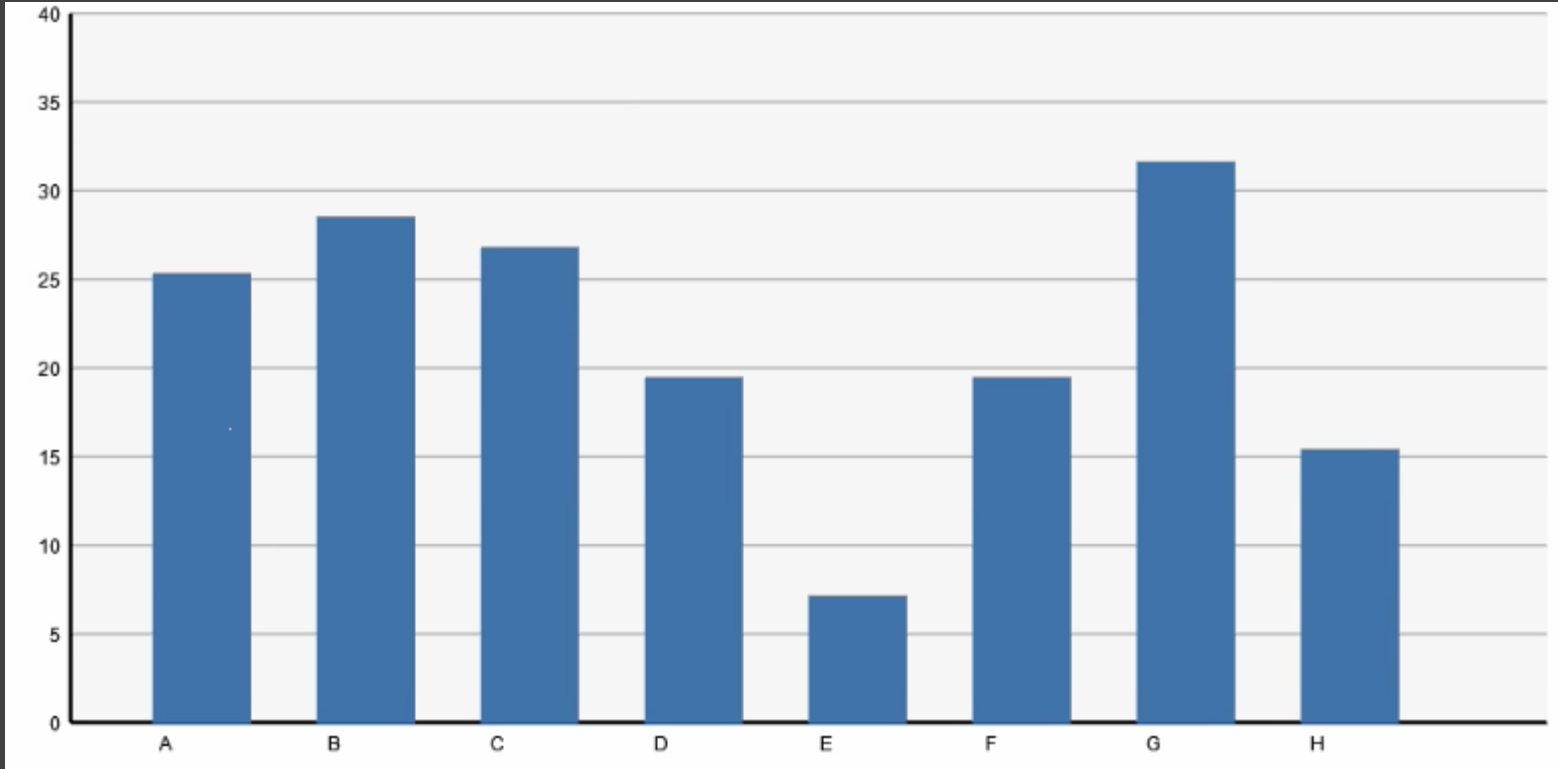
Log Transform



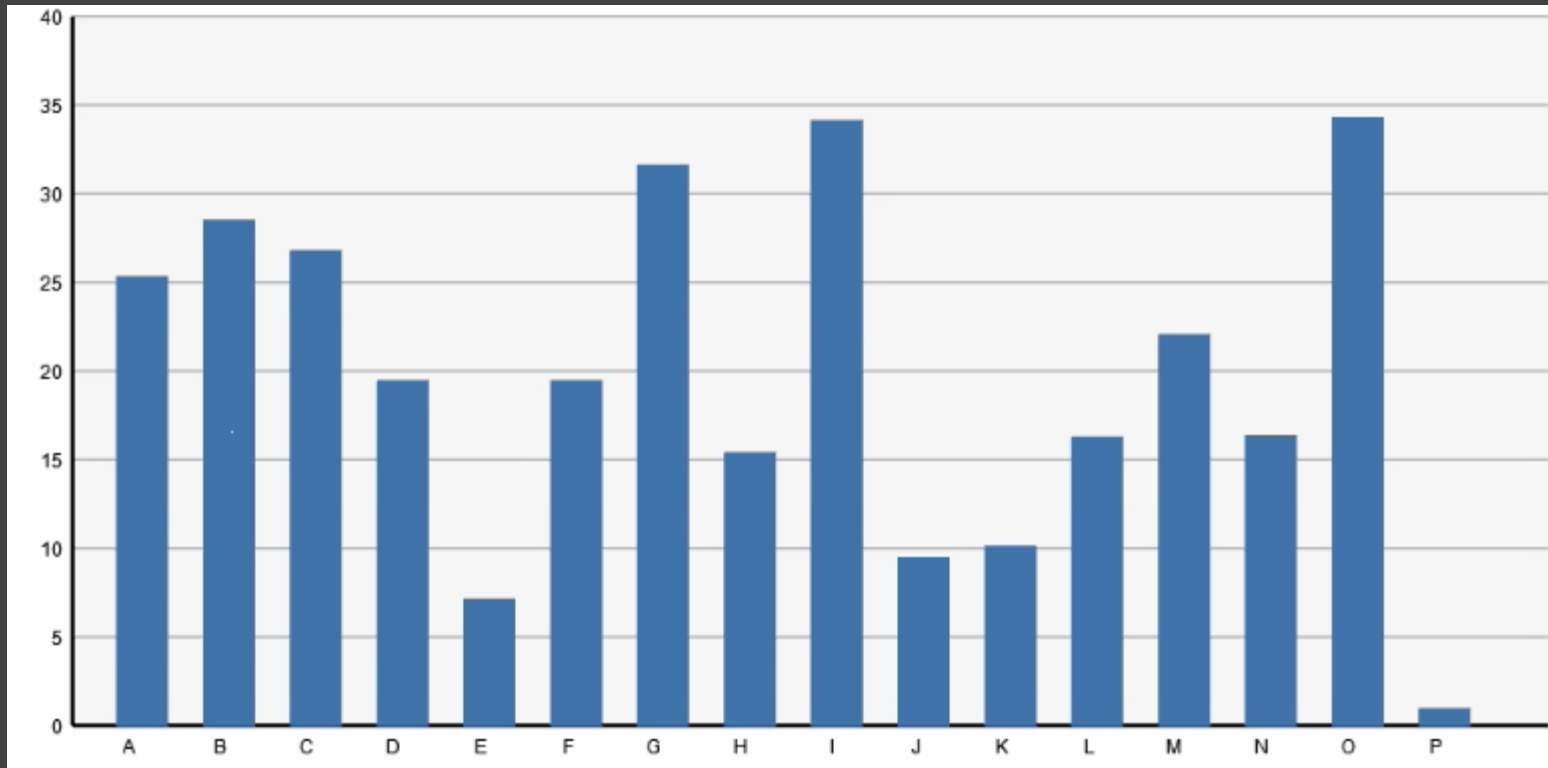


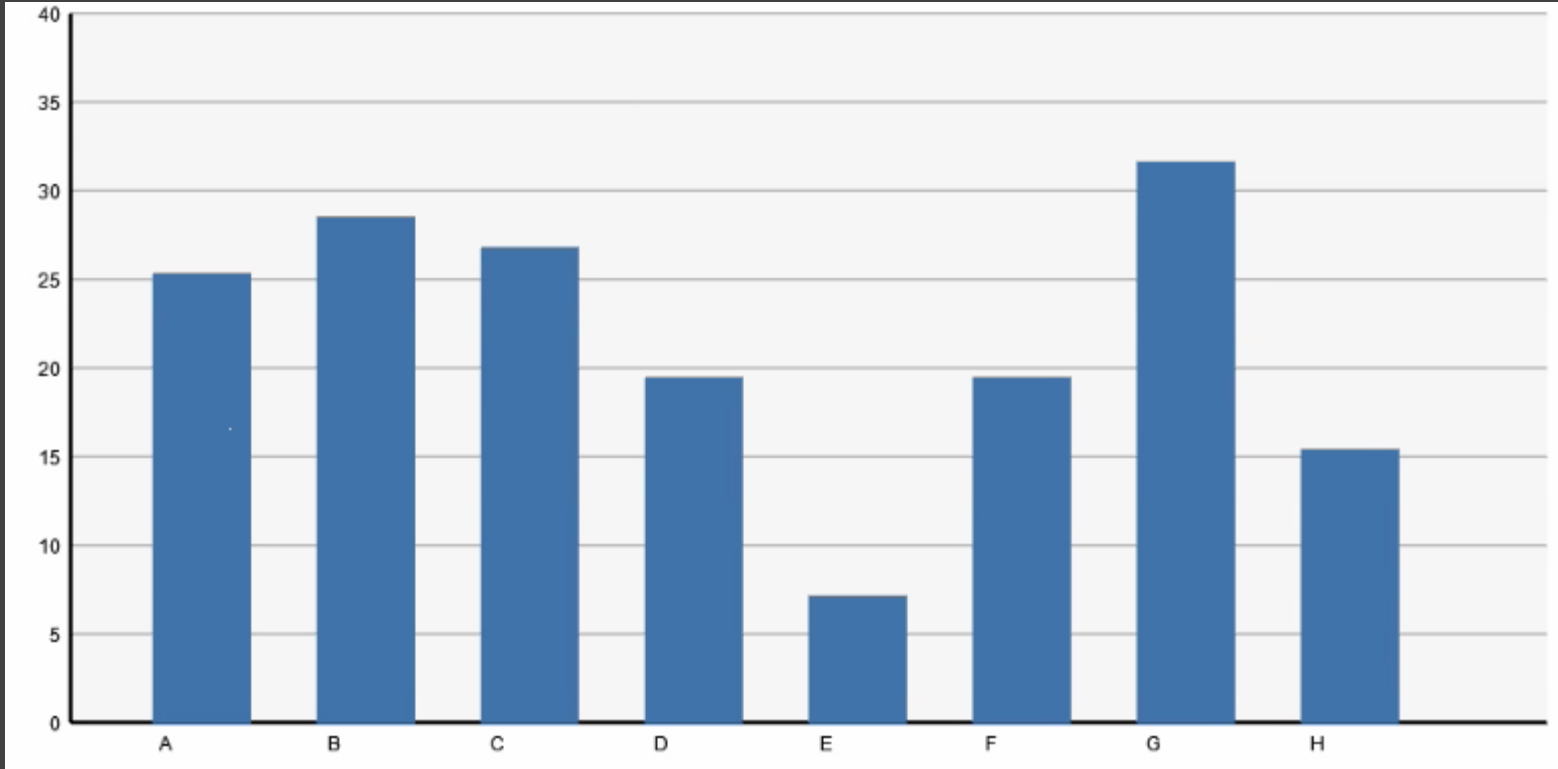
Sorting

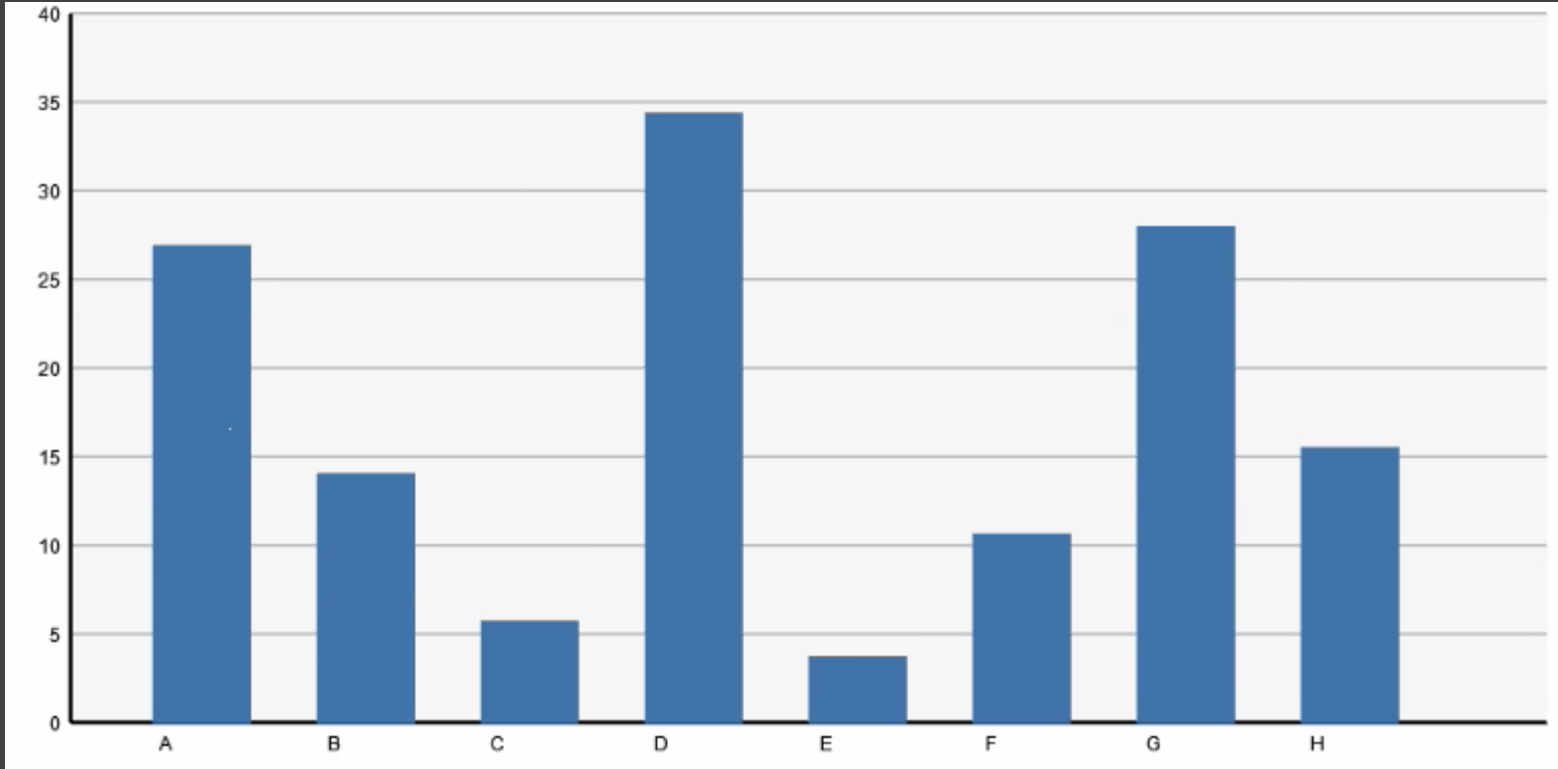


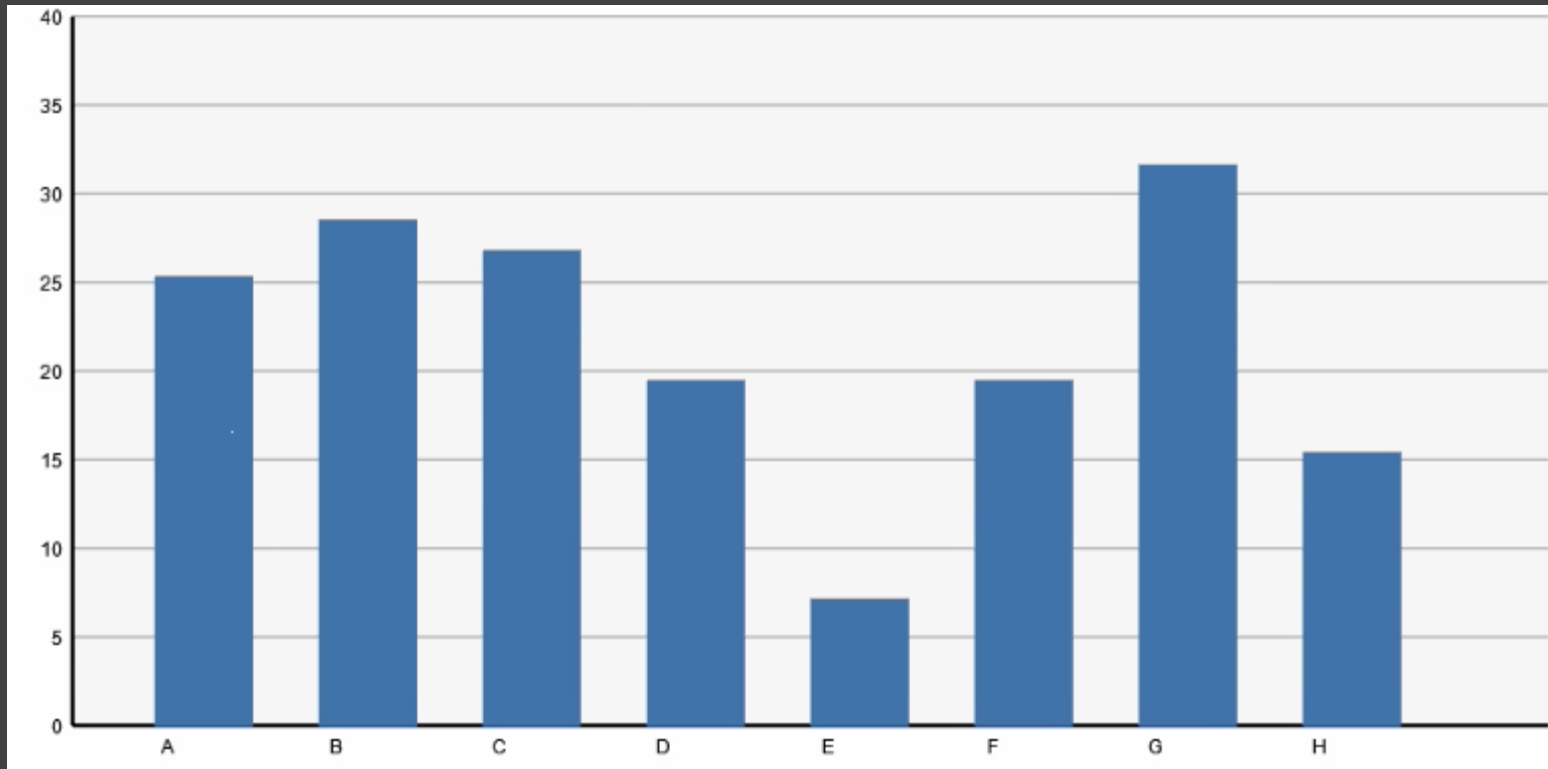


Filtering



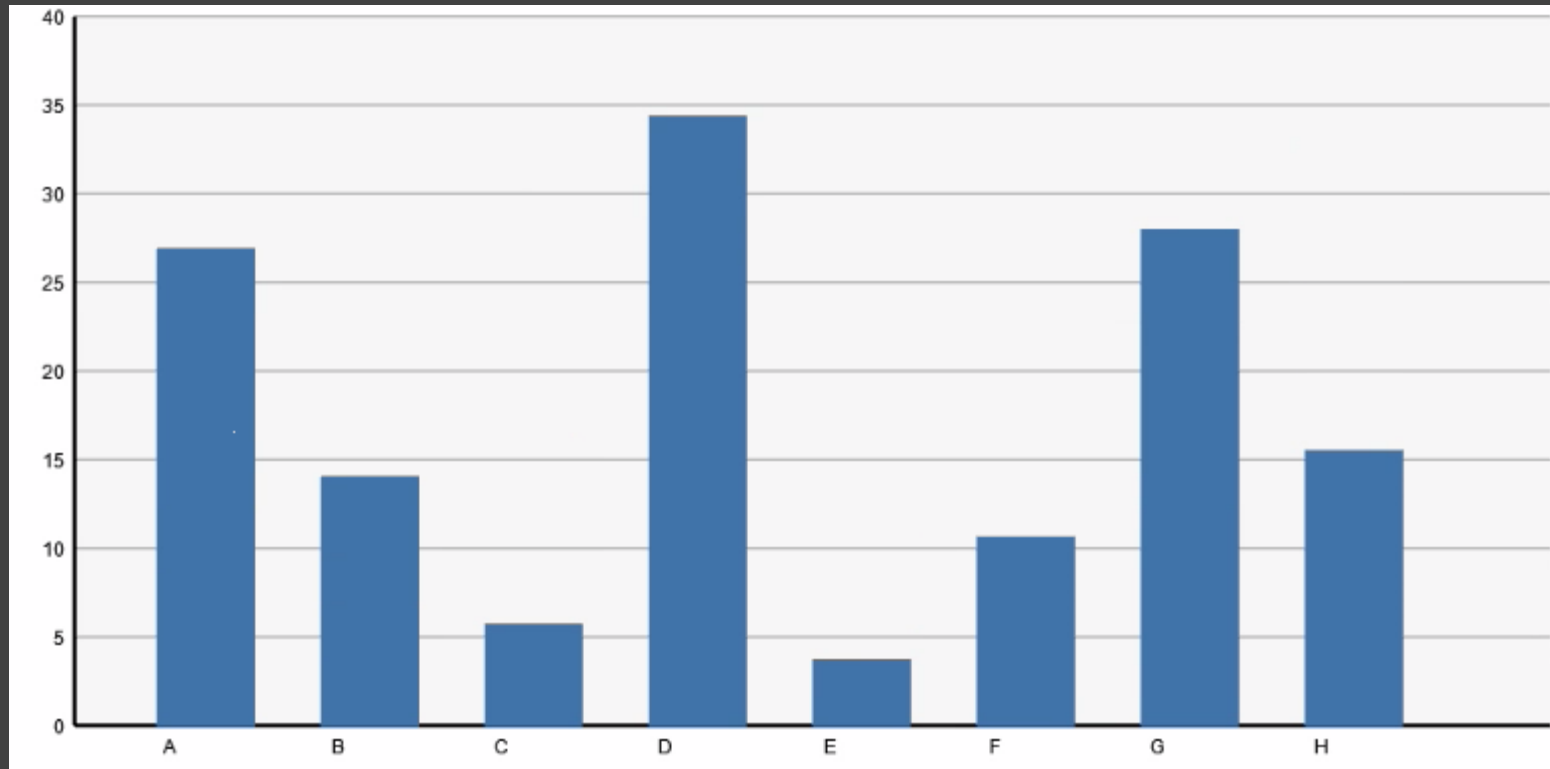




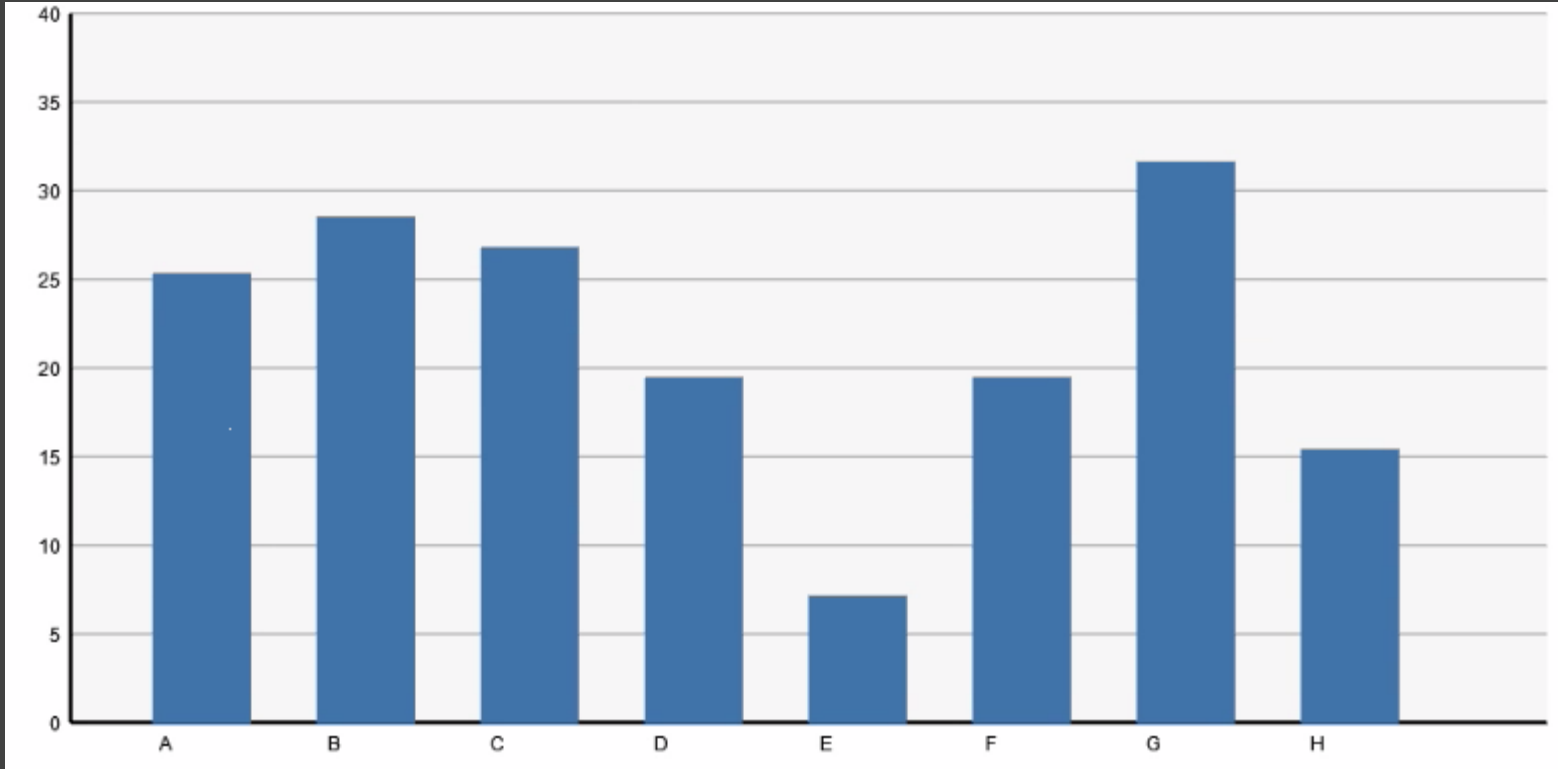


Month 1

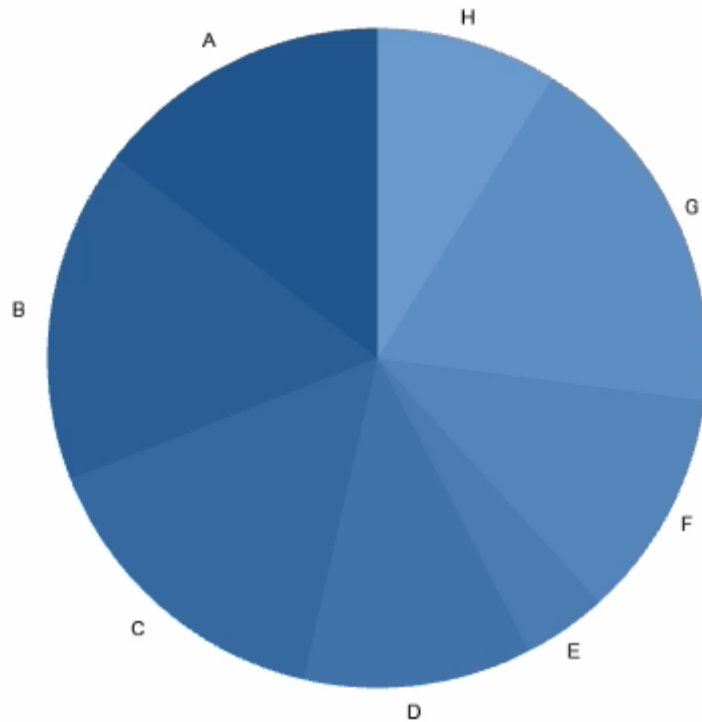
Timestep

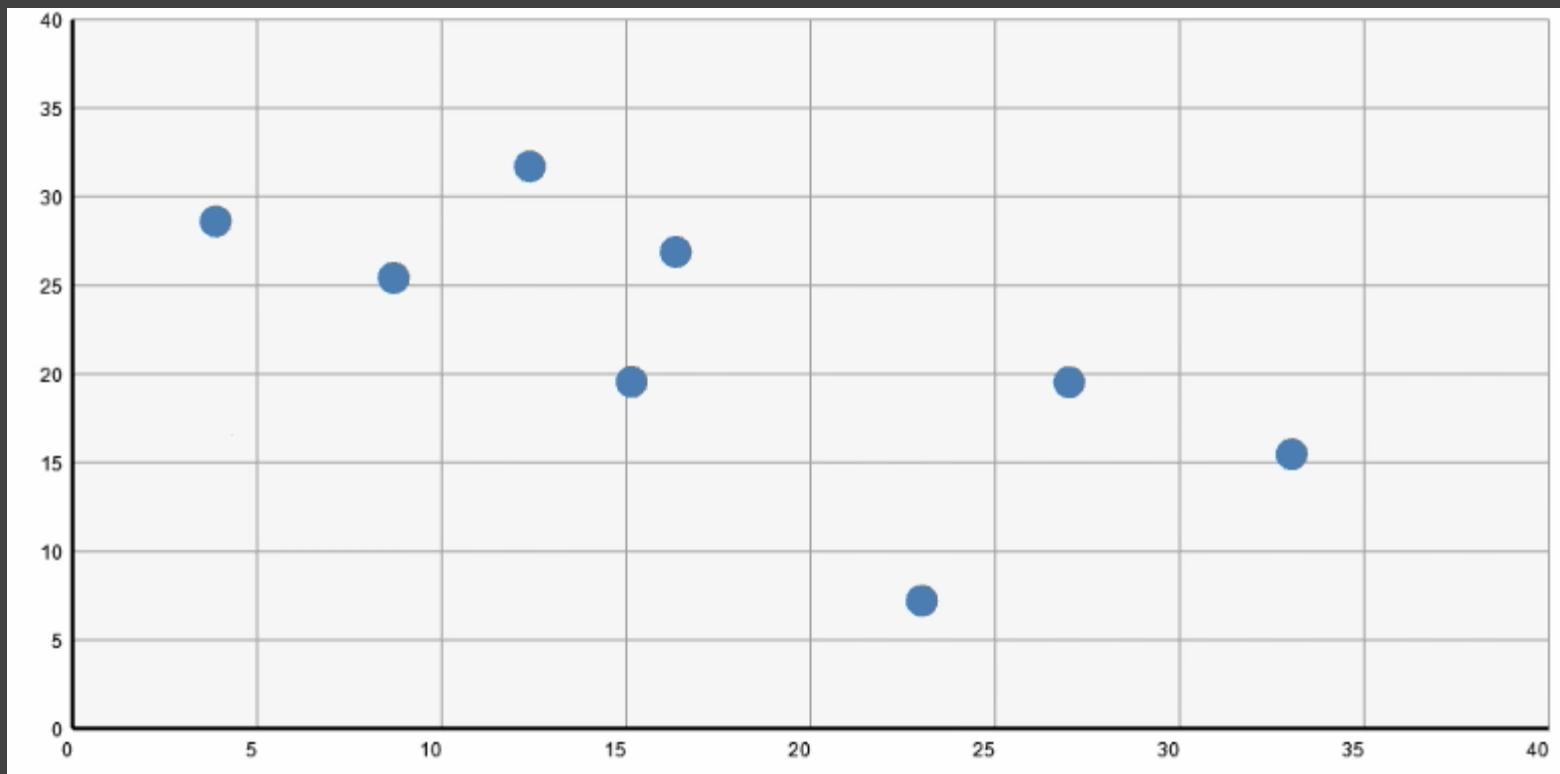


Month 2

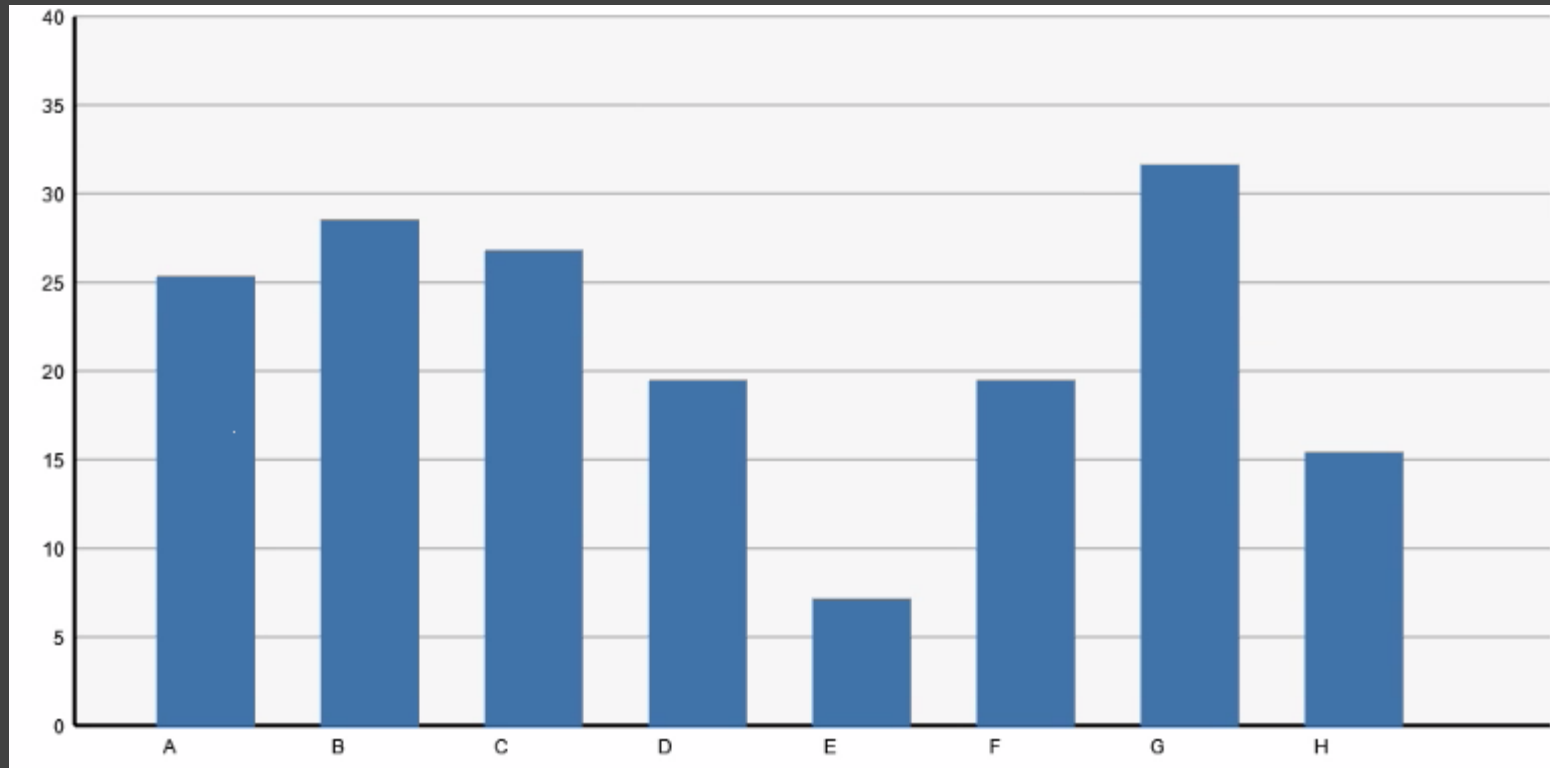


Change Encodings

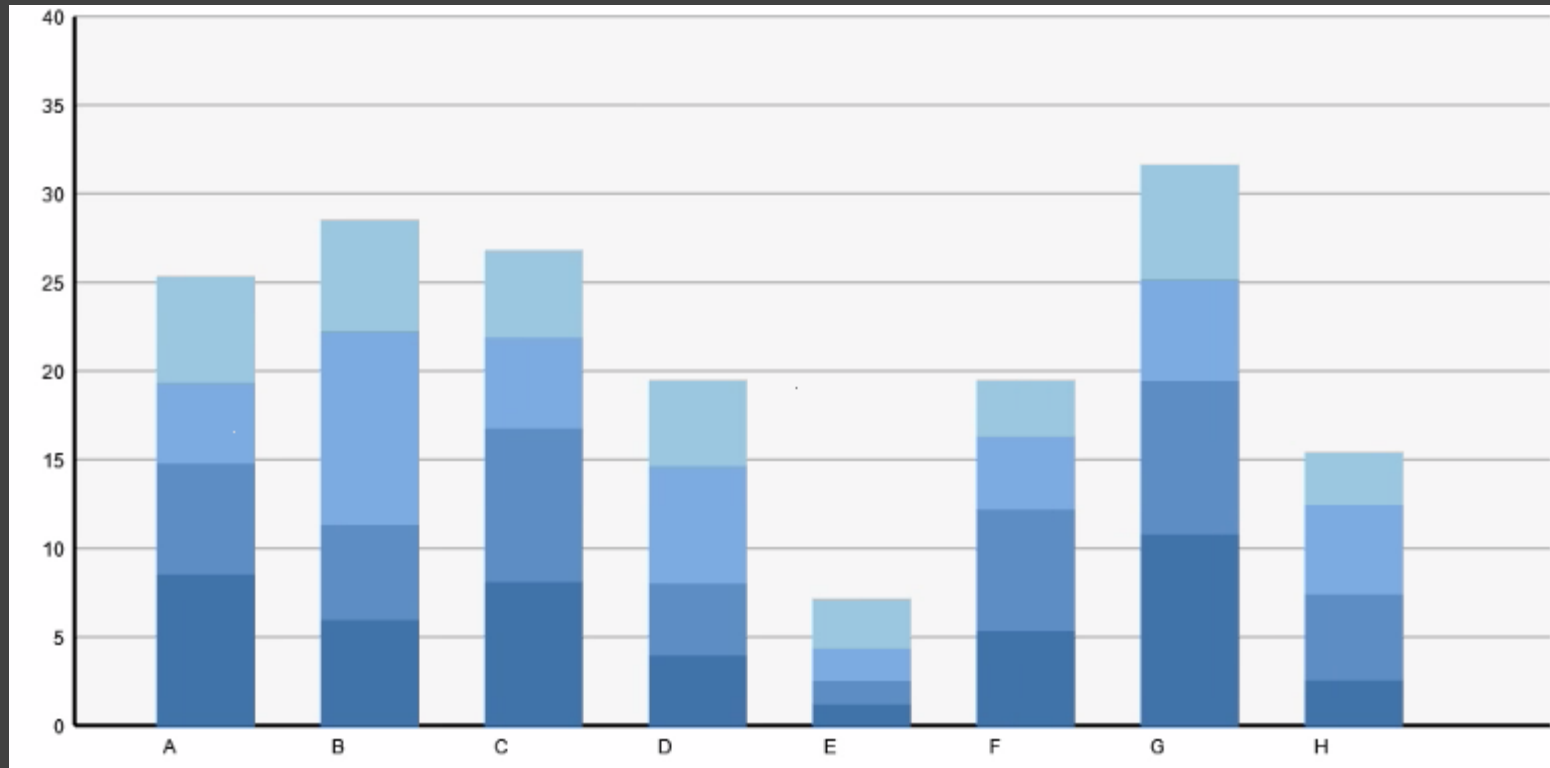




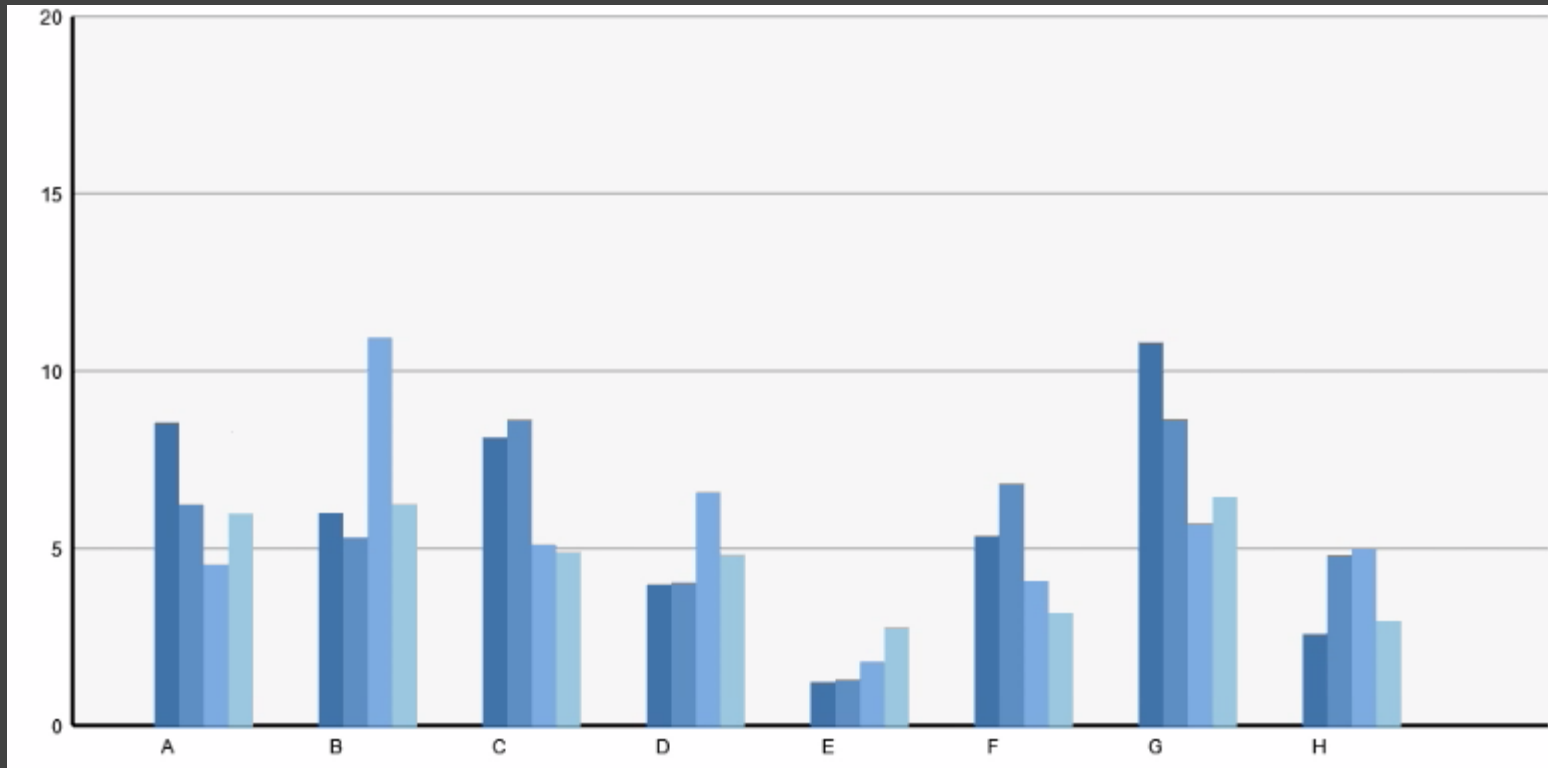
Change Data Dimensions



Change Data Dimensions



Change Encodings + Axis Scales

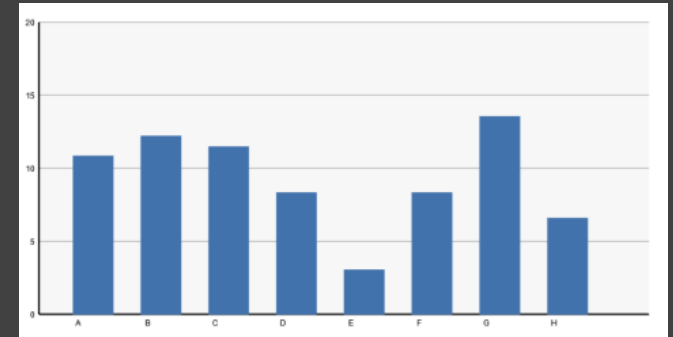


Data Graphics & Transitions

Category	Sales	Profit
A	11	7
B	13	10
C	12	6
D	8	5
E	3	1



Visual Encoding



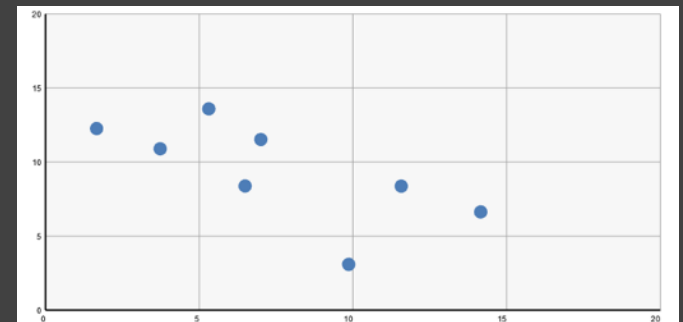
Change selected data dimensions or encodings



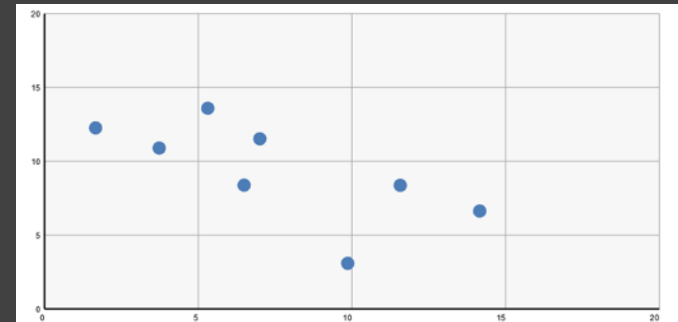
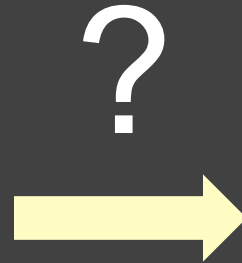
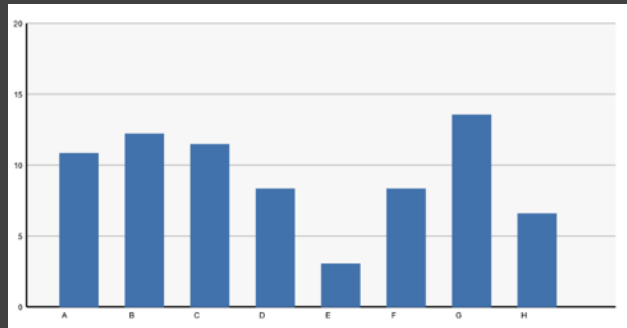
Category	Sales	Profit
A	11	7
B	13	10
C	12	6
D	8	5
E	3	1



Animation to communicate changes?



Transitions between Data Graphics



During analysis and presentation it is common to transition between *related* data graphics.

Can animation help?

How does this impact perception?

Principles for Animation

Congruence

The structure and content of the external representation should correspond to the desired structure and content of the internal representation.

Apprehension

The structure and content of the external representation should be readily and accurately perceived and comprehended.

[from Tversky 02]

Principles for Animation

Congruence

- Maintain valid data graphics during transitions
- Use consistent syntactic/semantic mappings
- Respect semantic correspondence
- Avoid ambiguity

Apprehension

- Group similar transitions
- Minimize occlusion
- Maximize predictability
- Use simple transitions
- Use staging for complex transitions
- Make transitions as long as needed, but no longer

Principles for Animation

Congruence

Maintain valid data graphics during transitions

Use consistent syntactic/semantic mappings

Respect semantic correspondence

Avoid ambiguity



Apprehension

Group similar transitions

Minimize occlusion

Maximize predictability

Use simple transitions

Use staging for complex transitions

Make transitions as long as needed, but no longer

Visual marks should always represent the same data tuple.

Principles for Animation

Congruence

Maintain valid data graphics during transitions

Use consistent syntactic/semantic mappings

Respect semantic correspondence

Avoid ambiguity

→ Different operators should have distinct animations.

Apprehension

Group similar transitions

Minimize occlusion

Maximize predictability

Use simple transitions

Use staging for complex transitions

Make transitions as long as needed, but no longer

Principles for Animation

Congruence

- Maintain valid data graphics during transitions
- Use consistent syntactic/semantic mappings
- Respect semantic correspondence
- Avoid ambiguity

Apprehension

- Group similar transitions
- Minimize occlusion
- Maximize predictability
- Use simple transitions
- Use staging for complex transitions
- Make transitions as long as needed, but no longer

Objects are harder to track when occluded.

Principles for Animation

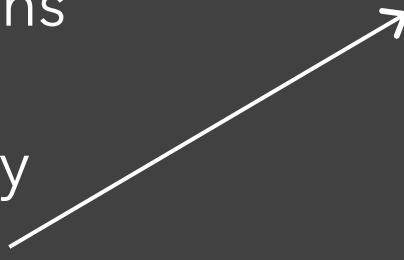
Congruence

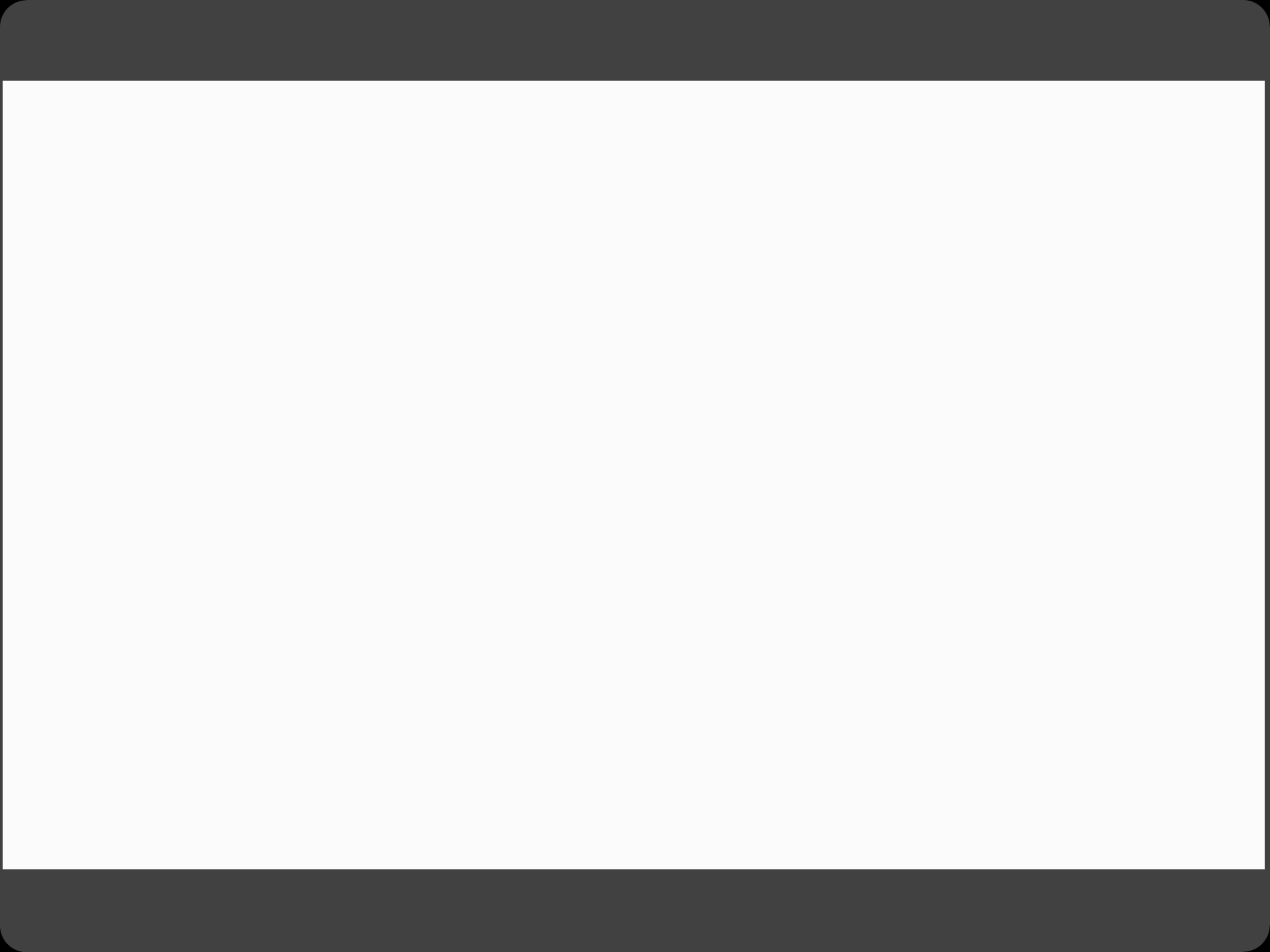
- Maintain valid data graphics during transitions
- Use consistent syntactic/semantic mappings
- Respect semantic correspondence
- Avoid ambiguity

Apprehension

- Group similar transitions
- Minimize occlusion
- Maximize predictability
- Use simple transitions
- Use staging for complex transitions
- Make transitions as long as needed, but no longer

Keep animation as simple as possible. If complicated, break into simple stages.





Study Conclusions

Appropriate animation improves graphical perception

Simple transitions beat *"do one thing at a time"*

Simple staging was preferred and showed benefits
but timing important and in need of study

Axis re-scaling hampers perception

Avoid if possible (use common scale)

Maintain landmarks better (delay fade out of lines)

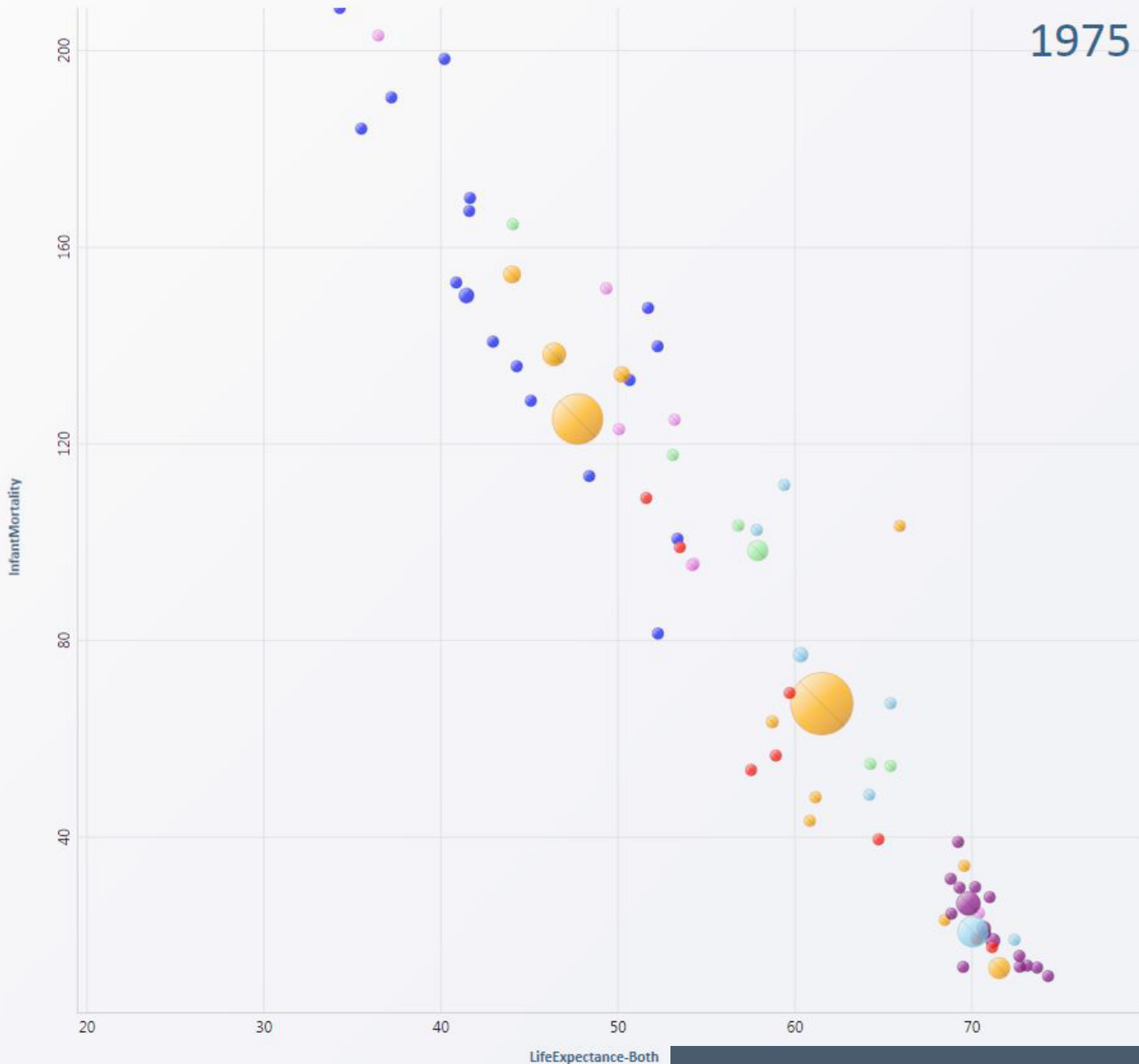
Subjects preferred animated transitions

Animation in Trend Visualization

Heer & Robertson study found that animated transitions are better than static transitions for estimating changing values.

How does animation fare vs. static time-series depictions (as opposed to static transitions)?

Experiments by Robertson et al, InfoVis 2008



Color Legend (continent)

- Africa
- Asia
- Europe
- Middle East
- North America
- Oceania
- South America

Task

Select two countries with decreasing InfantMortality, but little change in life expectancy.

Ctrl-Click on a country (in chart) to set an answer.

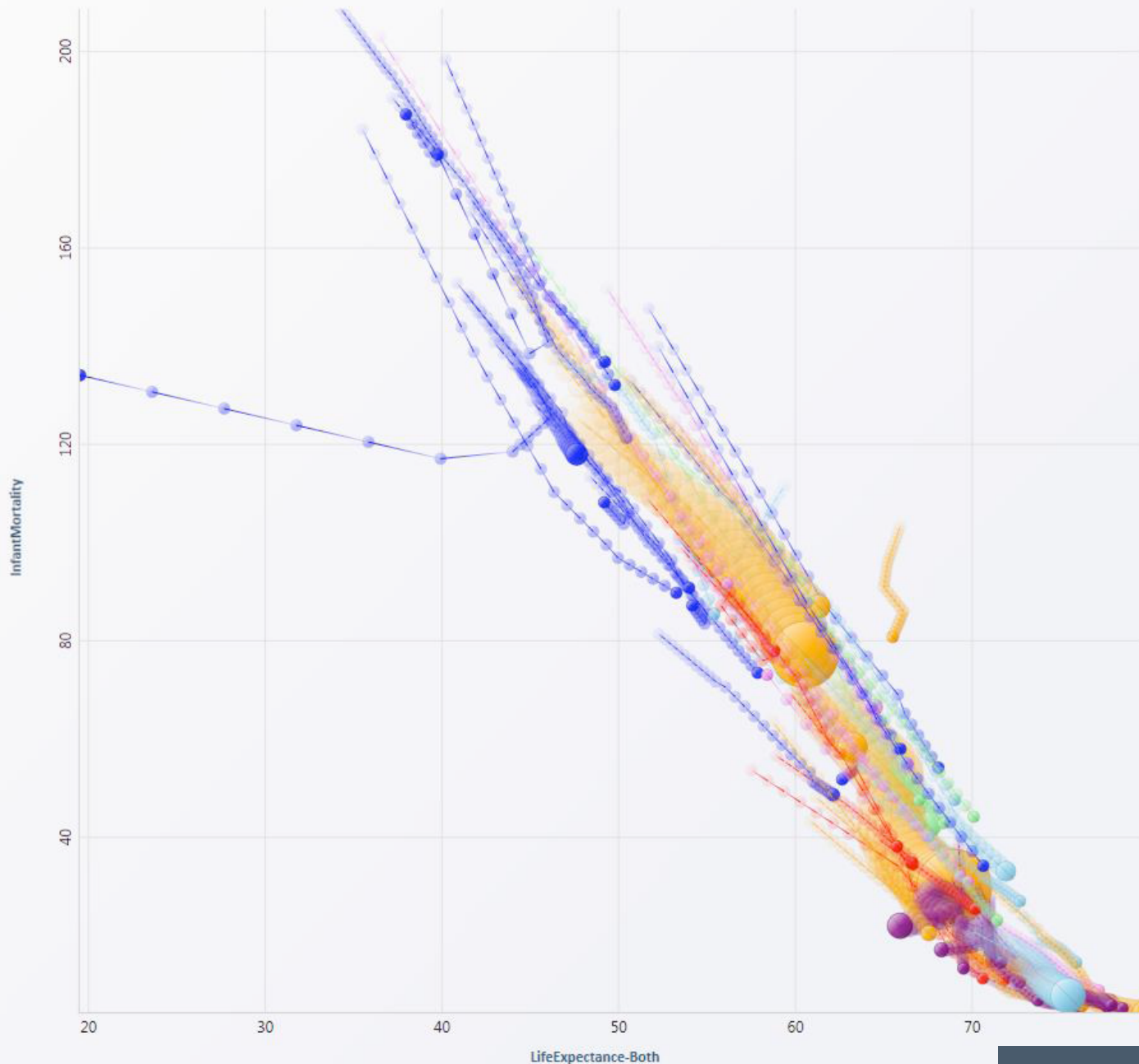
Answers set: 0/2

Next

Click on "Next" when finished (or "Give Up" if you cannot find all the answers)

Give Up

Next



Color Legend (continent)

- Africa
- Asia
- Europe
- Middle East
- North America
- Oceania
- South America

Task

Select two countries whose InfantMortality dropped first, then increased later.

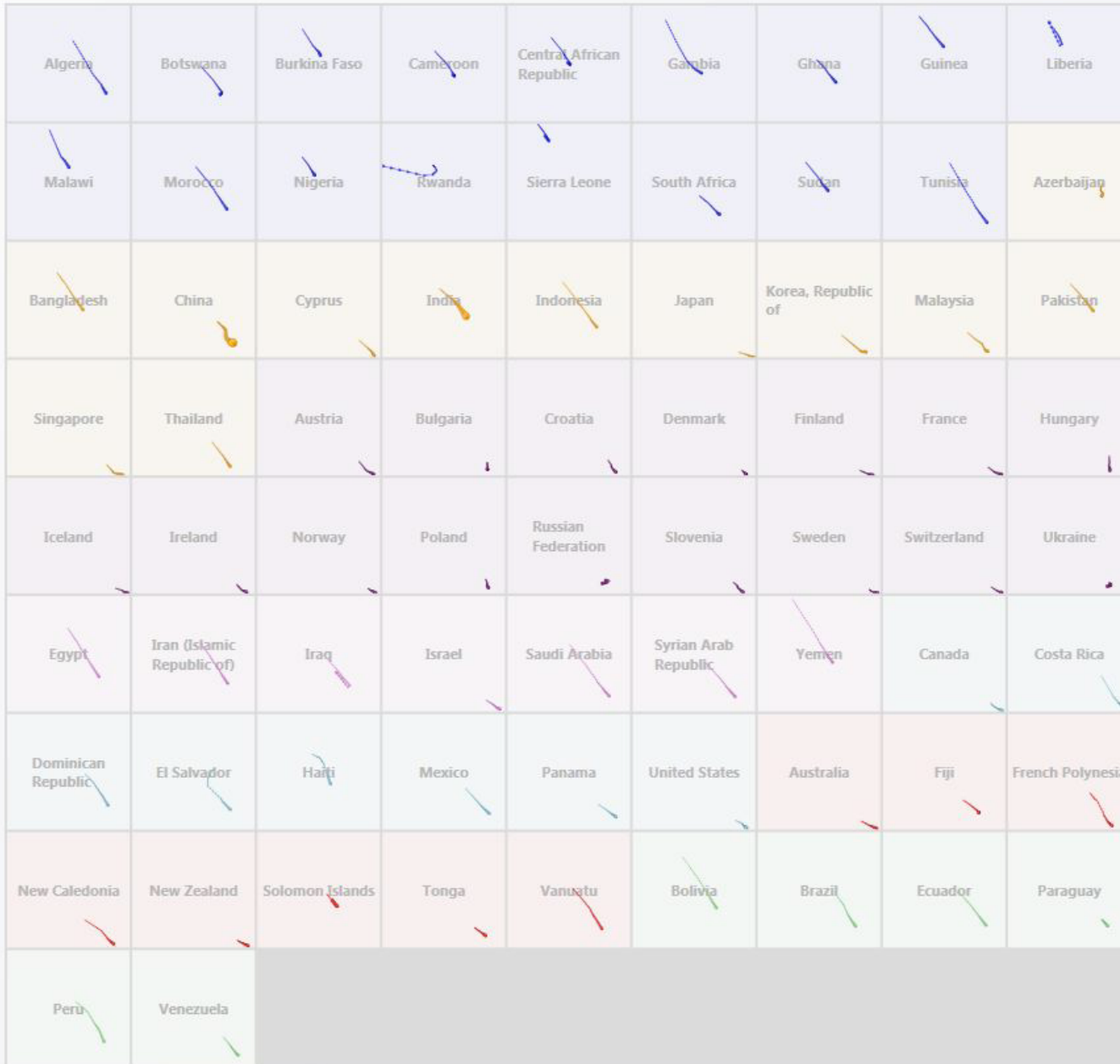
Ctrl-Click on a country (in chart) to set an answer.

Answers set: 0/2

Next

Click on "Next" when finished (or "Give Up" if you cannot find all the answers)

InfantMortality



LifeExpectance-Both

Color Legend (continent)

- Africa
- Asia
- Europe
- Middle East
- North America
- Oceania
- South America

Task

Select two countries whose InfantMortality dropped first, then increased later.

Ctrl-Click on a country (in chart) to set an answer.

Answers set: 0/2

Next

Click on "Next" when finished (or "Give Up" if you cannot find all the answers)

Give Up

Next

Study: Analysis & Presentation

Subjects asked comprehension questions.
Presentation condition included narration.

Multiples 10% *more accurate* than animation

Presentation: Anim. 60% faster than multiples

Analysis: Animation 82% slower than multiples

User preferences favor animation

Summary

Animation is a salient visual phenomenon

Attention, object constancy, causality, timing

Design with care: congruence & apprehension

For processes, **static images** may be preferable

For transitions, animation has demonstrated benefits, but **consider task and timing**