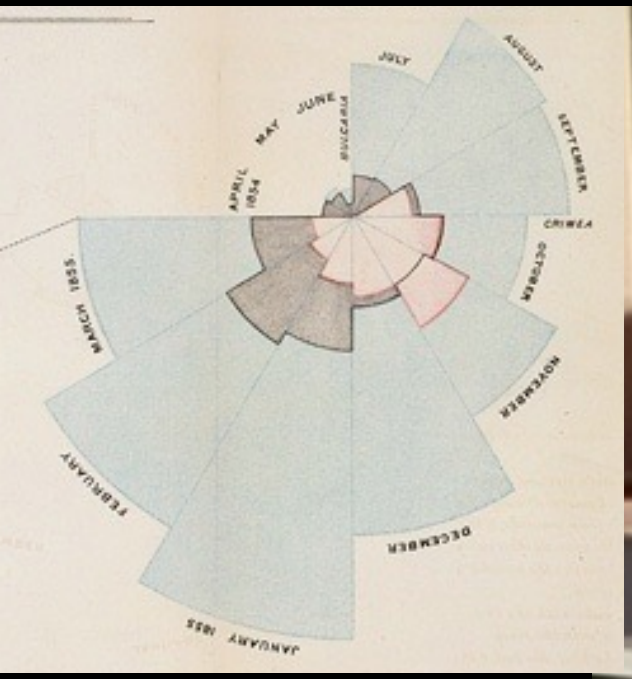
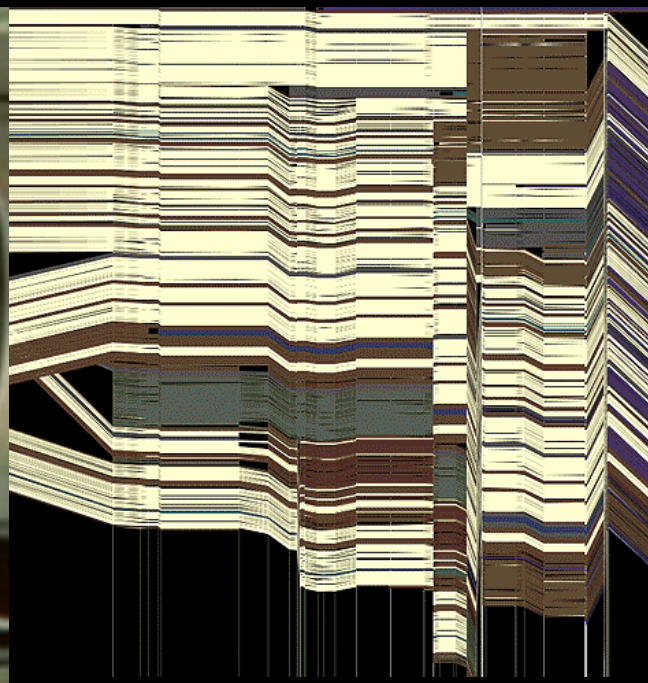
CSE 512 - Data Visualization

Animation





Jeffrey Heer University of Washington

Why Use Motion?

Visual variable to encode data

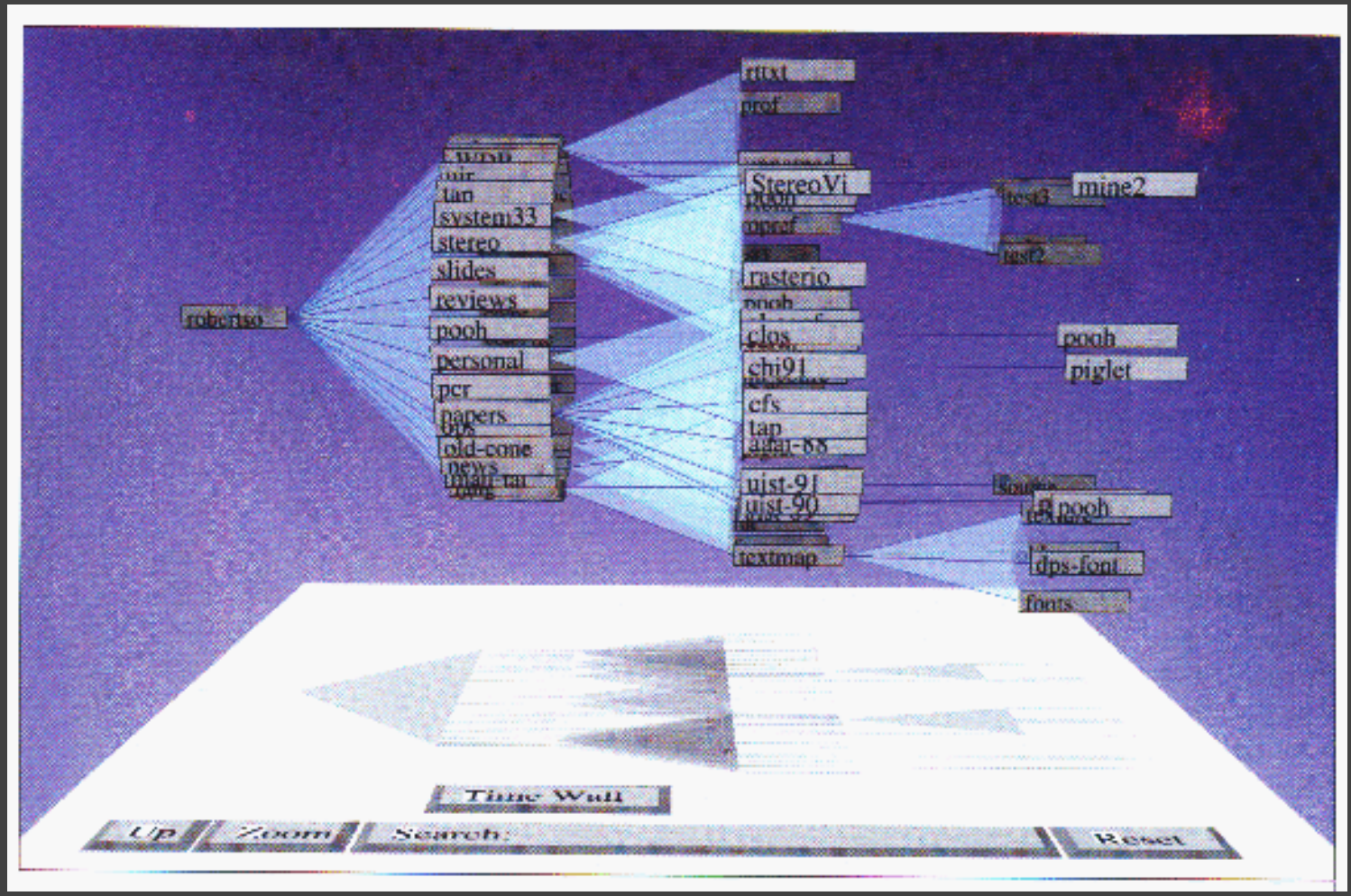
Direct attention

Understand system dynamics

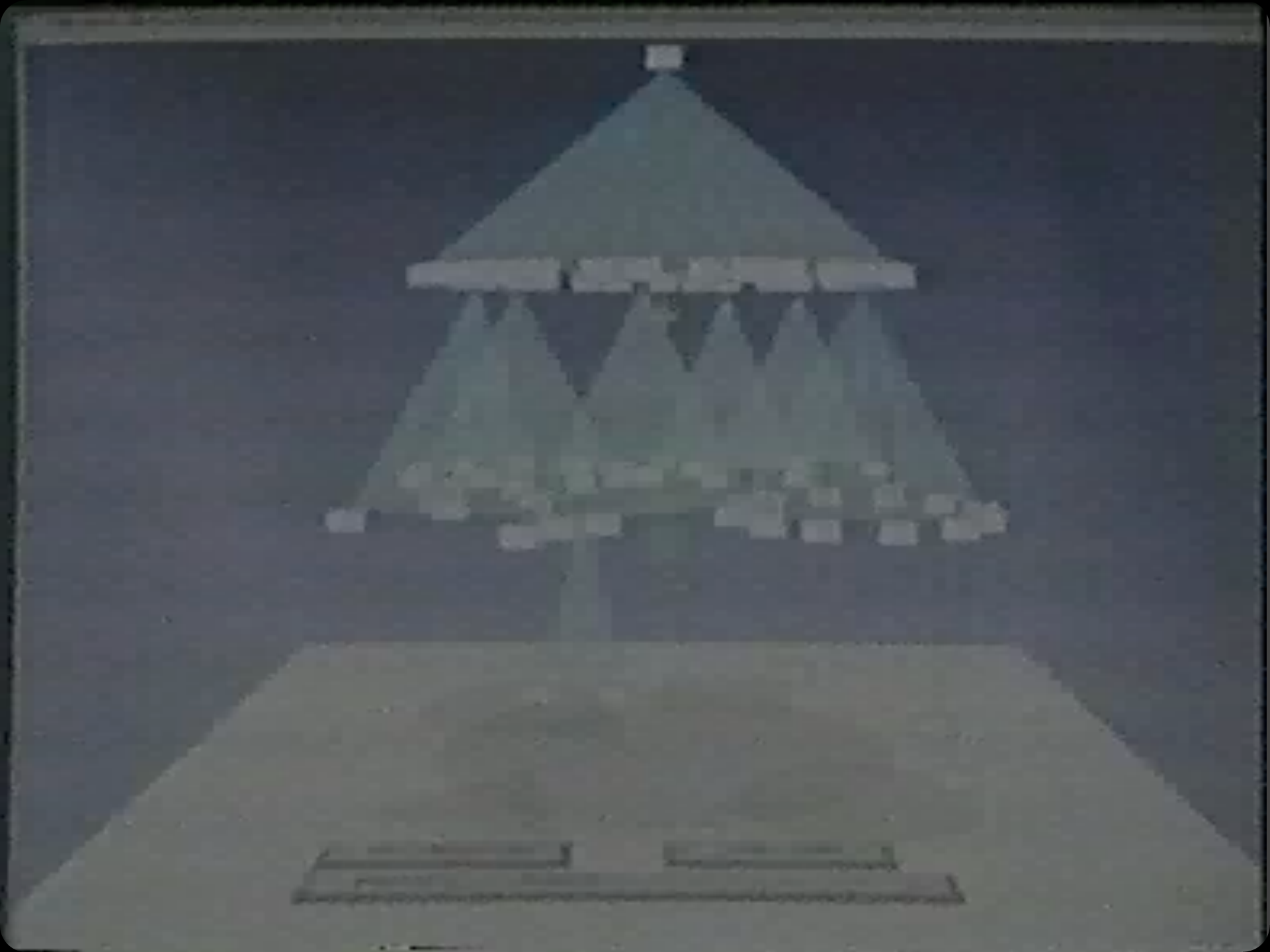
Understand state transition

Increase engagement

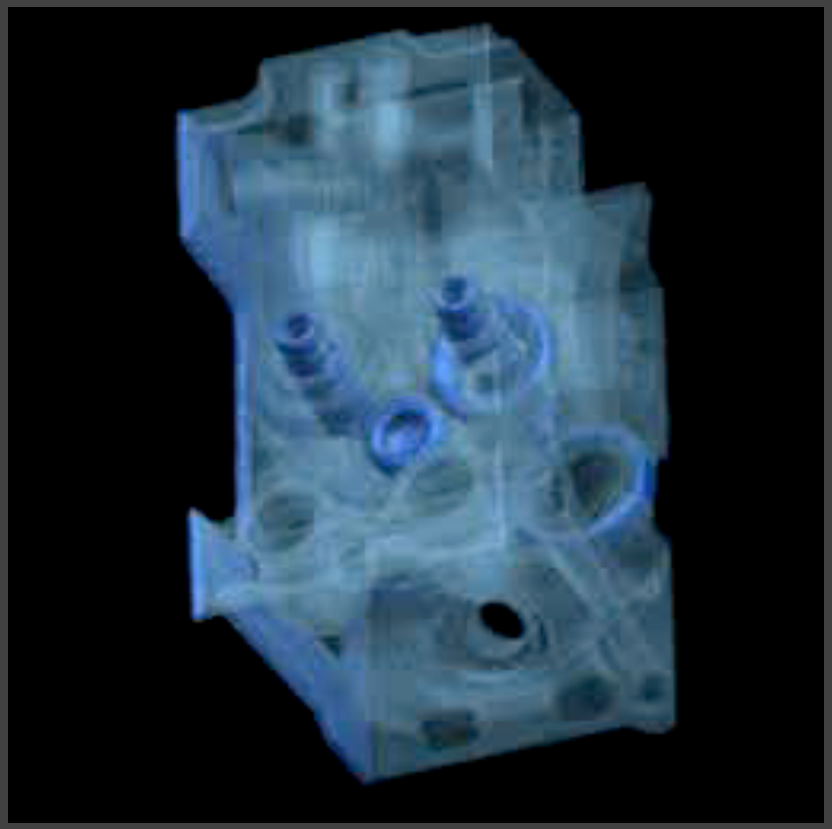
Cone Trees [Robertson 91]



Video

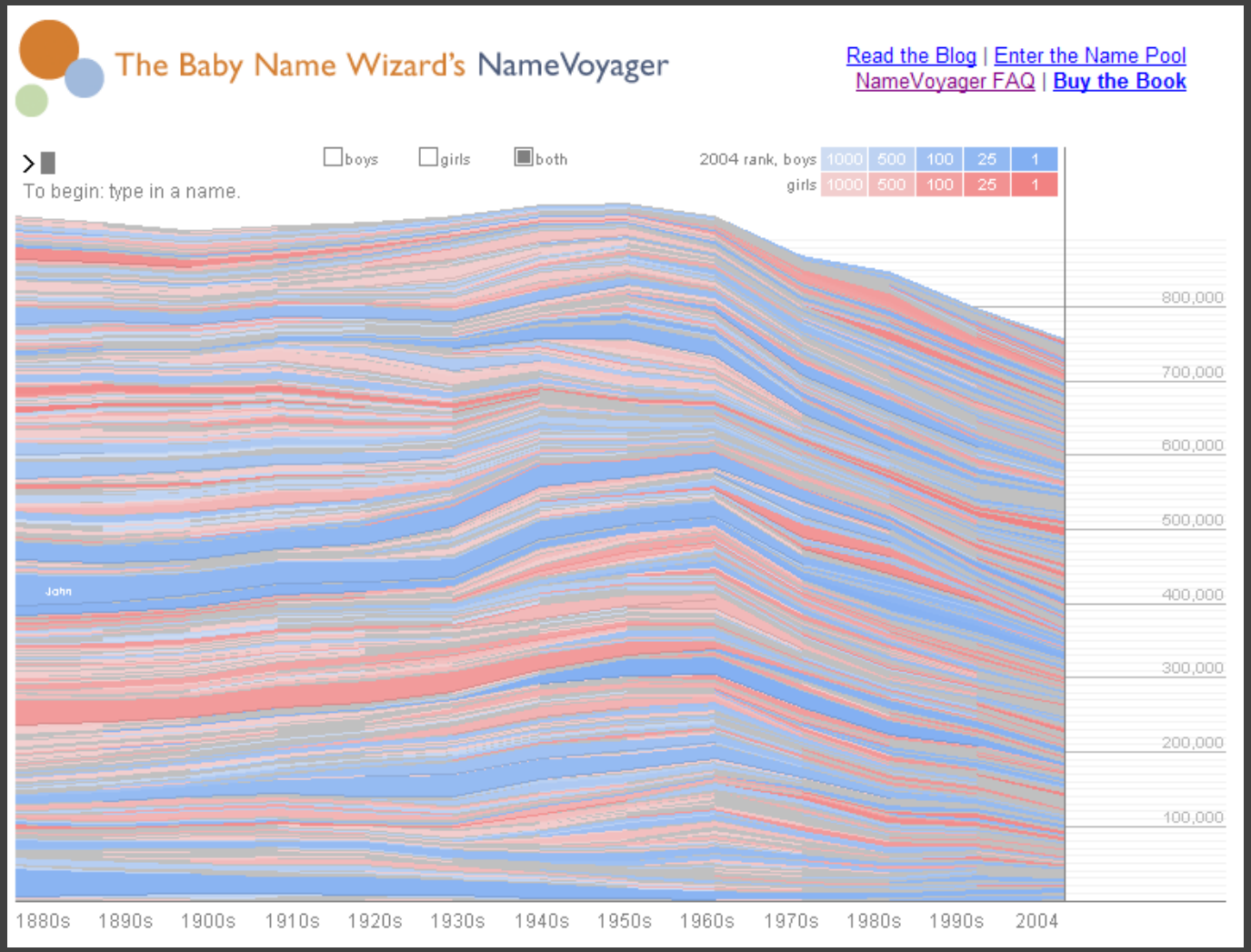


Volume Rendering [Lacroute 95]



Video

NameVoyager [Wattenberg 04]



http://www.babynamewizard.com/namevoyager/lnv0105.html

Topics

Motion perception

Principles for animation

Animated transitions in visualizations

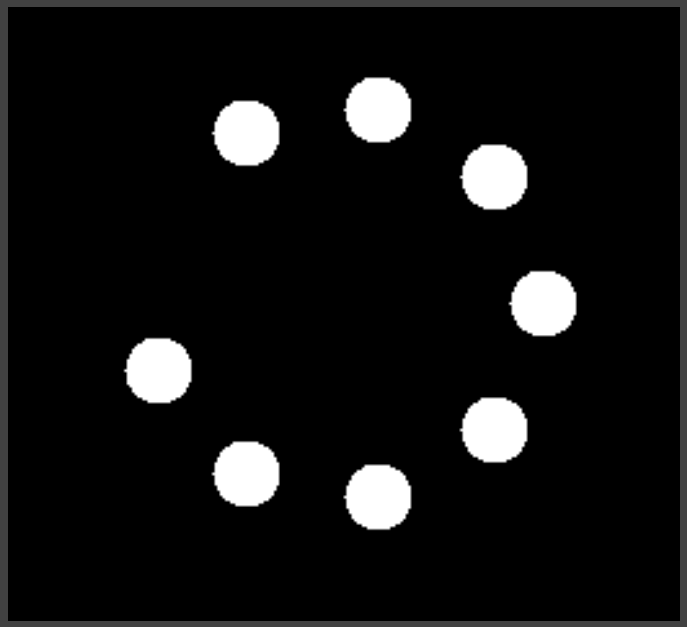
Motion Perception

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/PhiIsNotBeta/phi2.html

Motion as Visual Cue

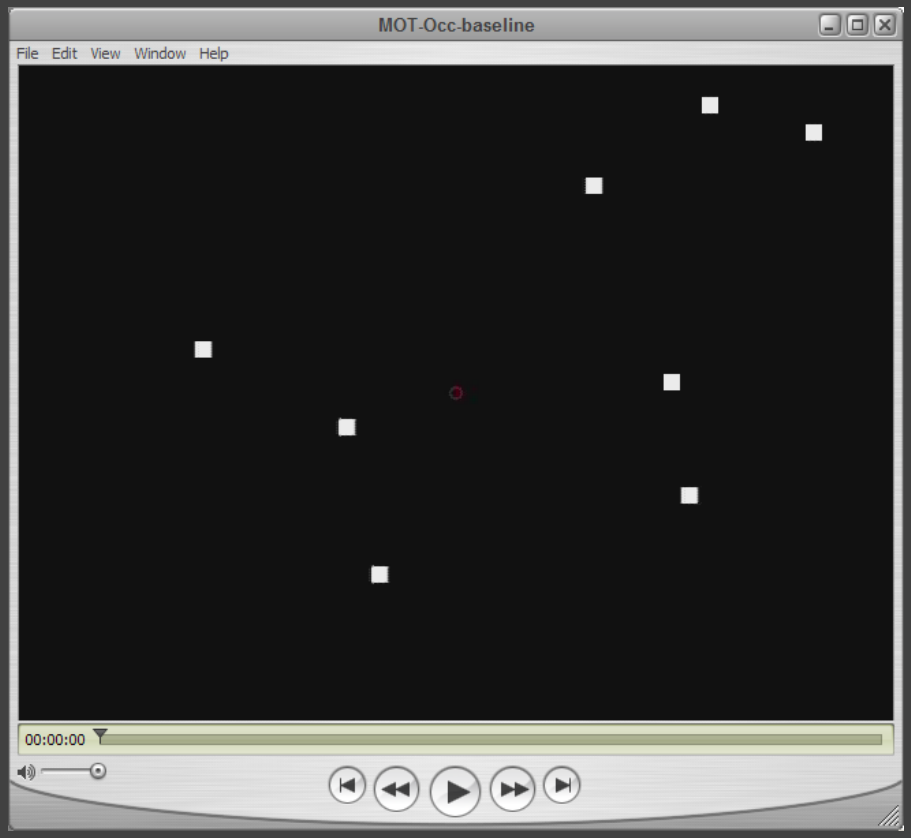
Pre-attentive, stronger than color, shape, …

More sensitive to motion at periphery

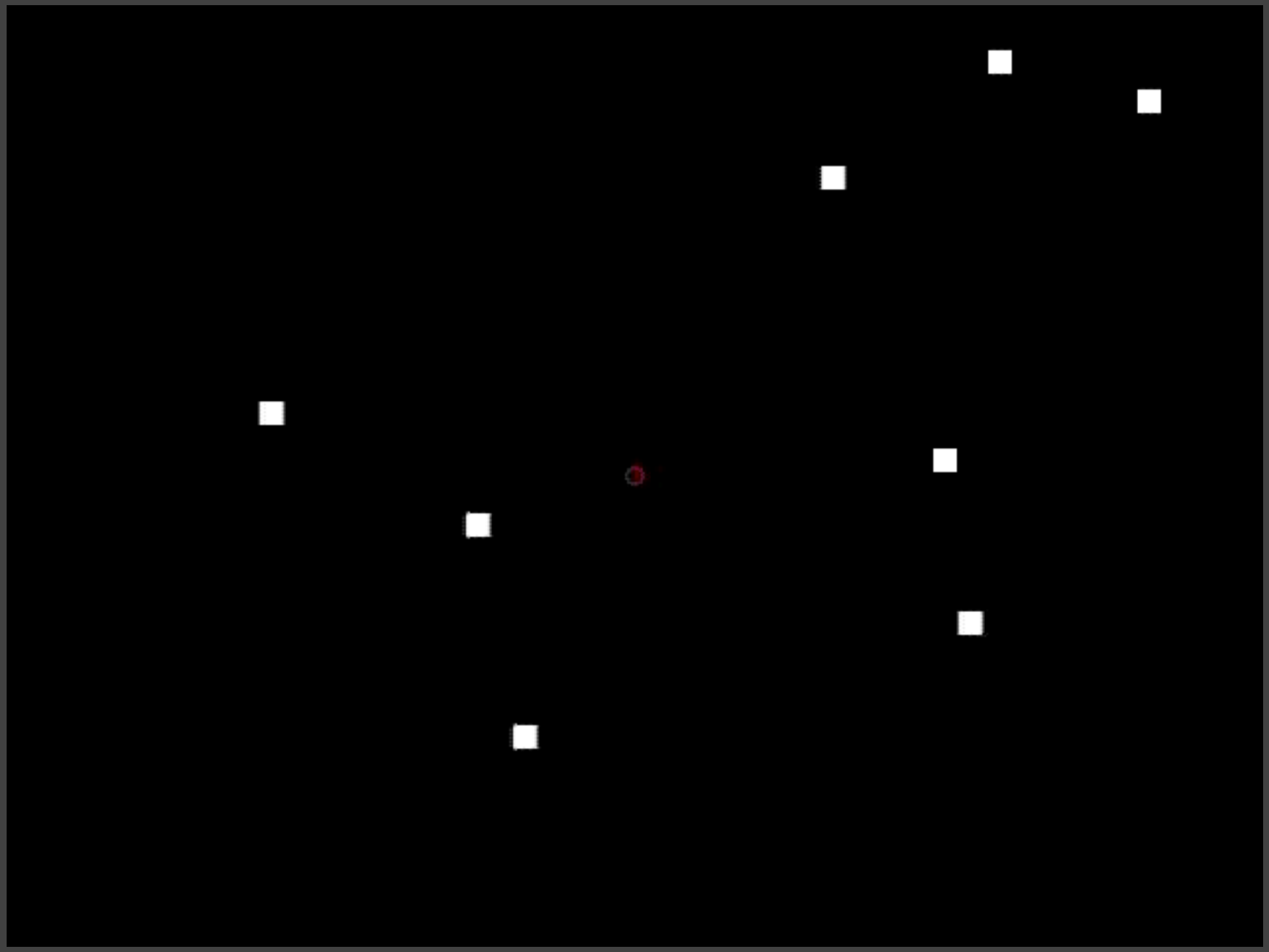
Similar motions perceived as a group

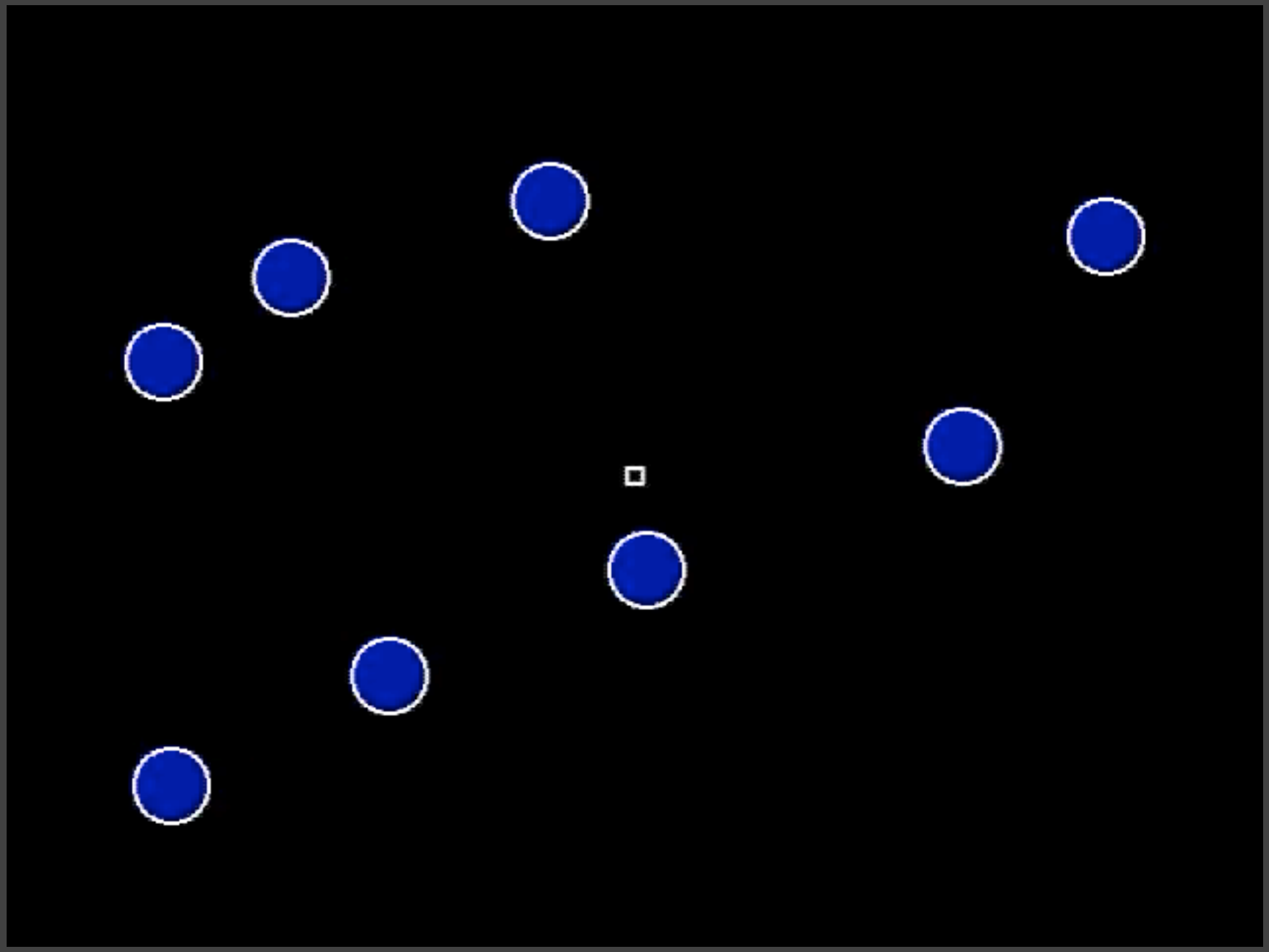
Motion parallax provide 3D cue (like stereopsis)

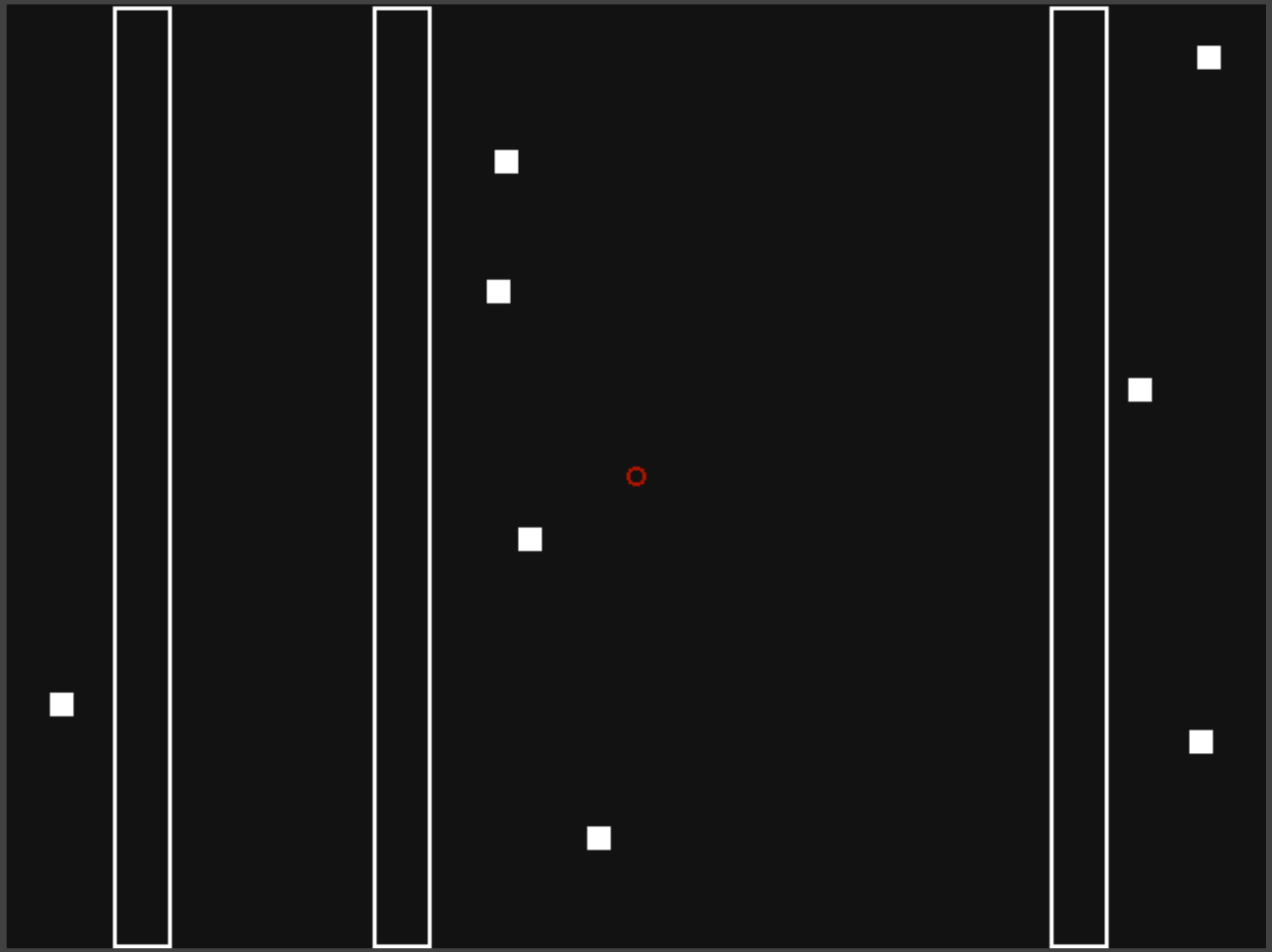
Tracking Multiple Targets

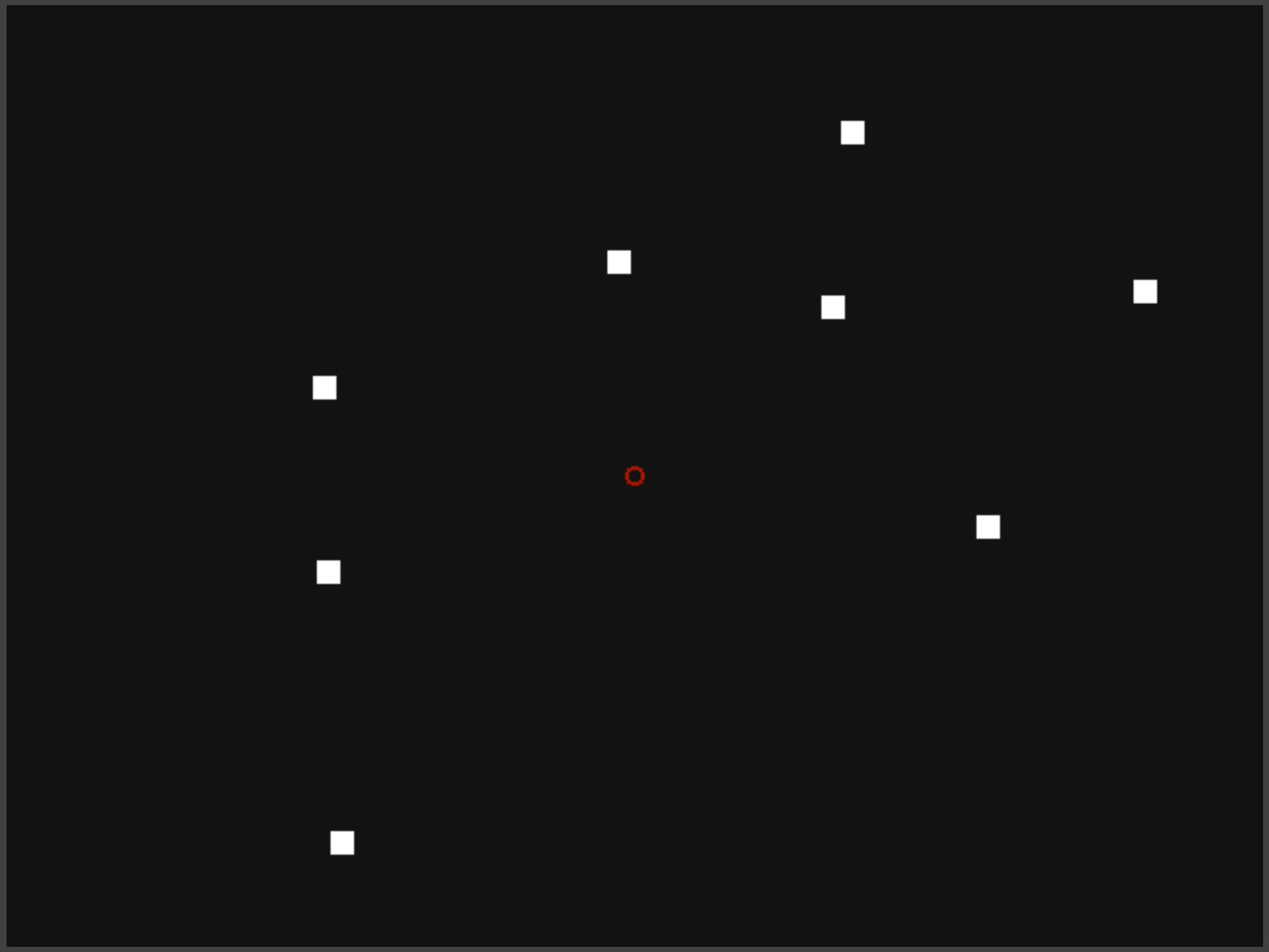


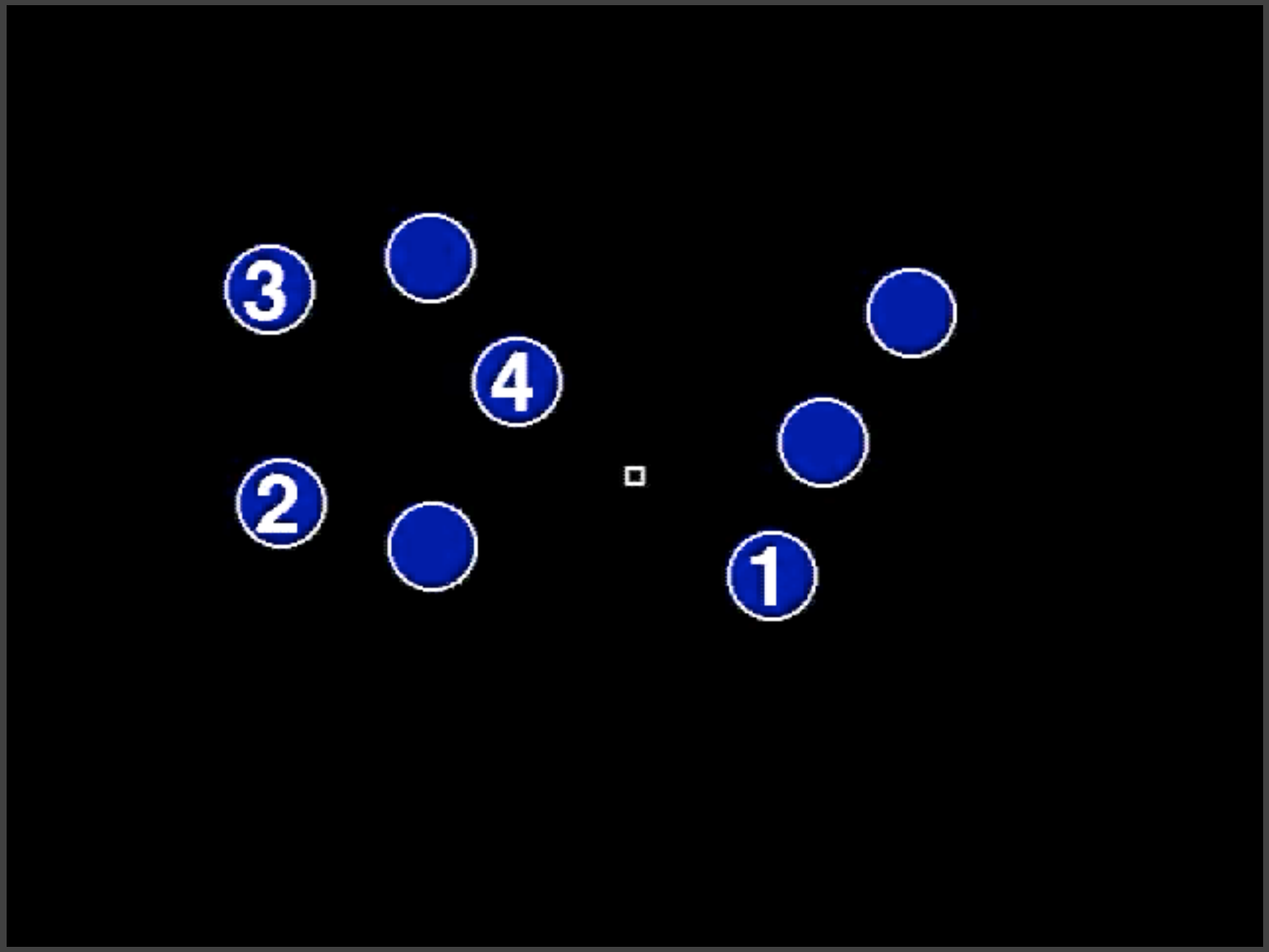
How many dots can we simultaneously track?







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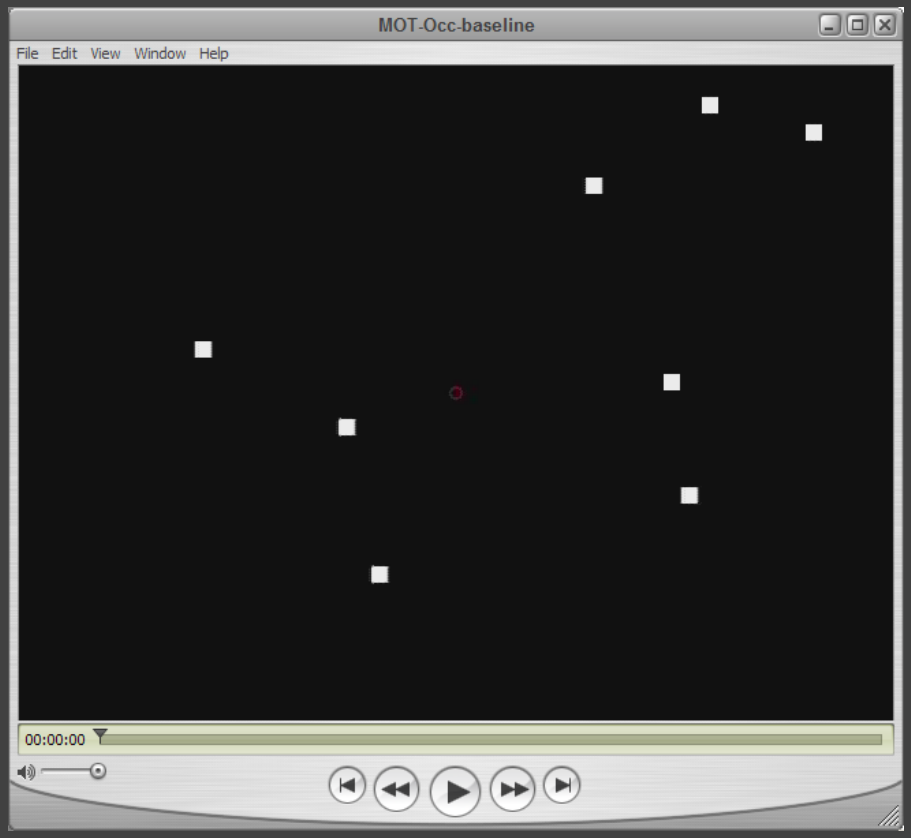
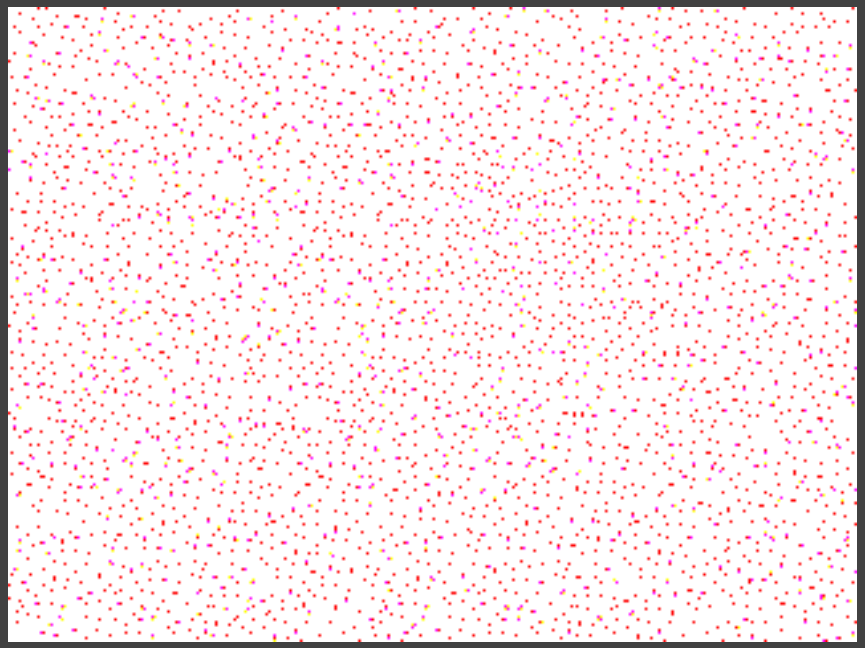
Tracking Multiple Targets



How many dots can we simultaneously track?

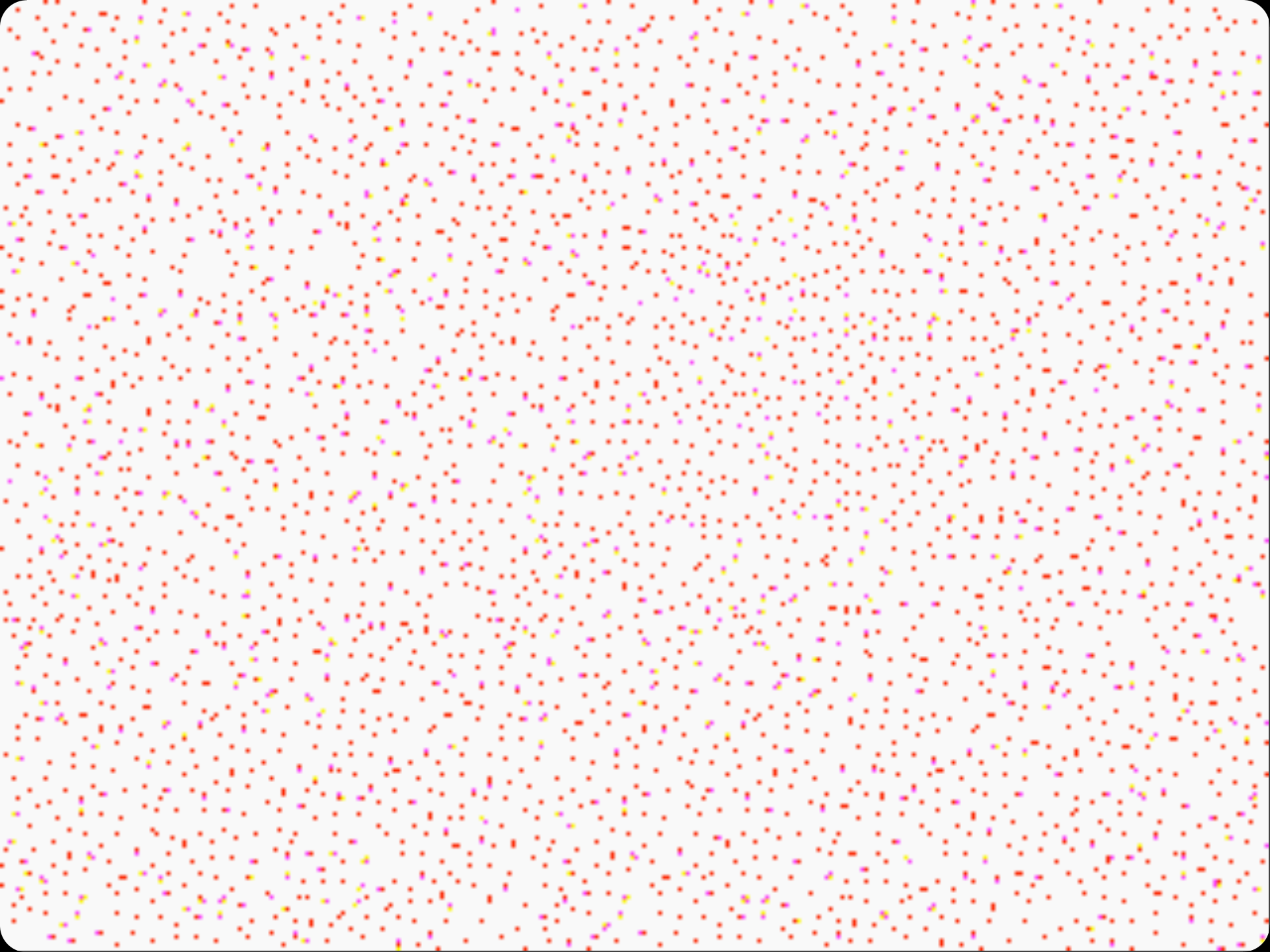
~4-6. Difficulty increases sig. at 6. [Yantis 92, Pylyshn 88, Cavanagh 05]

Segment by Common Fate

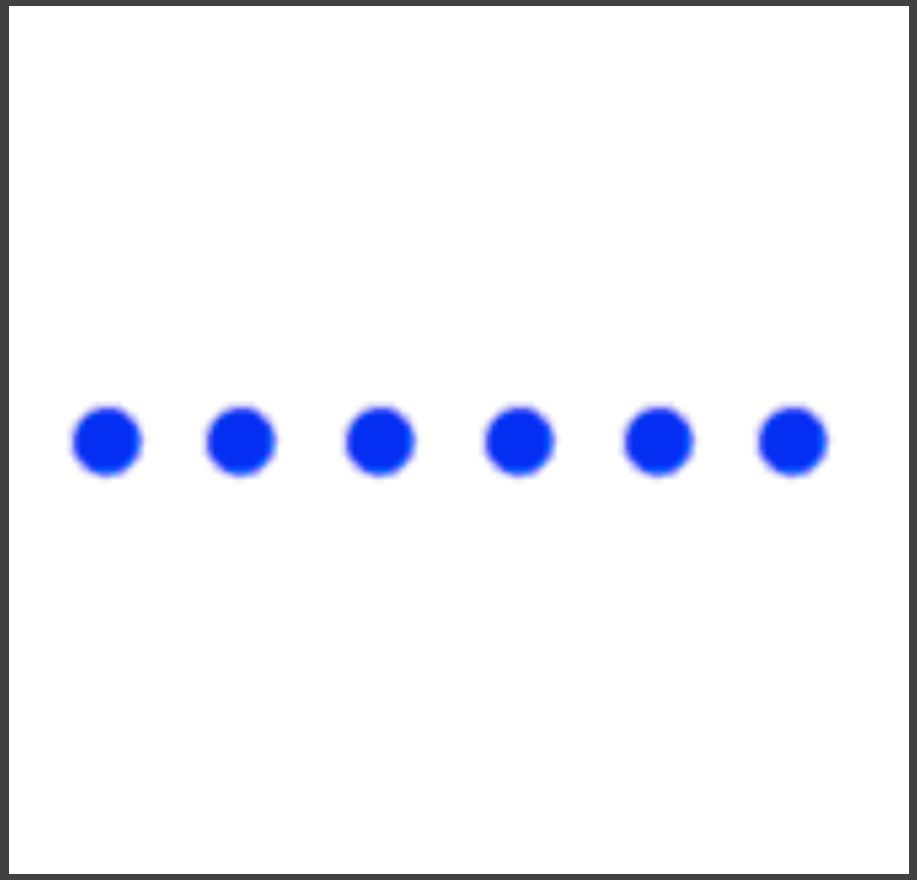


http://dragon.uml.edu/psych/commfate.html

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



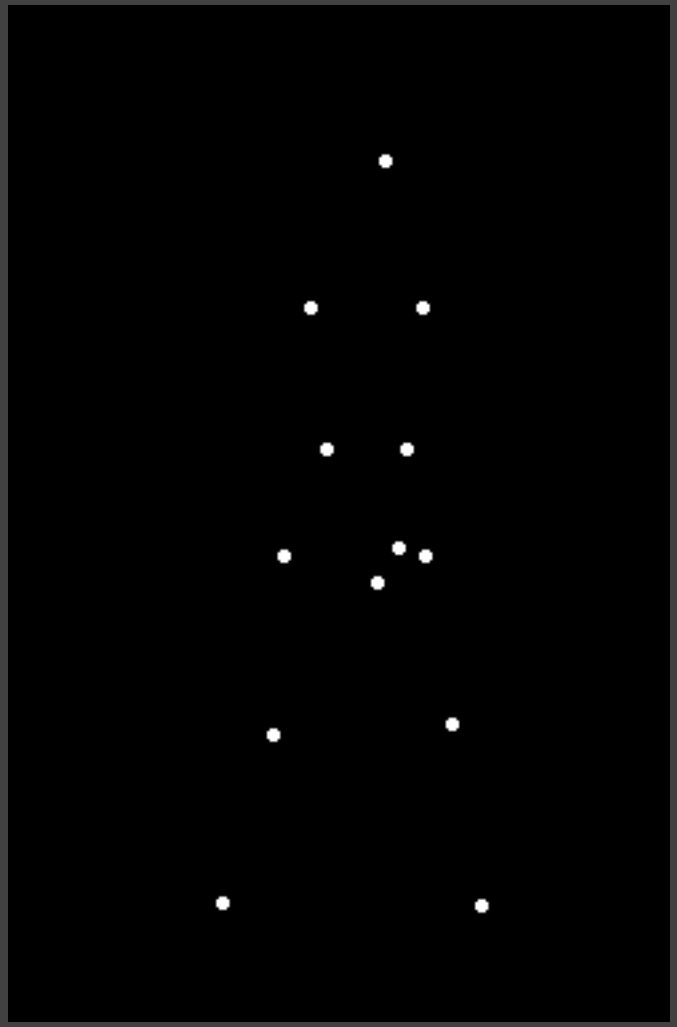
Grouped Dots Count as 1 Object



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

Velocity Perception

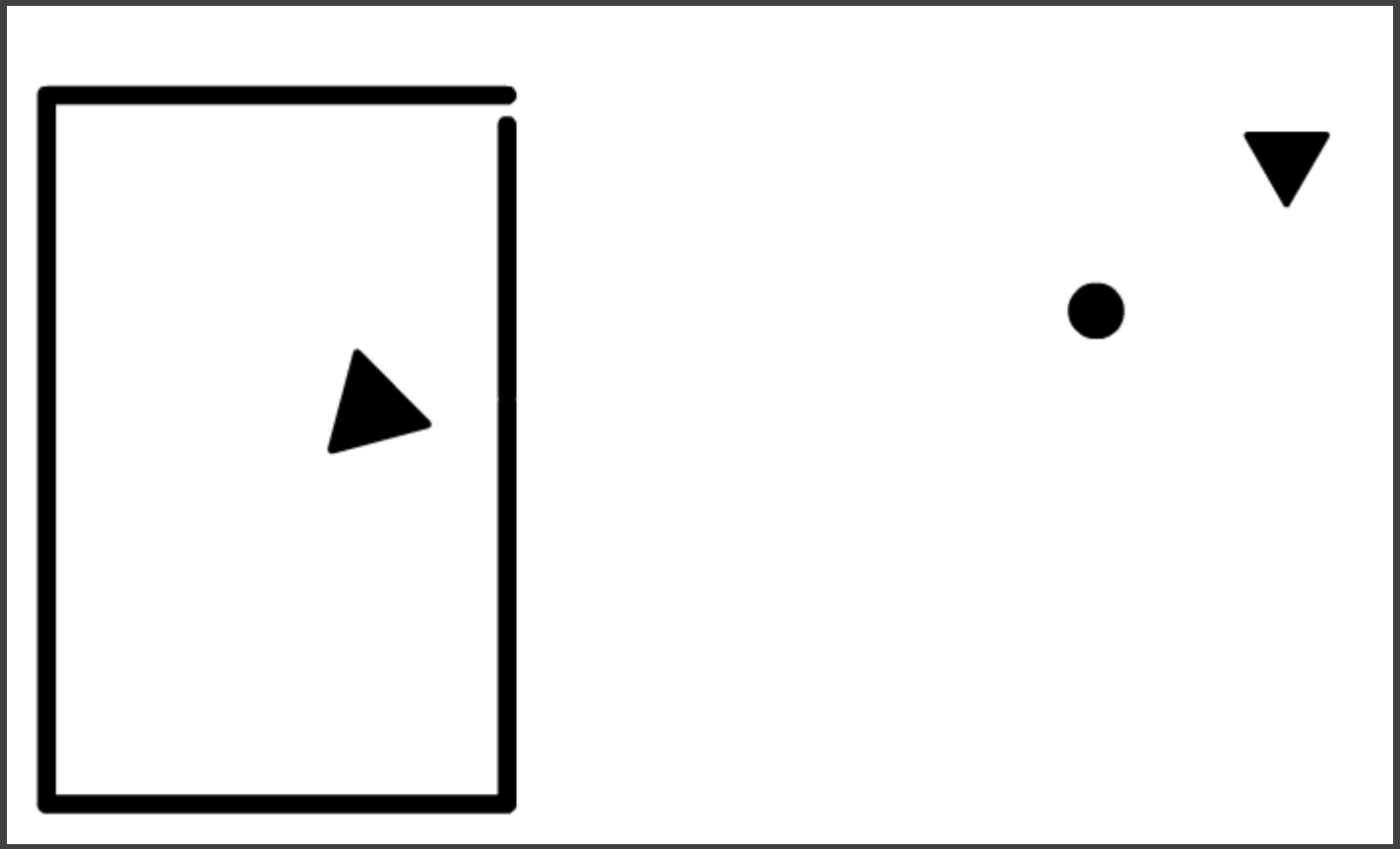
What is perceived as smooth, uniform motion?

Velocity perception can be affected by:

- Path curvature
- Size / depth perception
- Luminance contrast

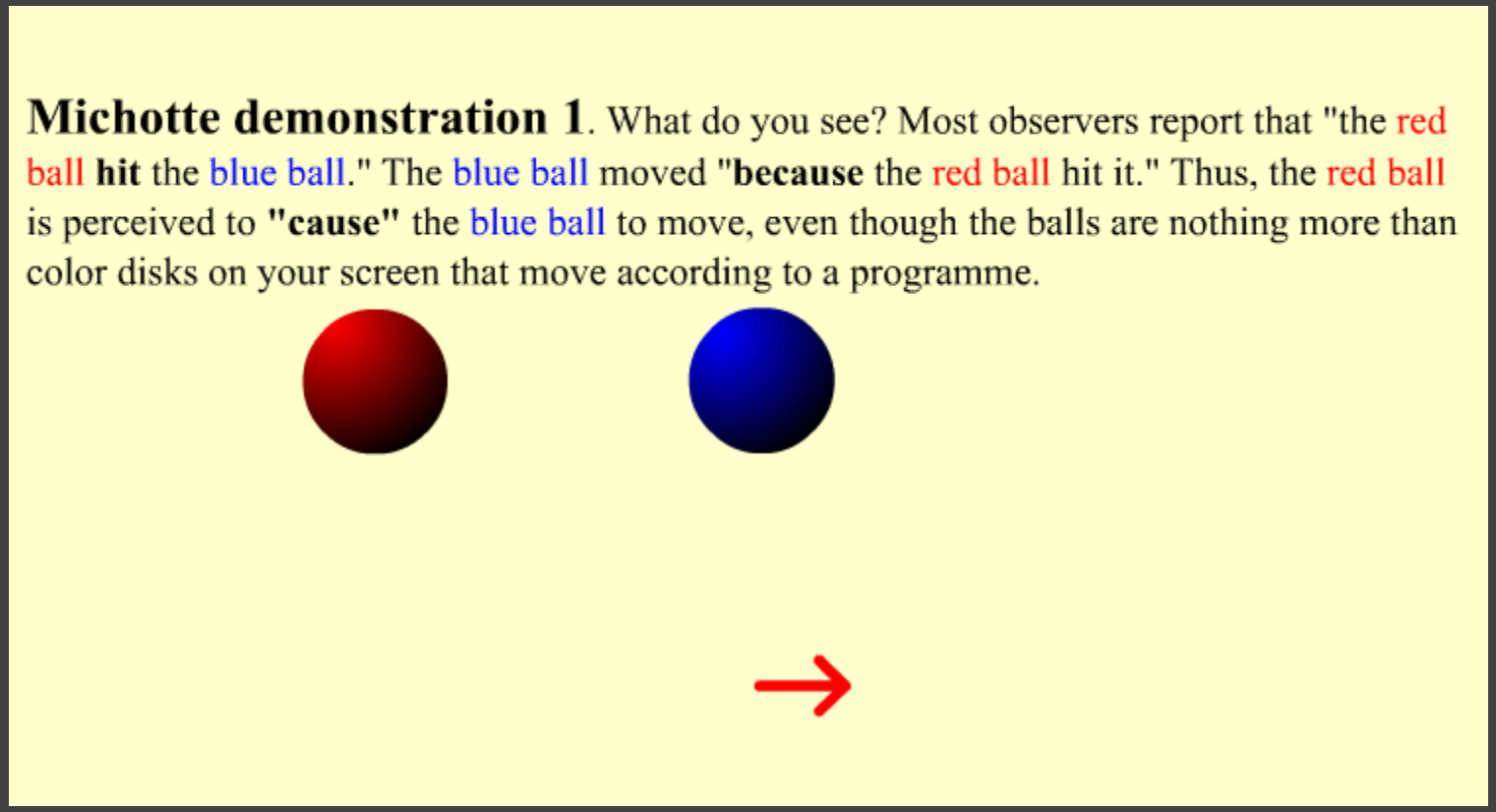
(DEMO)

Constructing Narratives



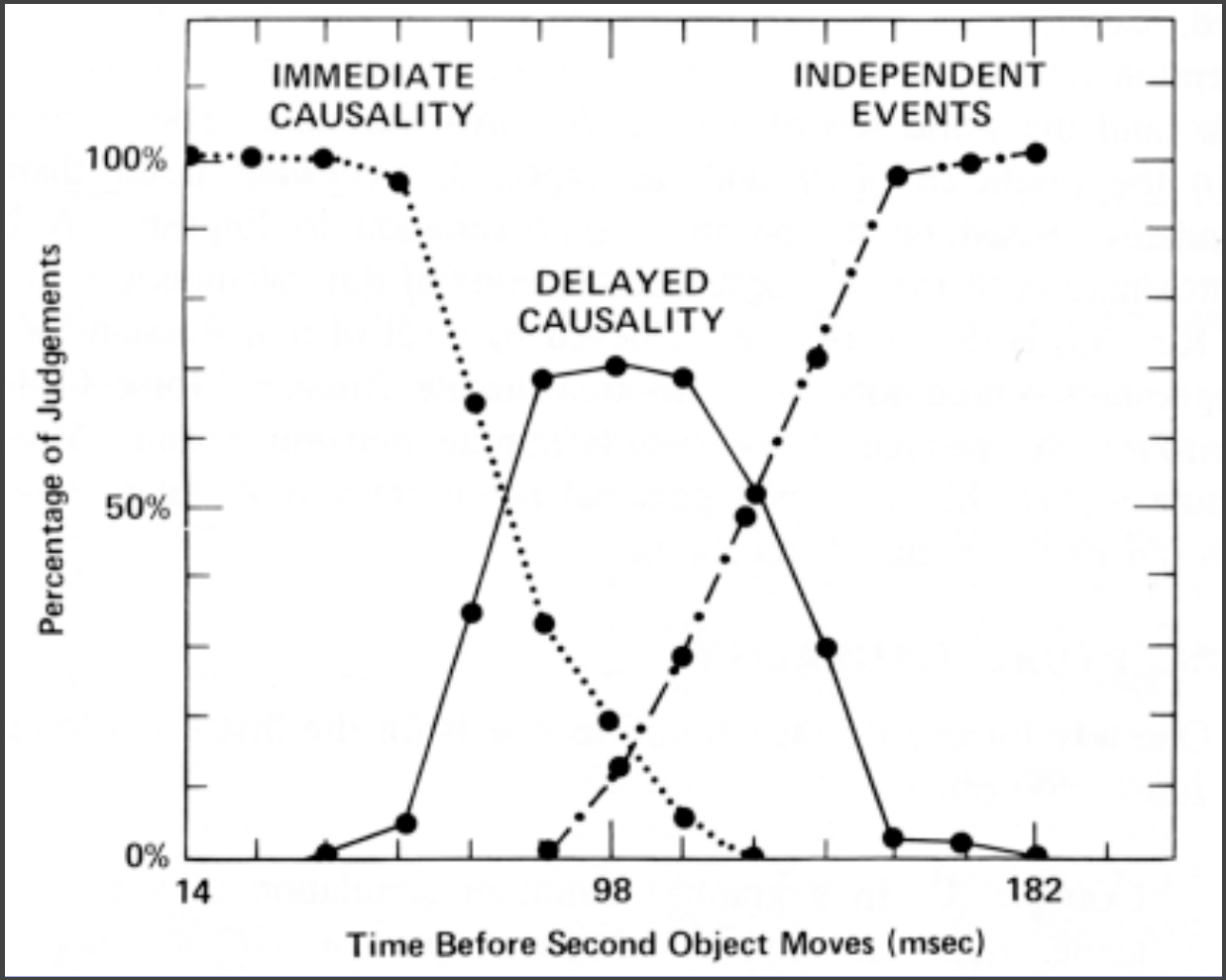
http://anthropomorphism.org/img/Heider_Flash.swf

Attribution of Causality [Michotte 46]



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

Attribution of Causality [Michotte 46]

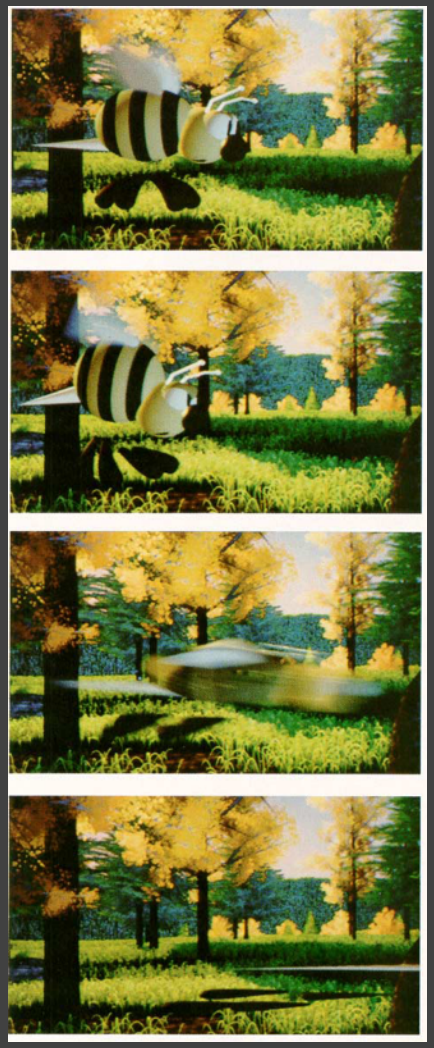


[Reprint from Ware 04]

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)

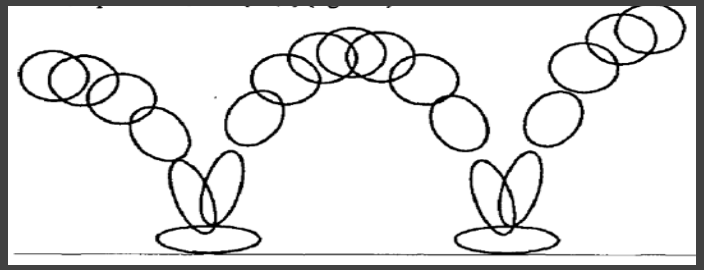
Squash and stretch

Exaggeration

Anticipation, Follow-through

Staging, Overlapping Action

Slow-in / Slow-out



Squash & Stretch

Defines rigidity of material

Should maintain constant volume

Smoothes fast motion, similar to motion blur

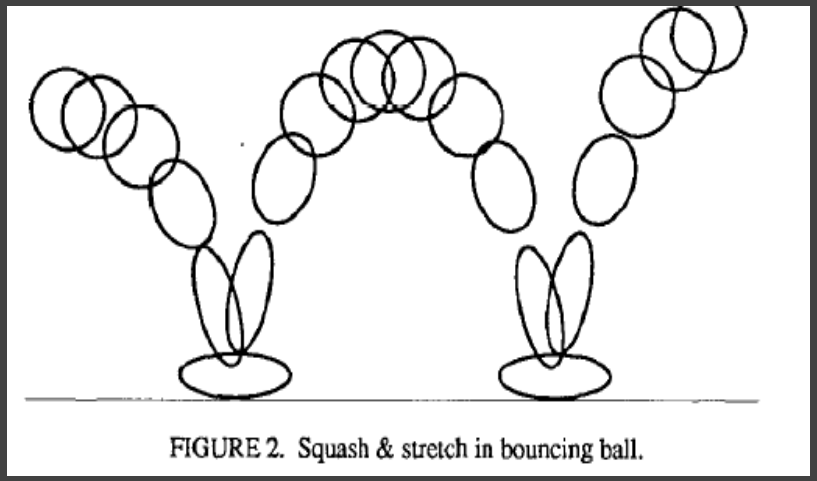
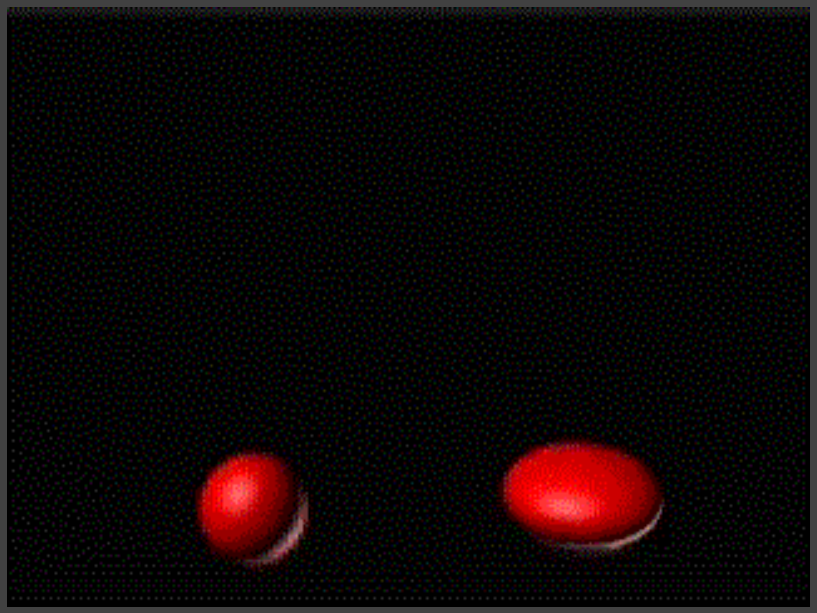


FIGURE 2. Squash & stretch in bouncing ball.



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

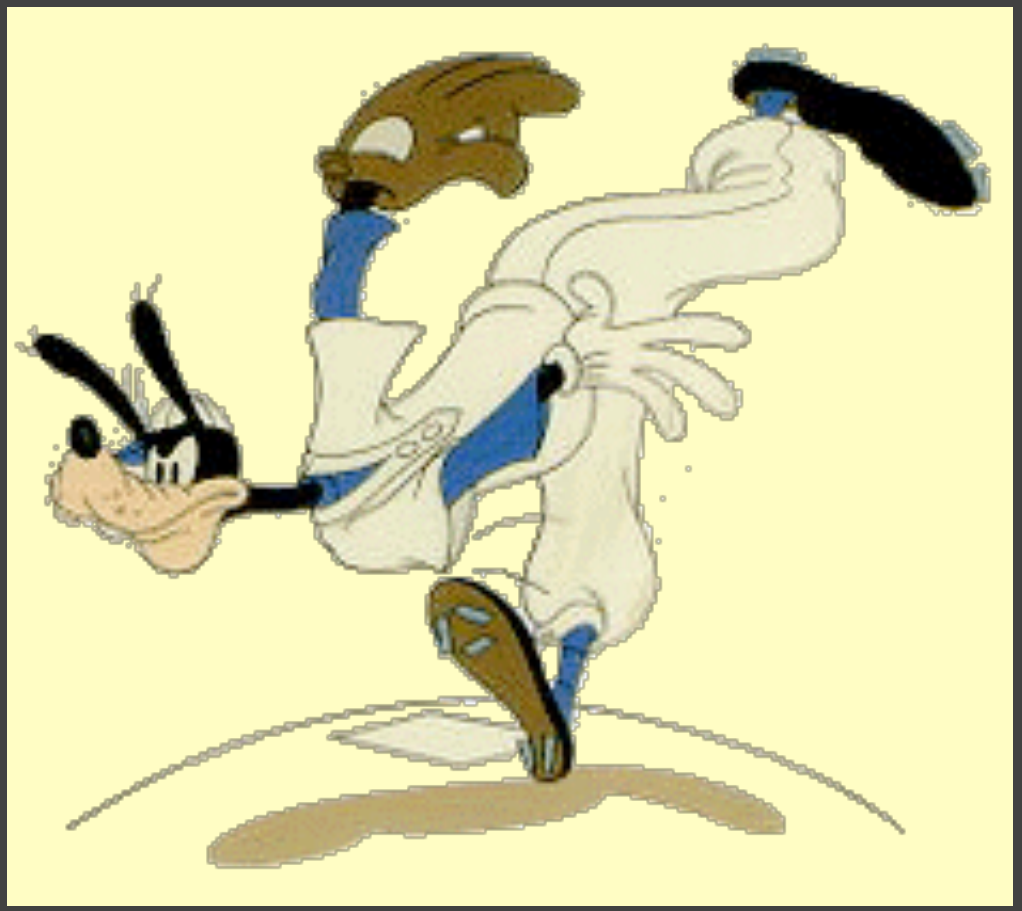
Motion clearest at silhouette

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

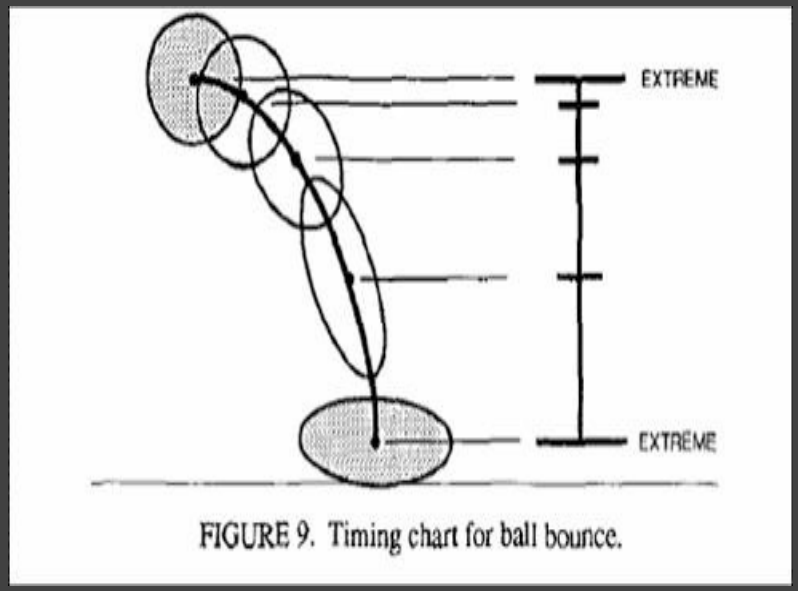
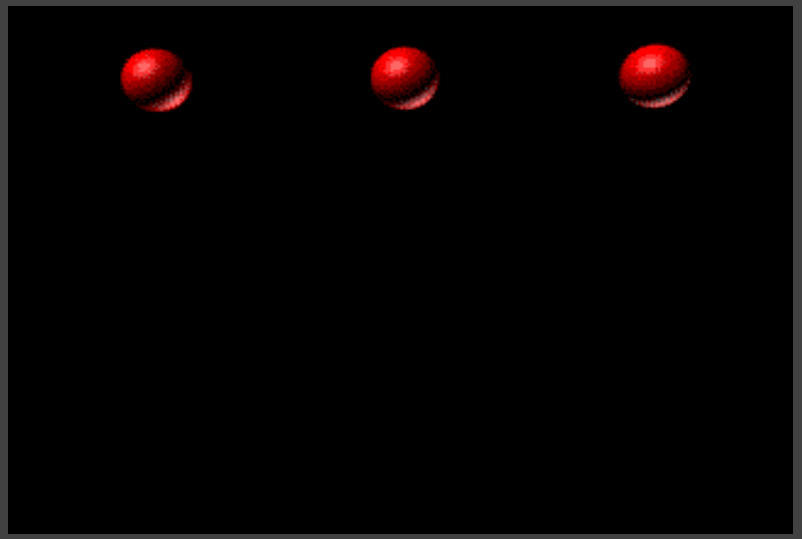


FIGURE 9. Timing chart for ball bounce.



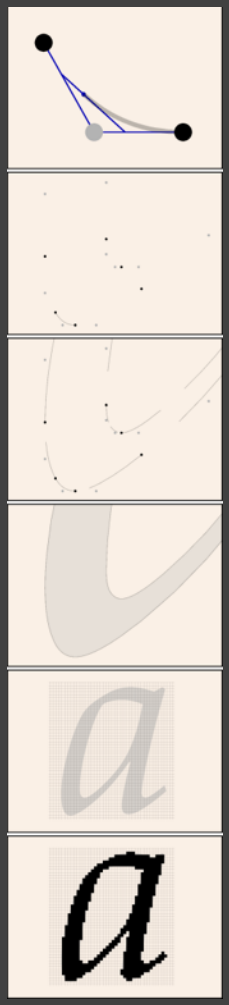
Example: Andre and Wally B.

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

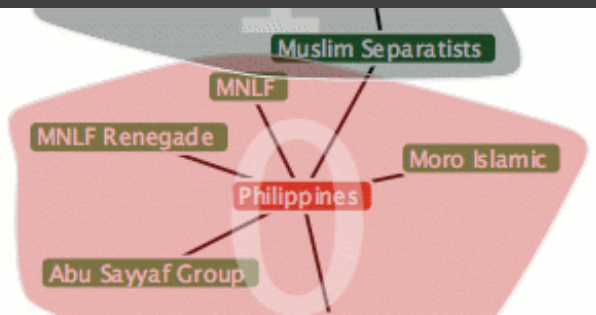
A3: Interactive Visualization

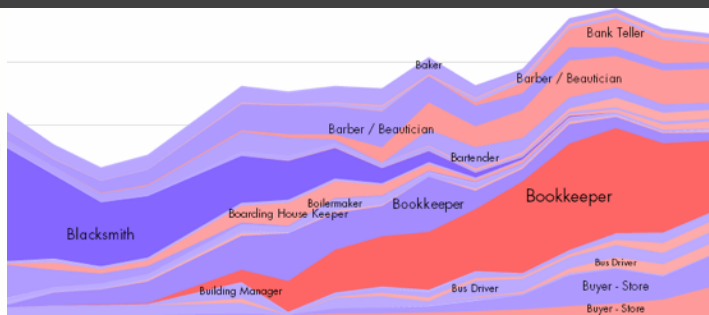
Create an interactive visualization application. Choose a data domain and an appropriate visualization technique.

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.

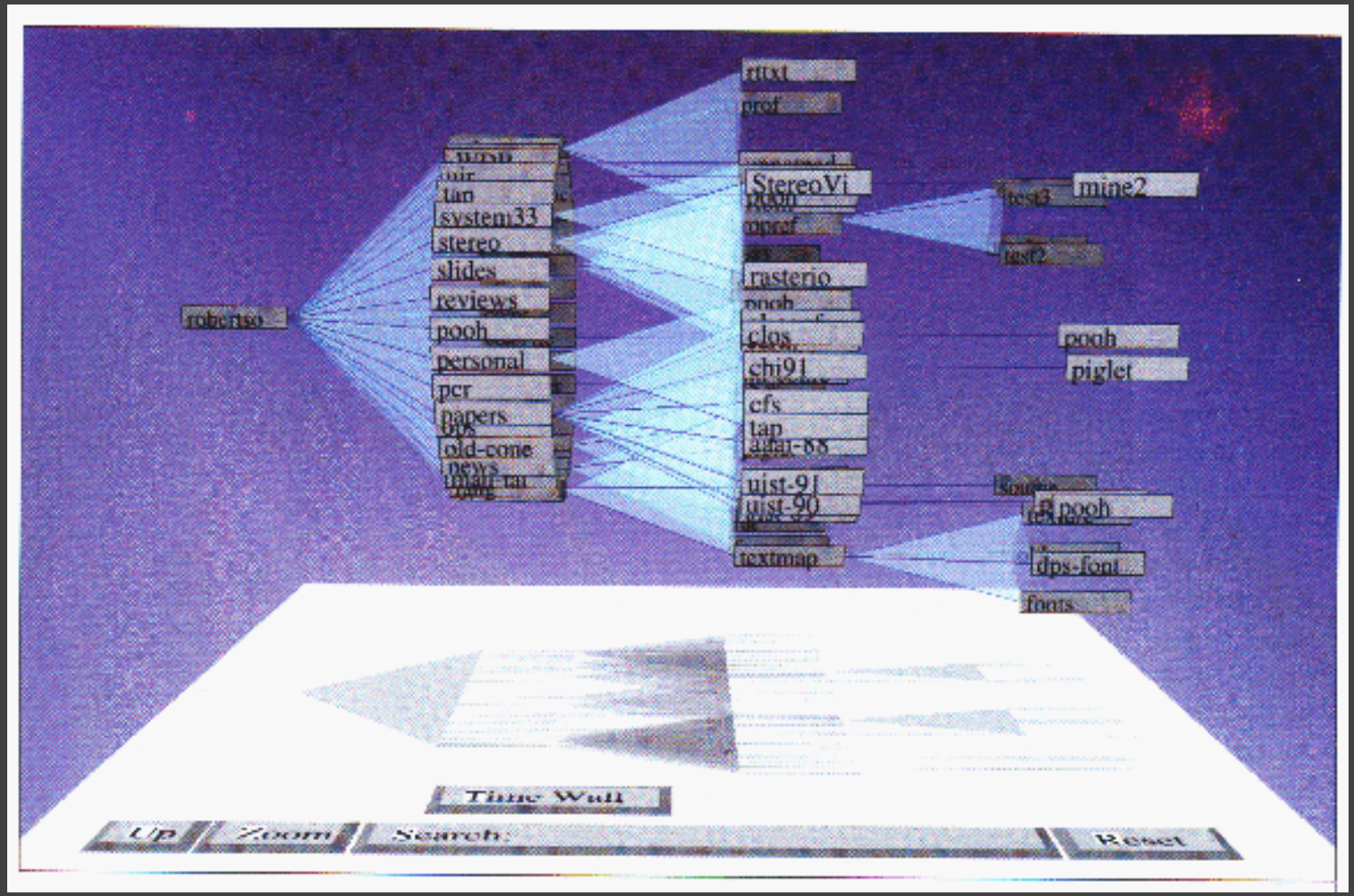
Due by *5pm* on **Monday, May 4**





Animated Transitions

Cone Trees [Robertson 91]



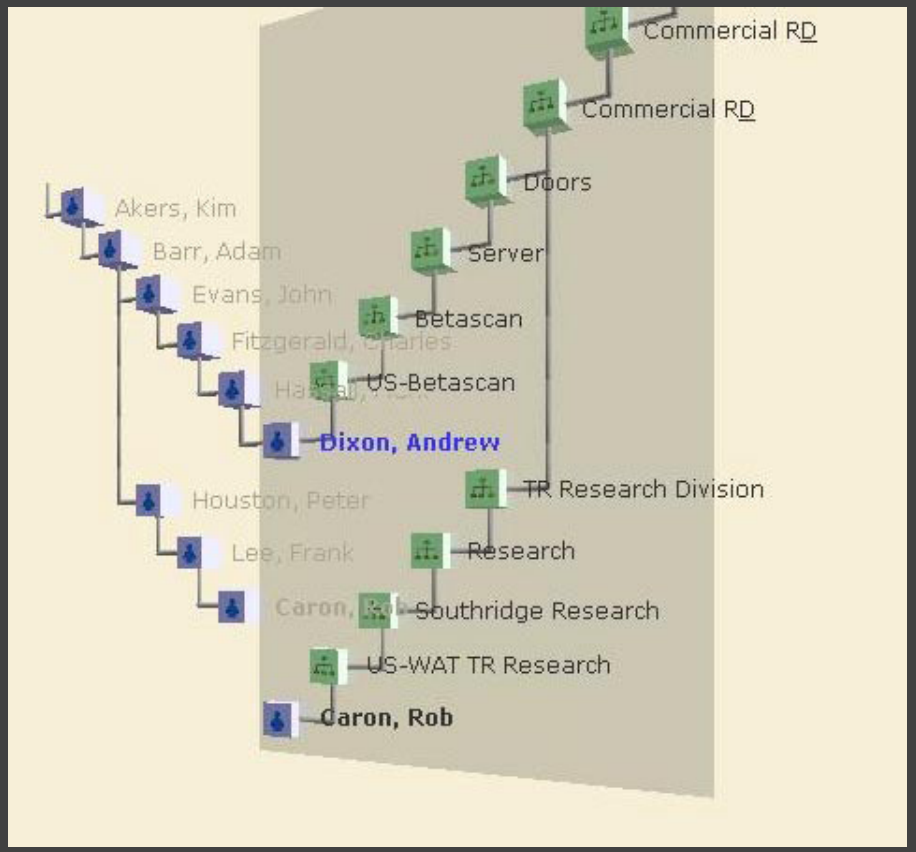
Polyarchies [Robertson 02]

Animate pivots across intersecting hierarchies.

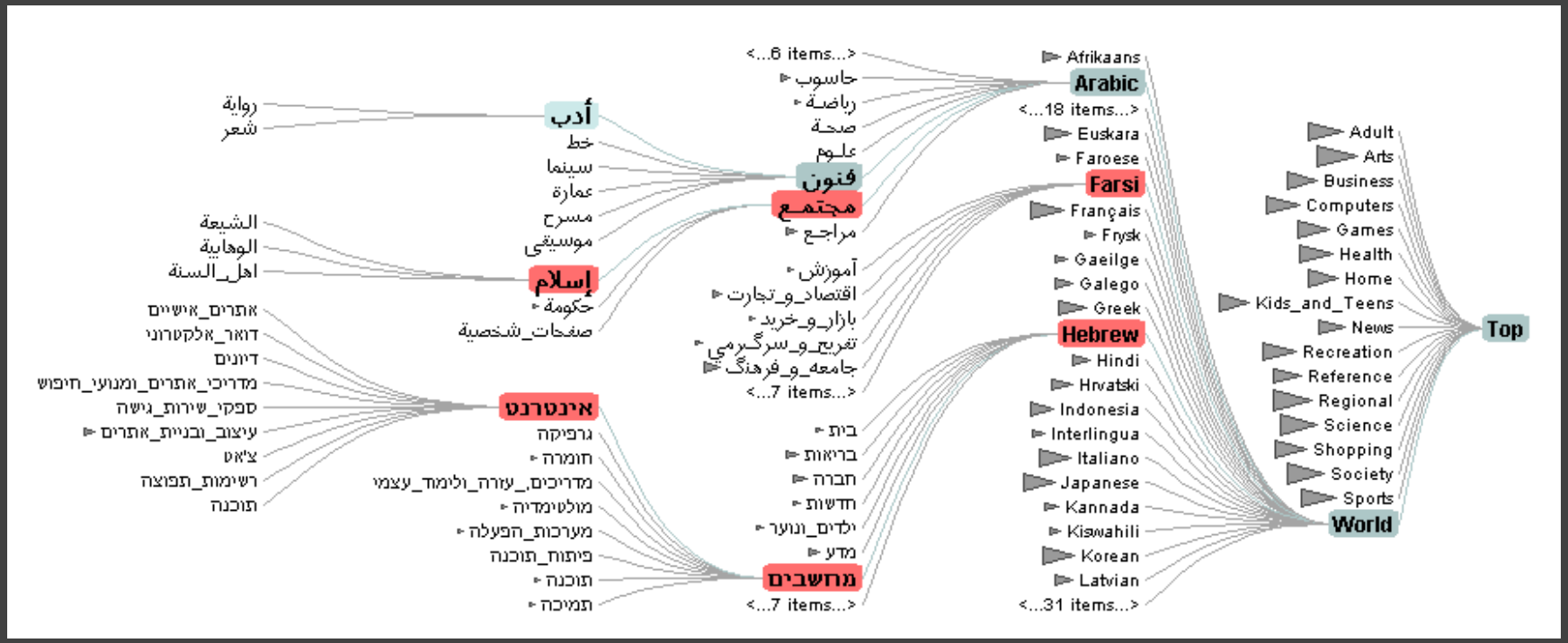
Tested a number of animation parameters.

Best duration: ~1 sec

Rotational movement degraded performance, translation preferred.

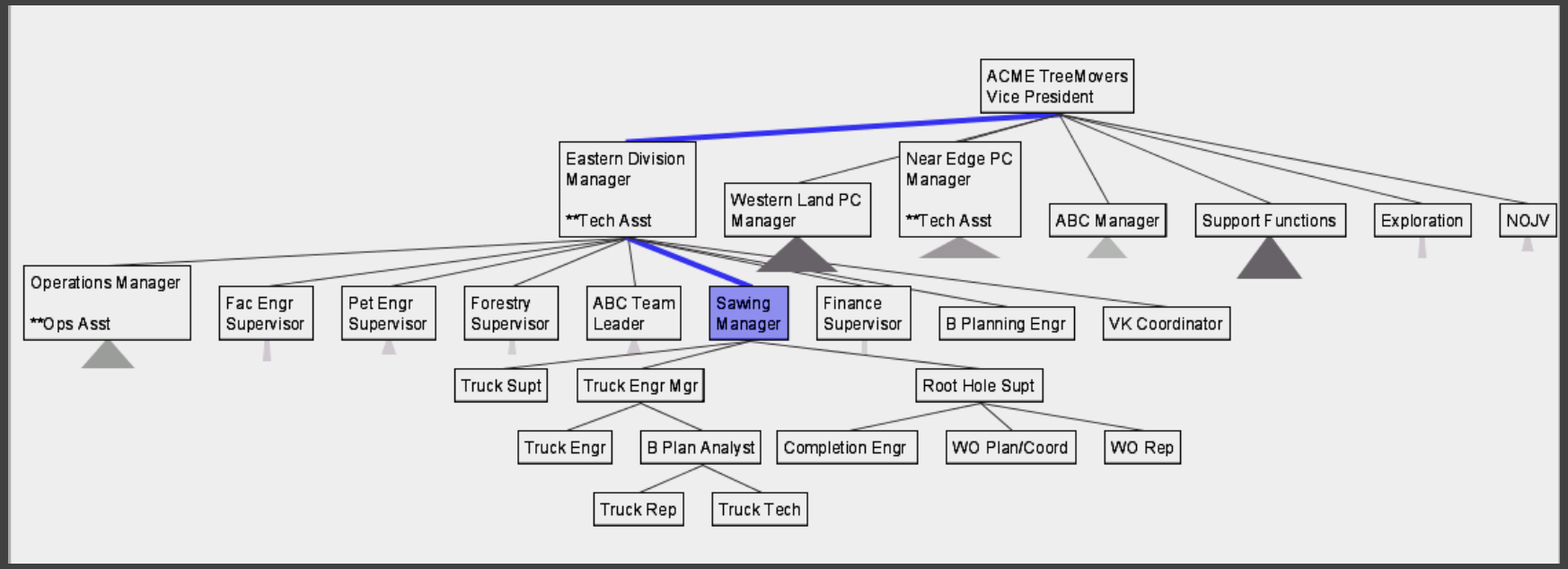


Degree-of-Interest Trees [Heer 04]



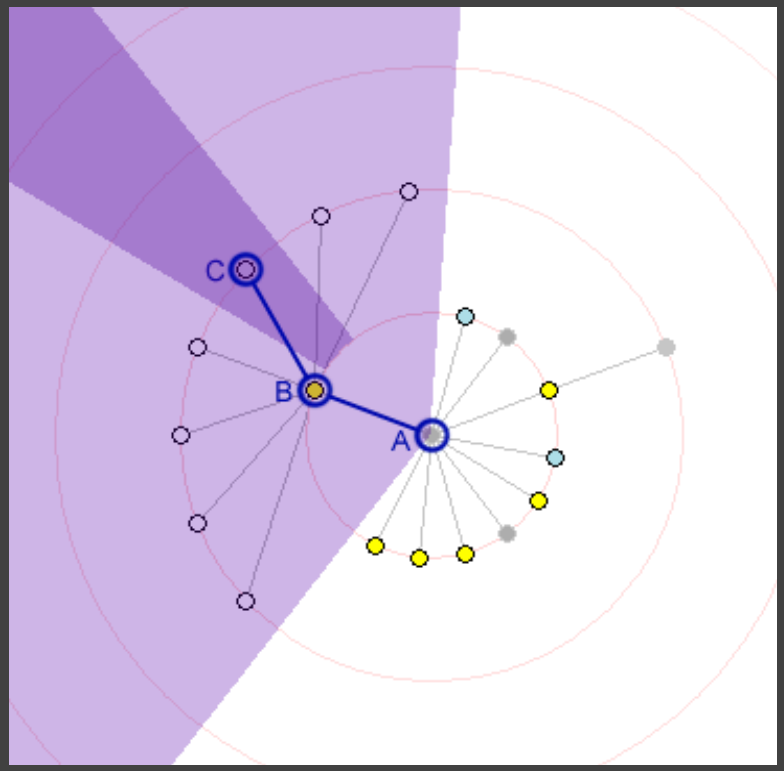
Animation of expanding/collapsing branches

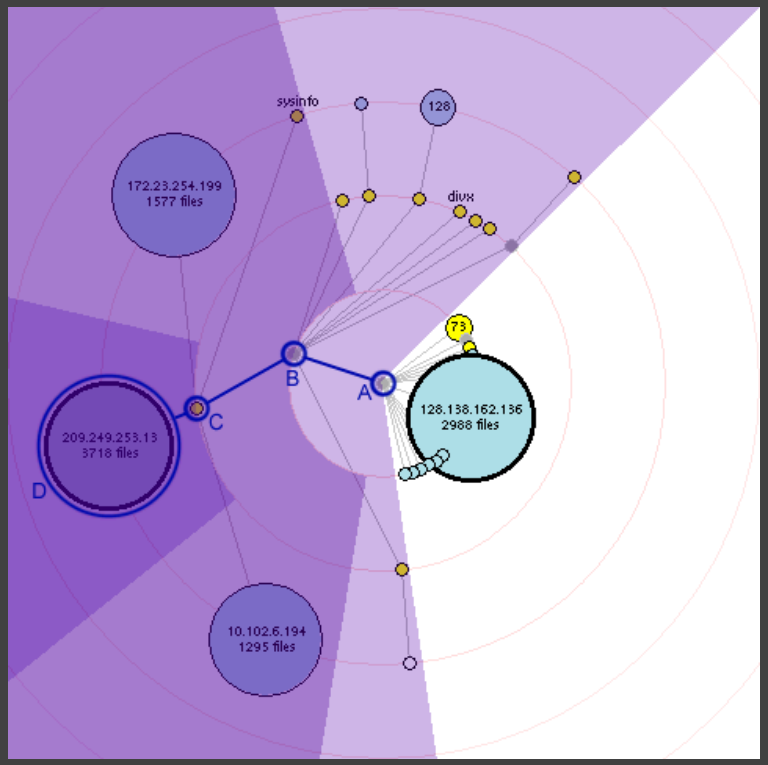
Space Tree [Grosjean 04]



Break animated transitions into discrete stages

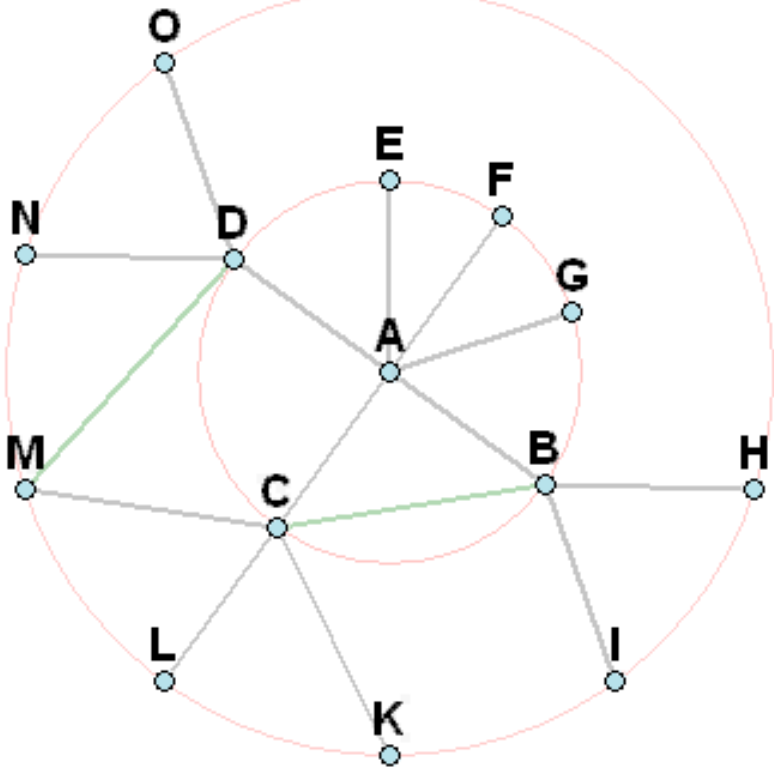
Radial Graph Layout





Optimize animation to aid comprehension

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

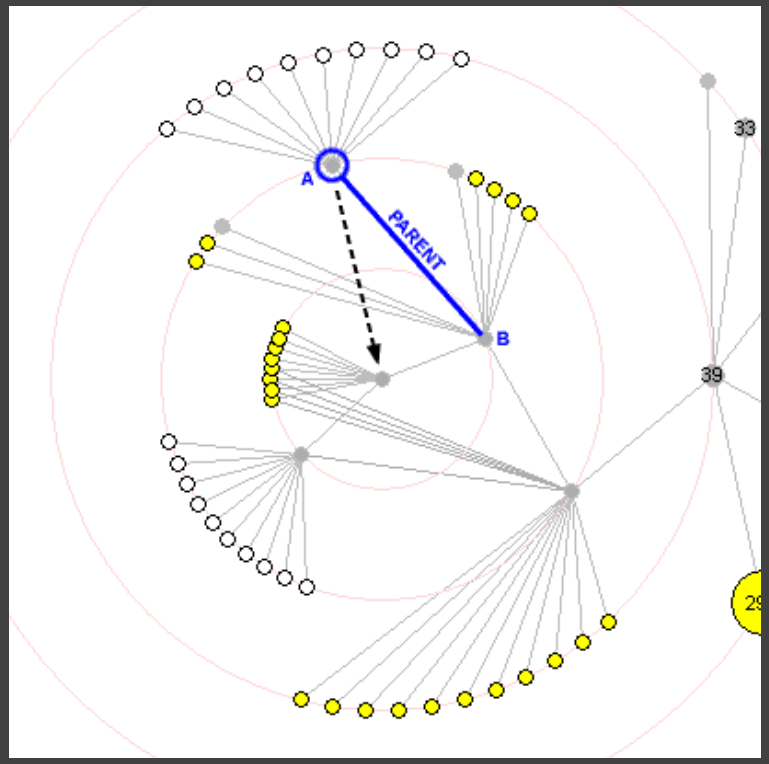
Animation in Radial Graph Layout

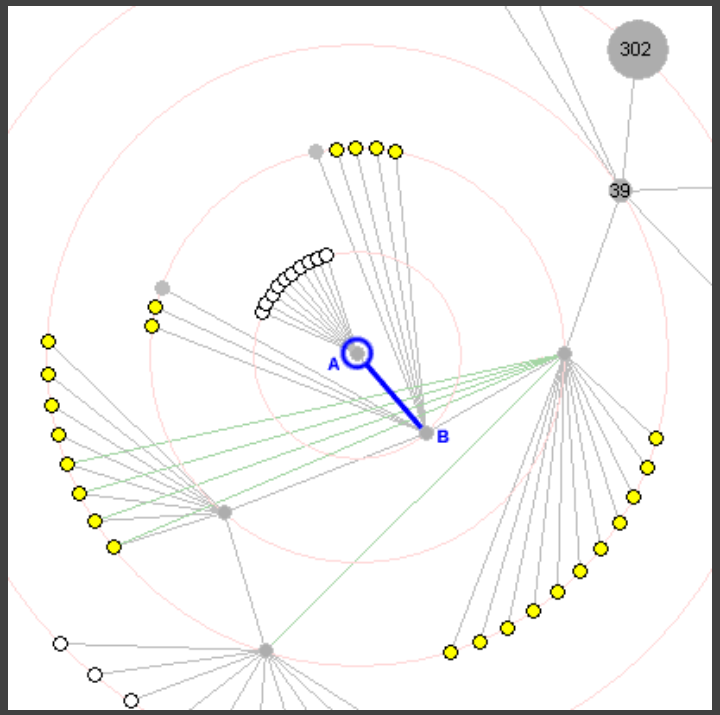
Transition constraints

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

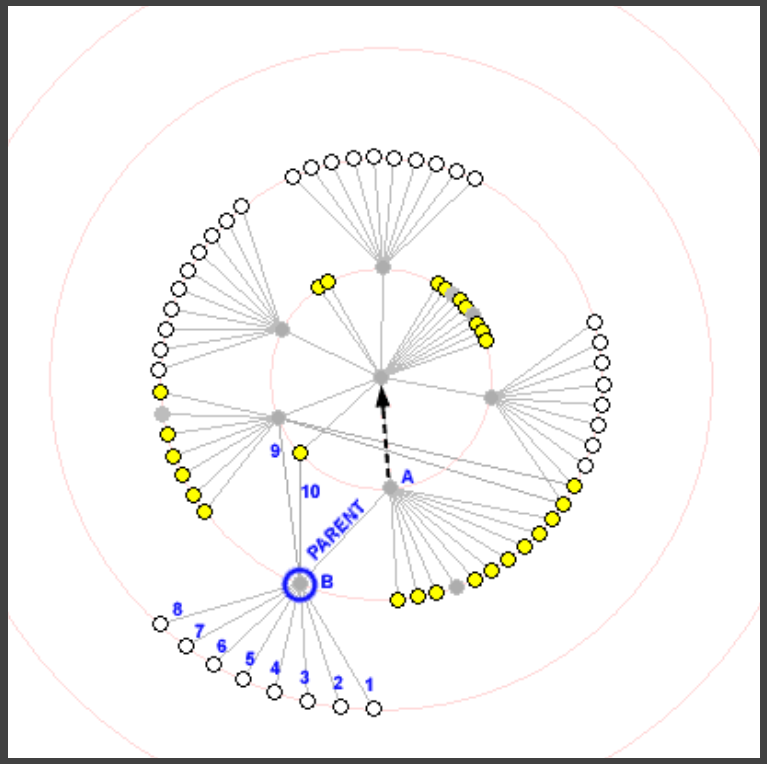
Avoid cross-over of edges

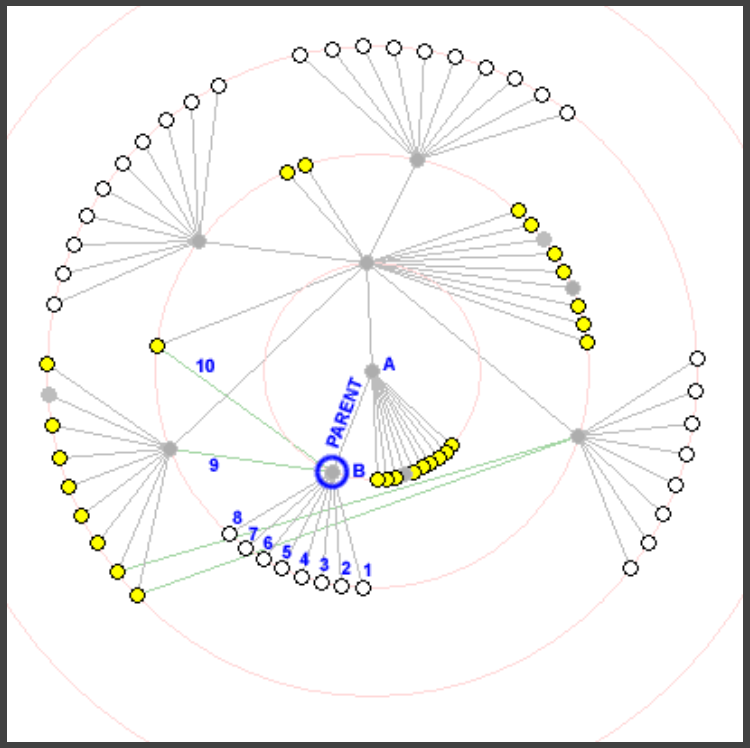
Retain Edge Orientation



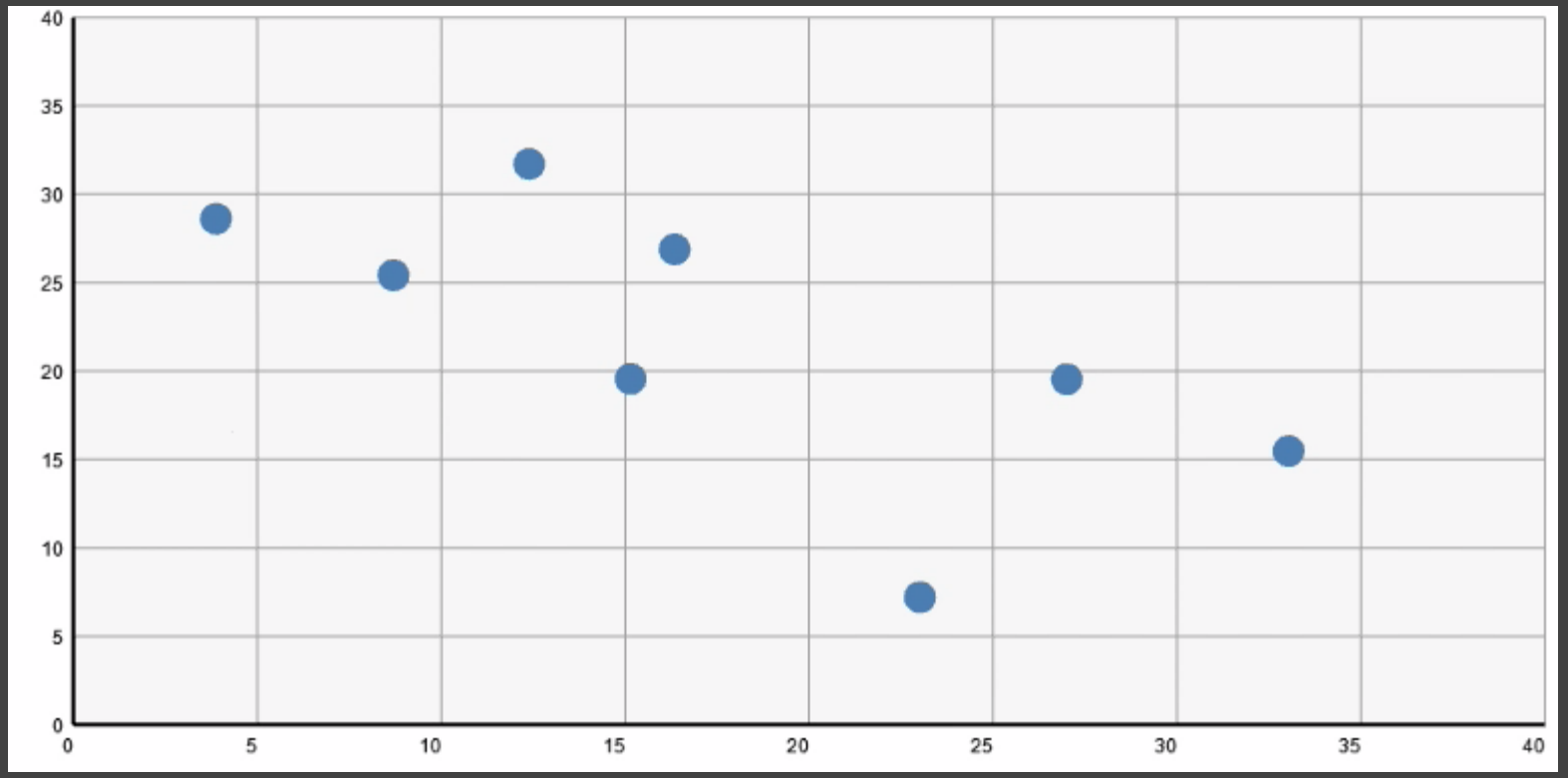


Retain Neighbor Order





Animated Transitions in Statistical Graphics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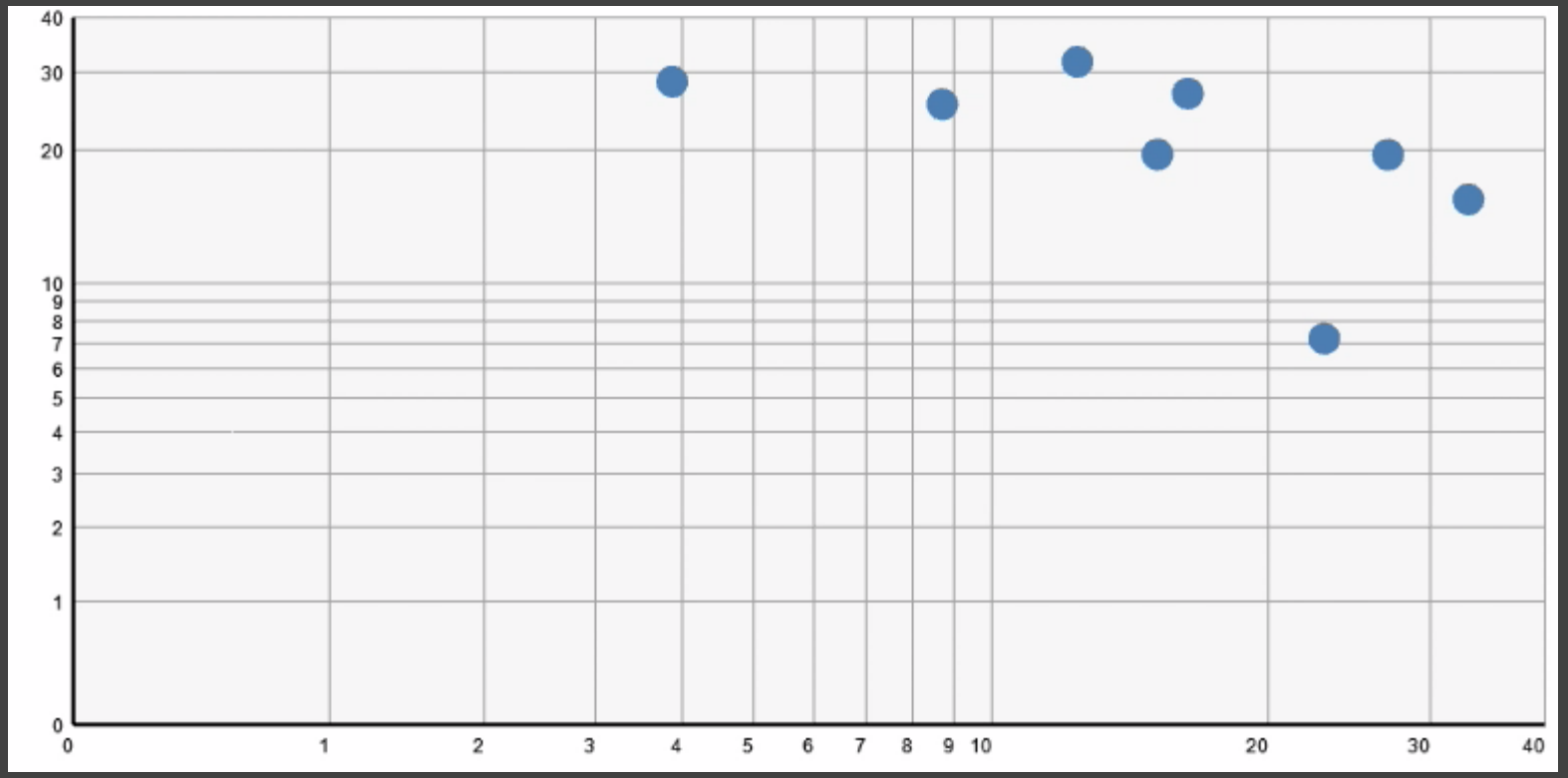
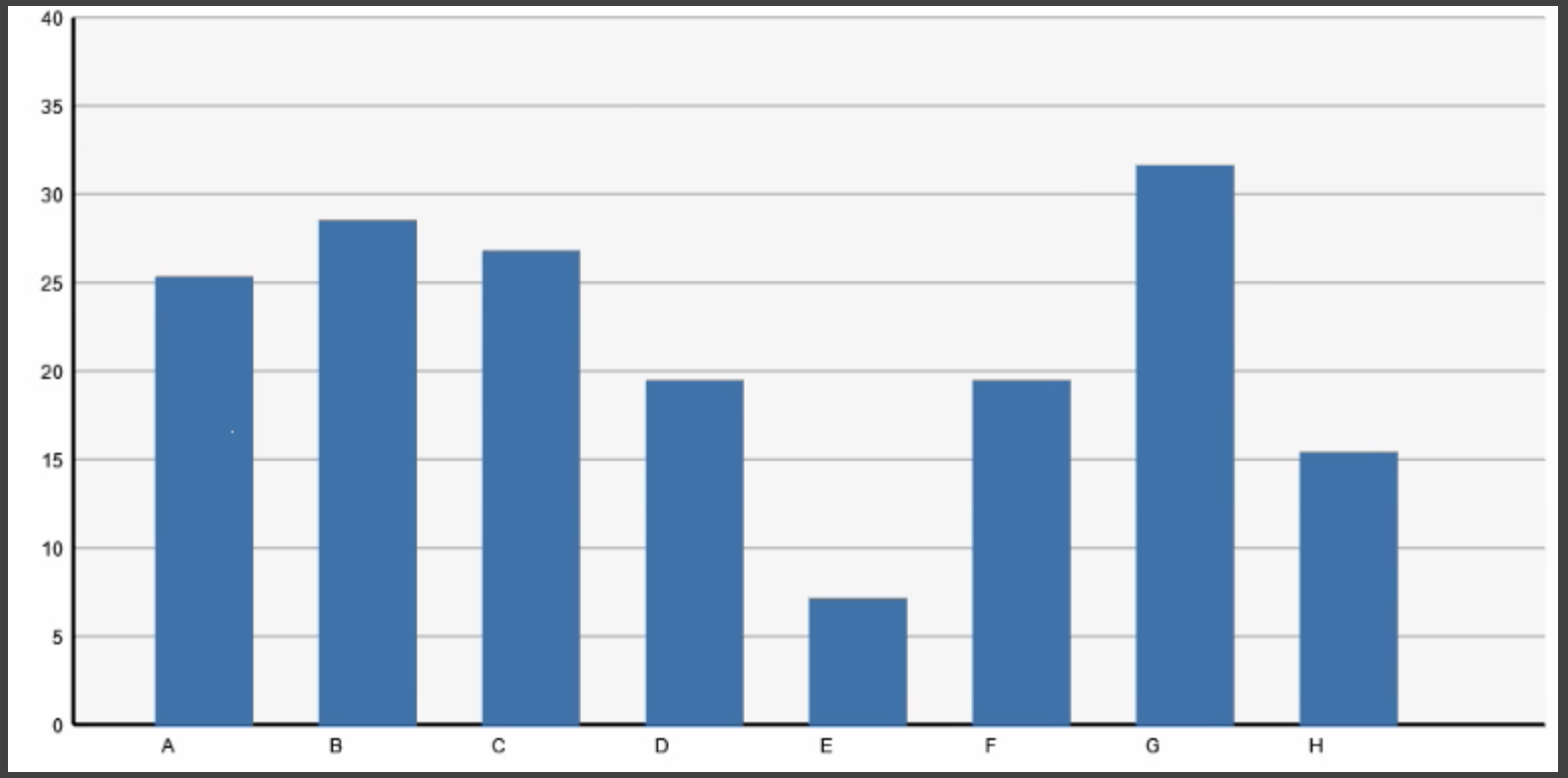
Log Transform

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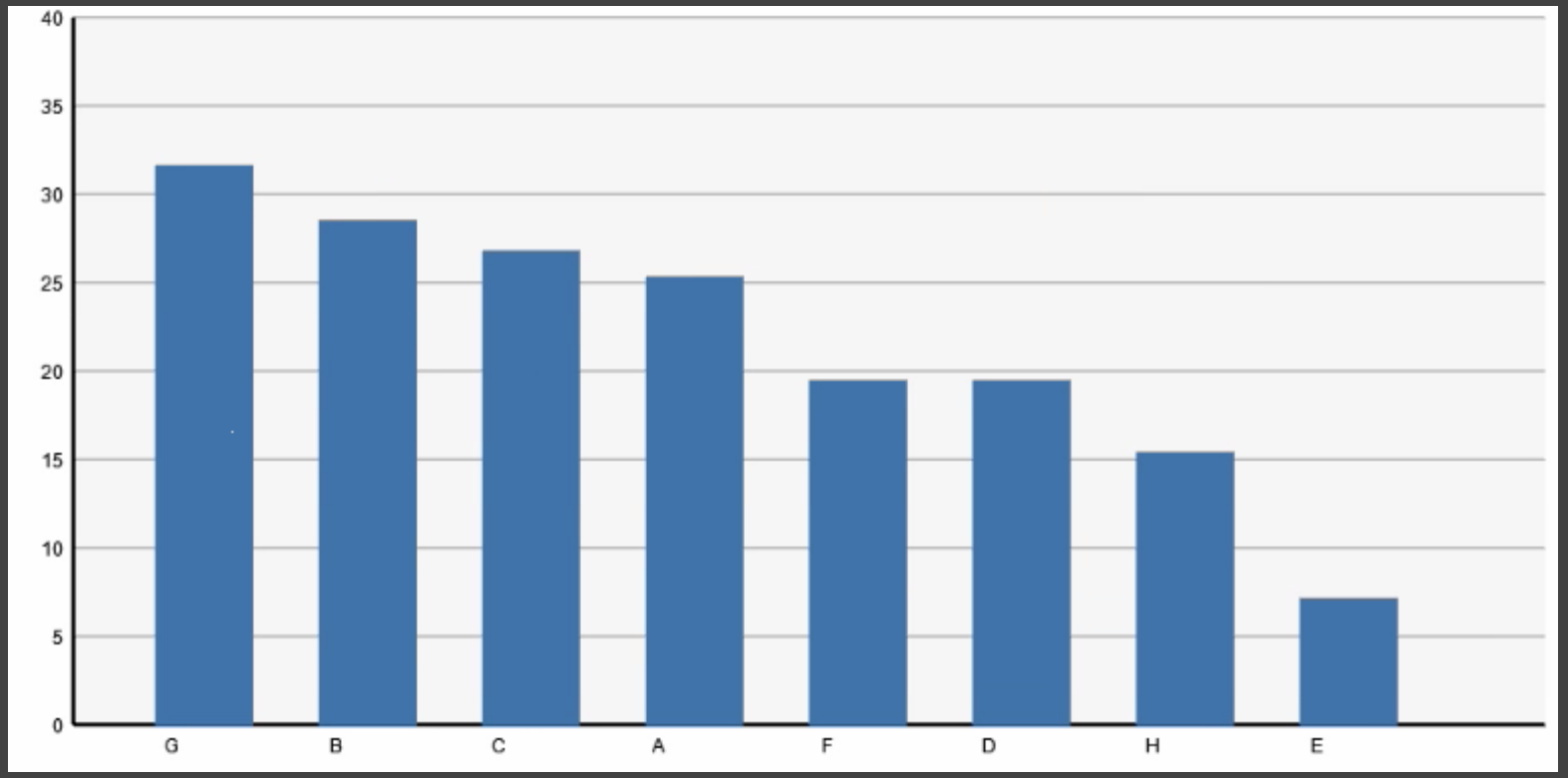
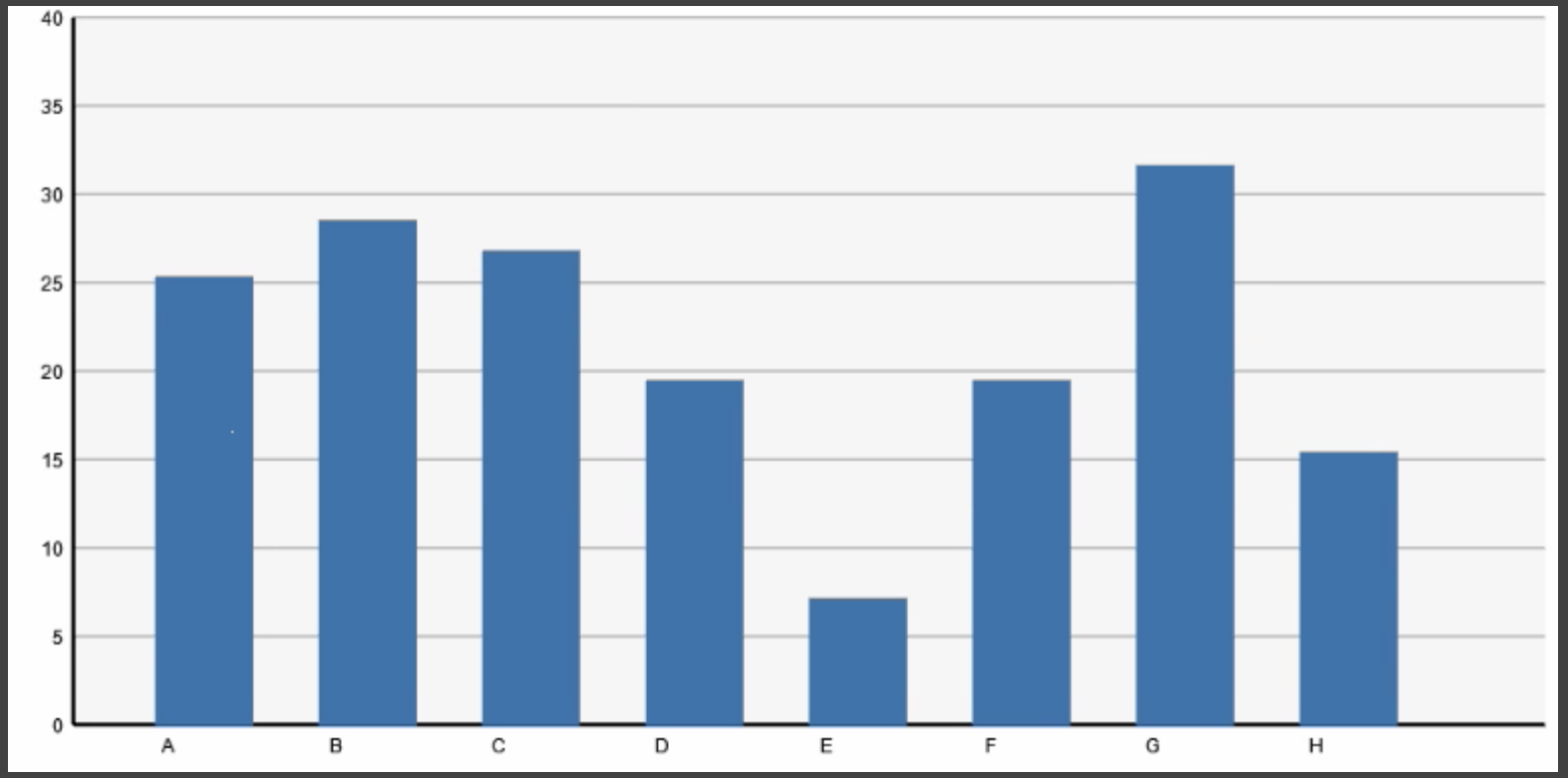
Sorting

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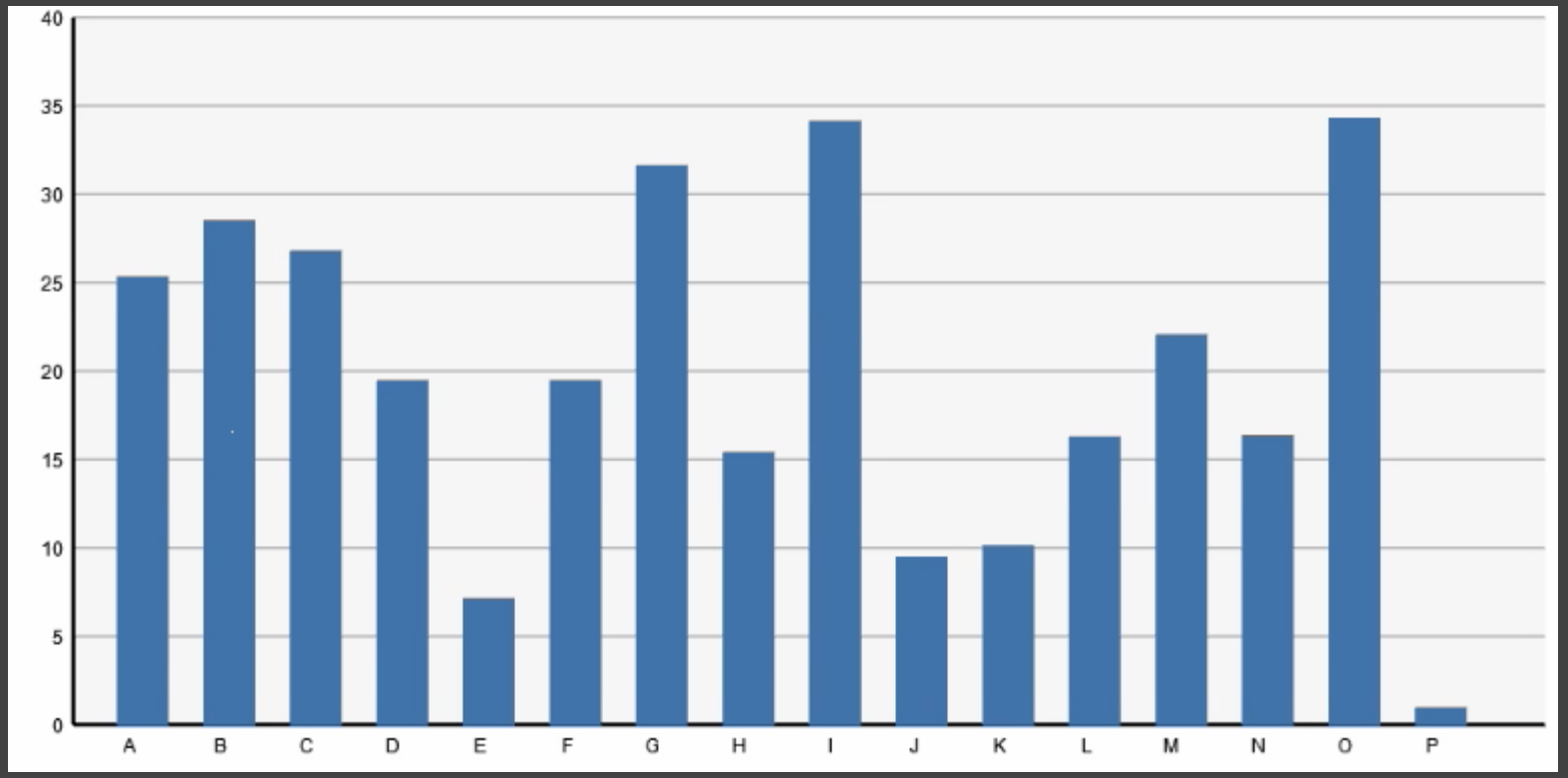
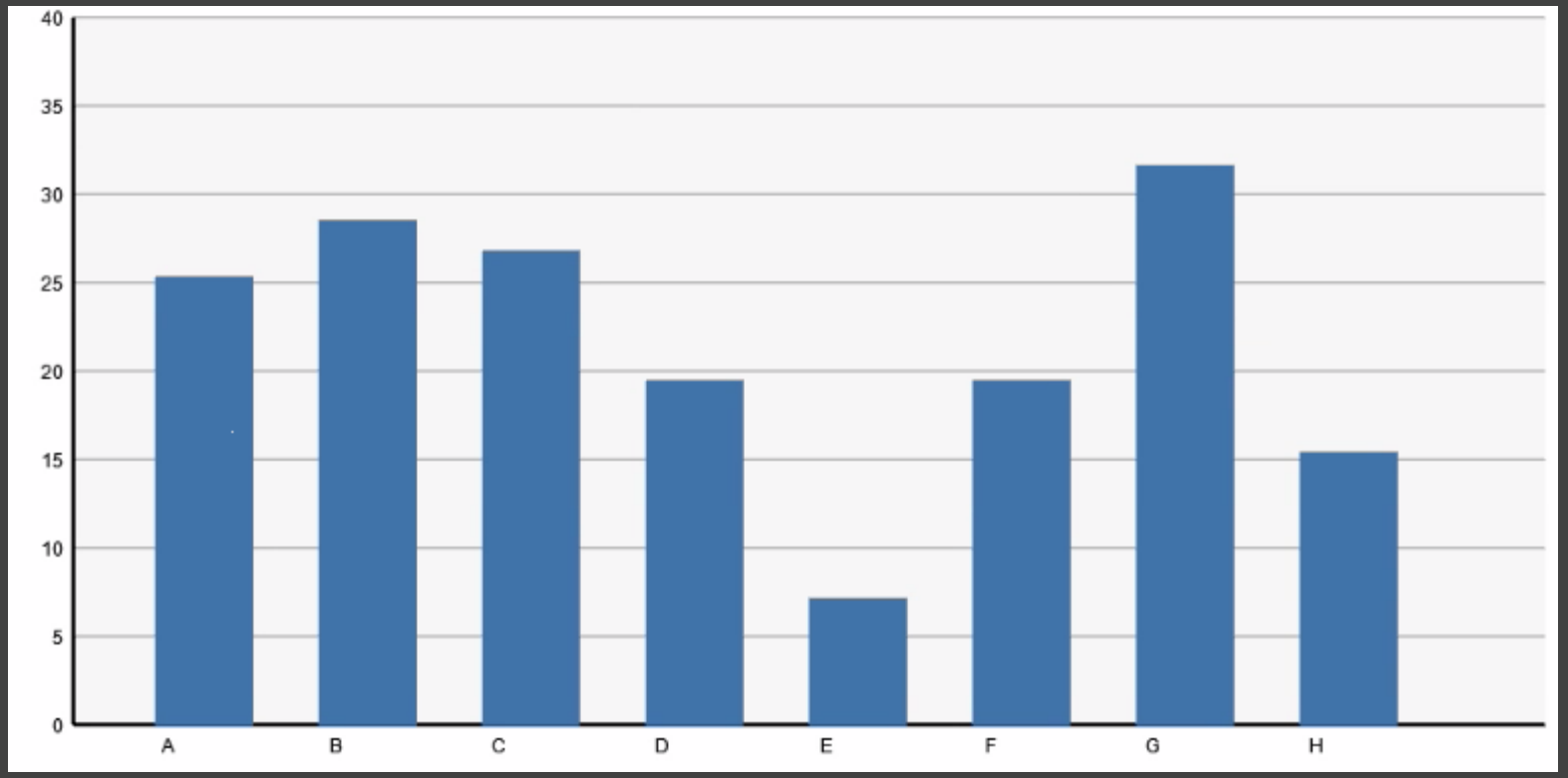
Filtering

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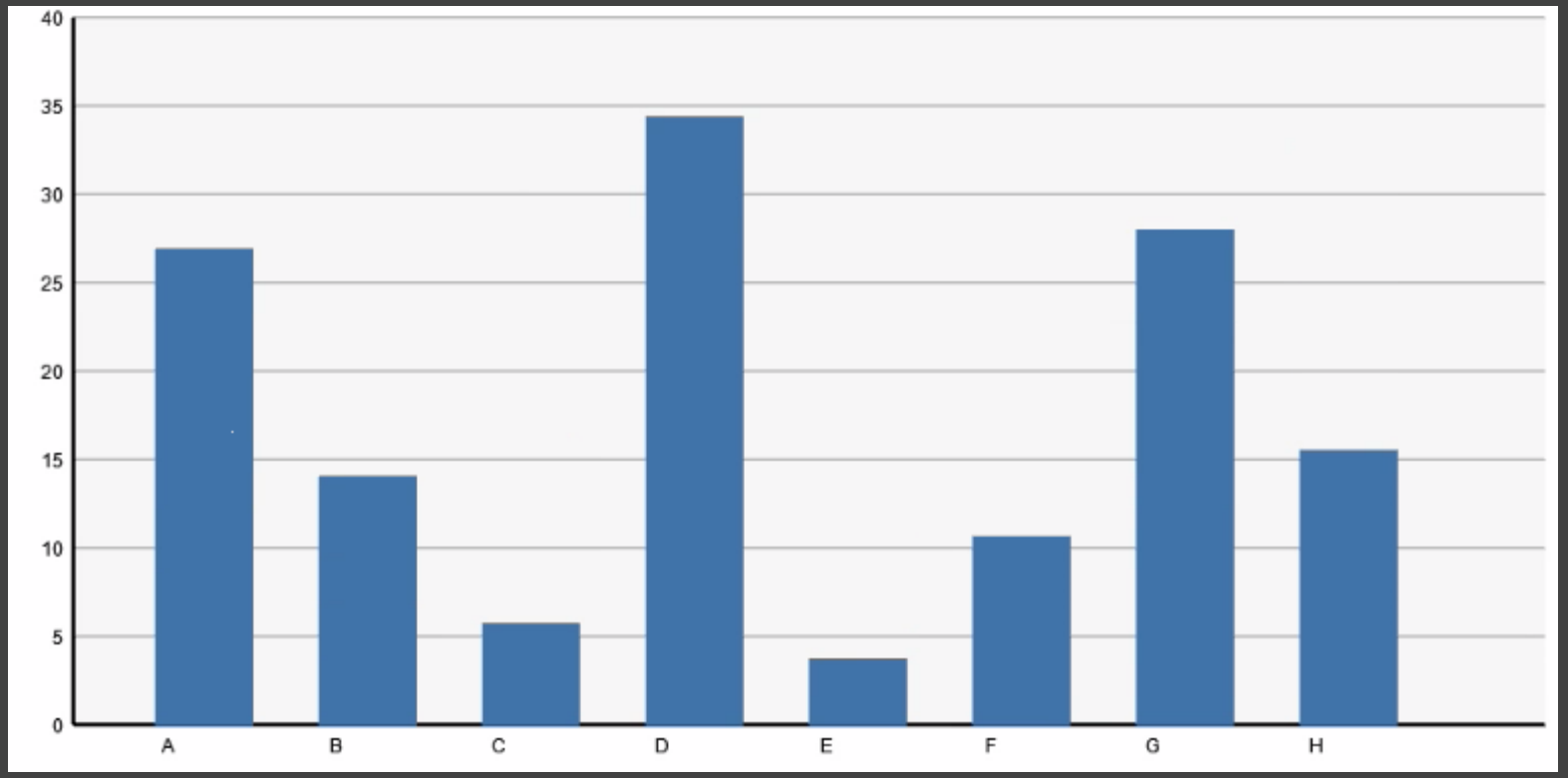
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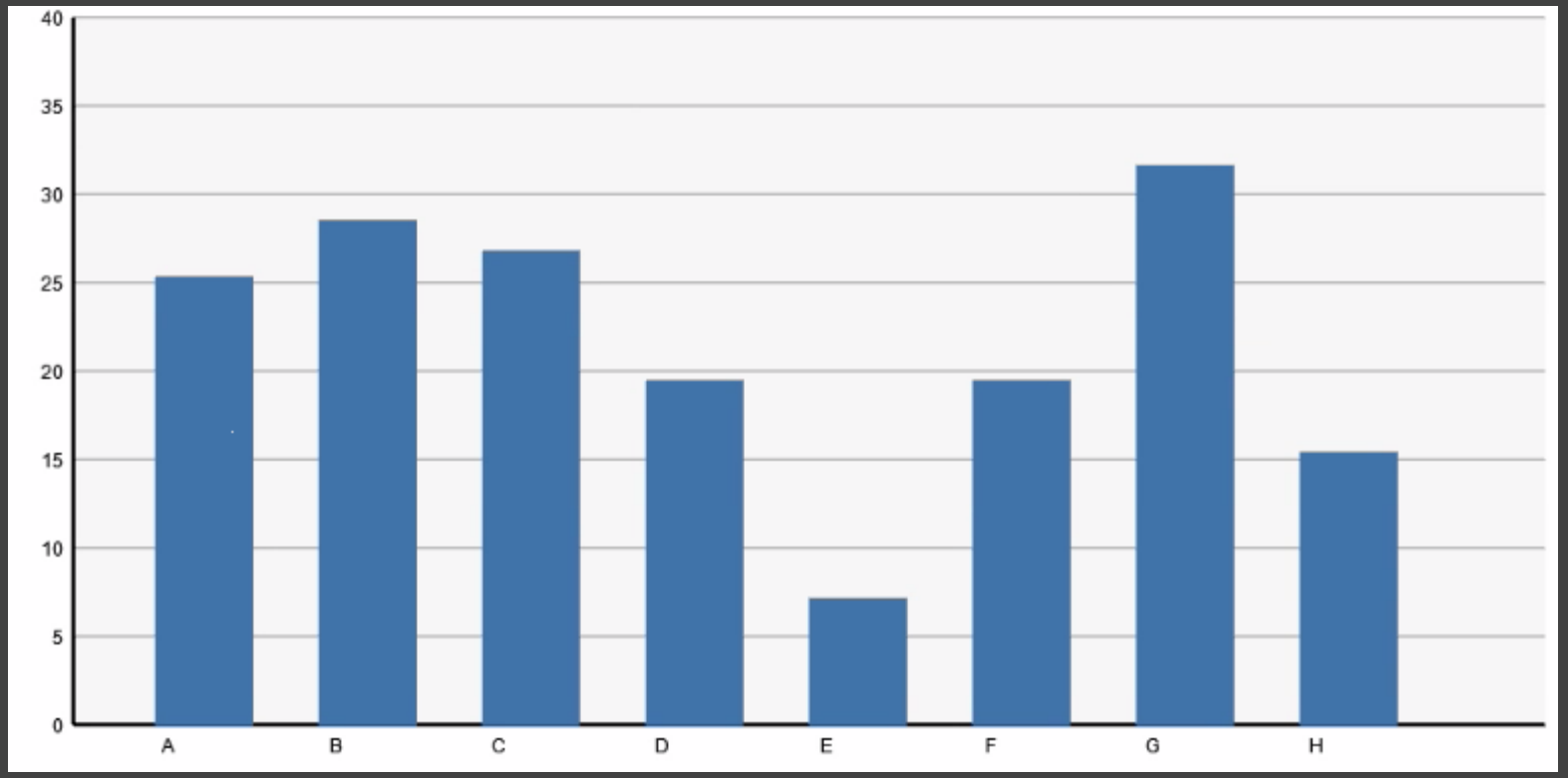
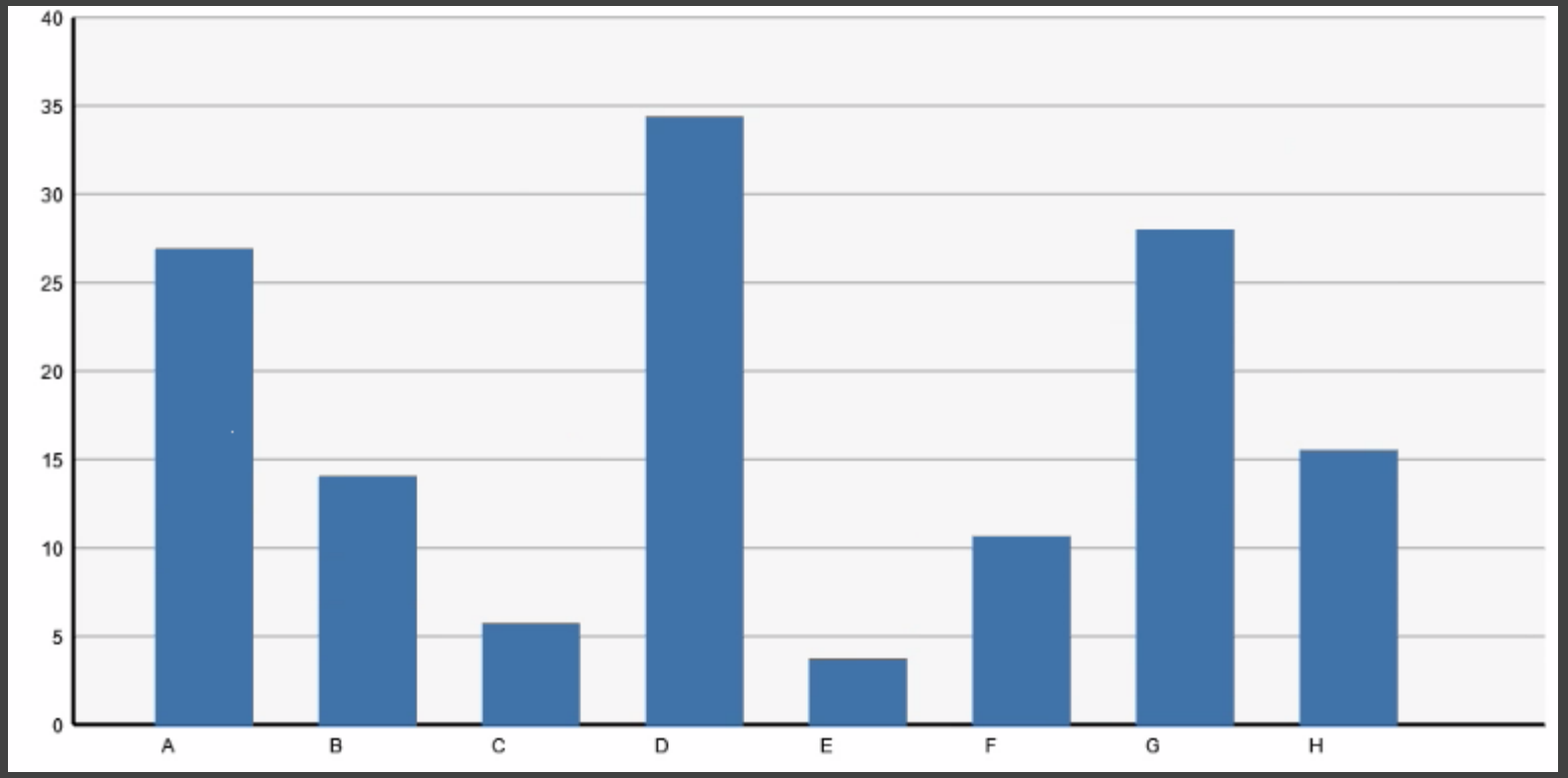
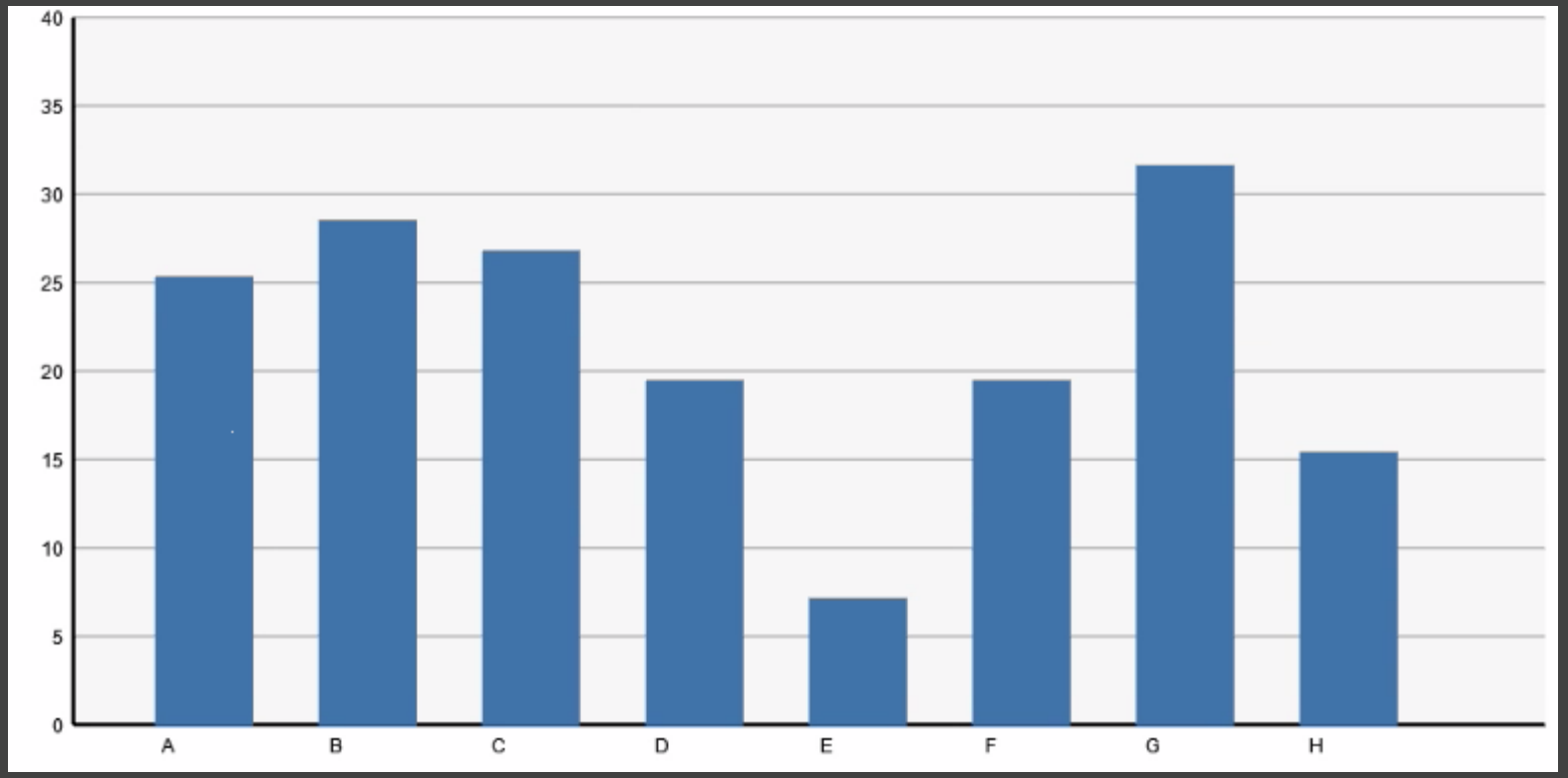


Month 1

Timestep



Month 2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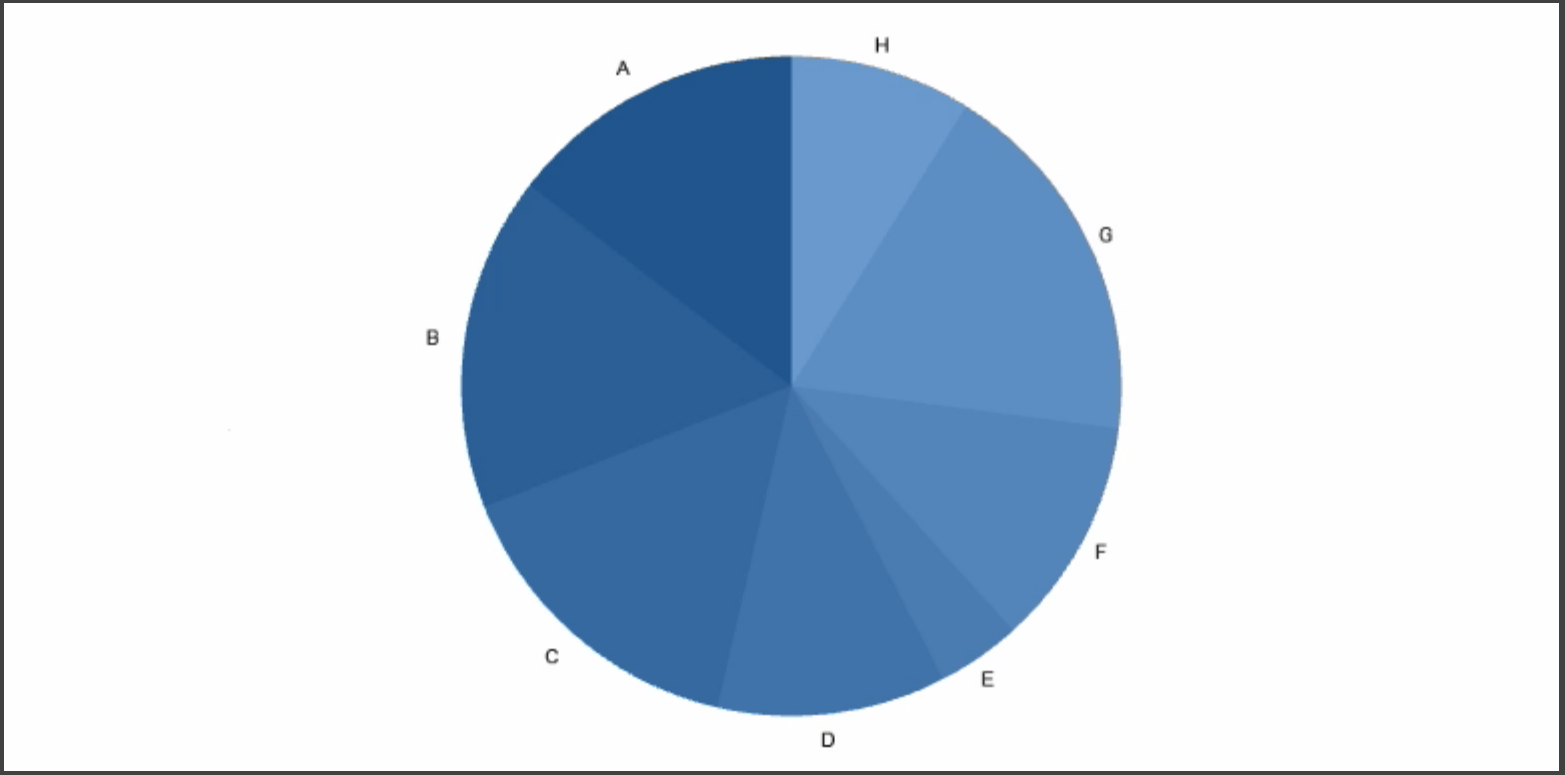
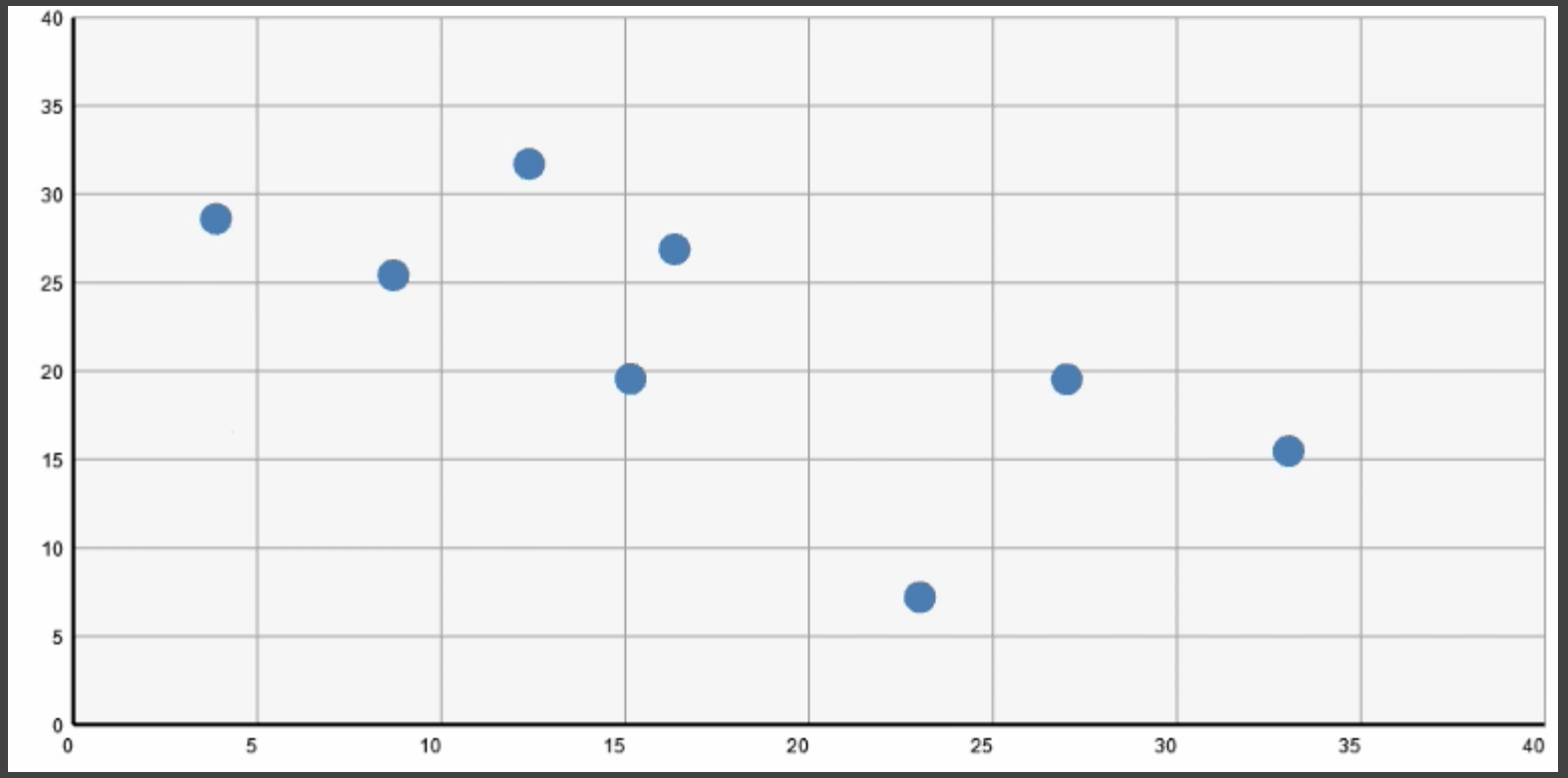
Change Encodings

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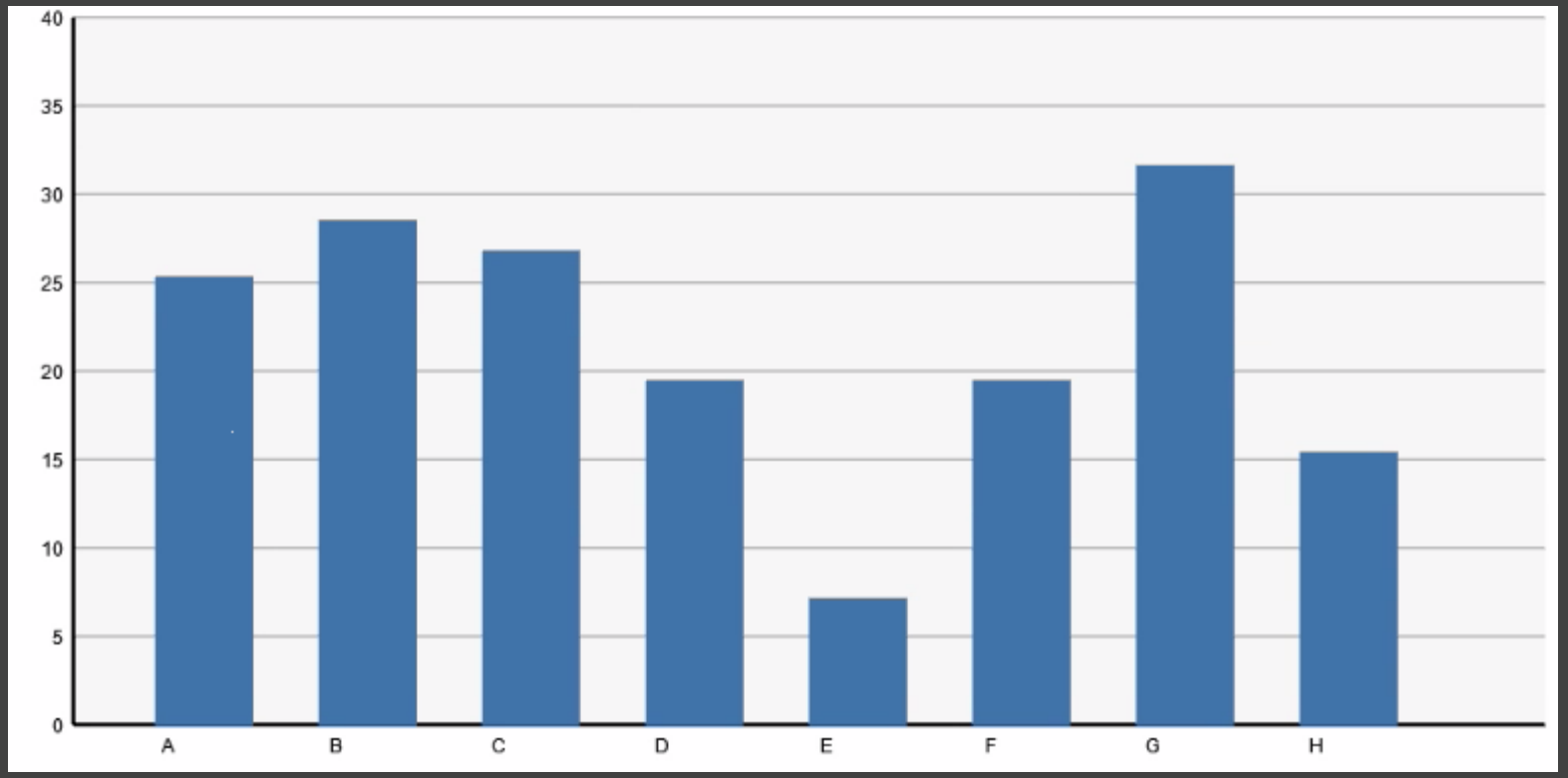
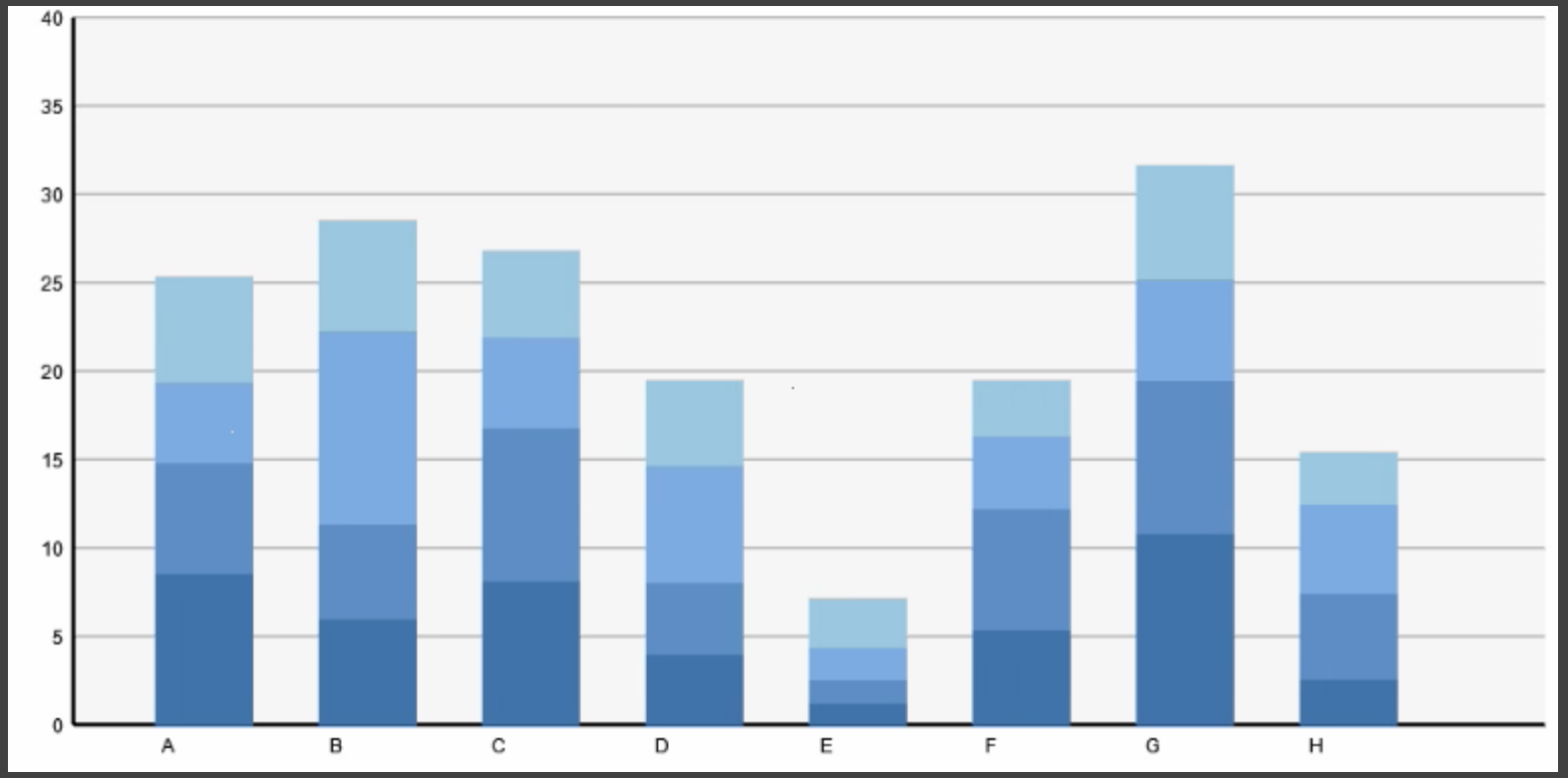
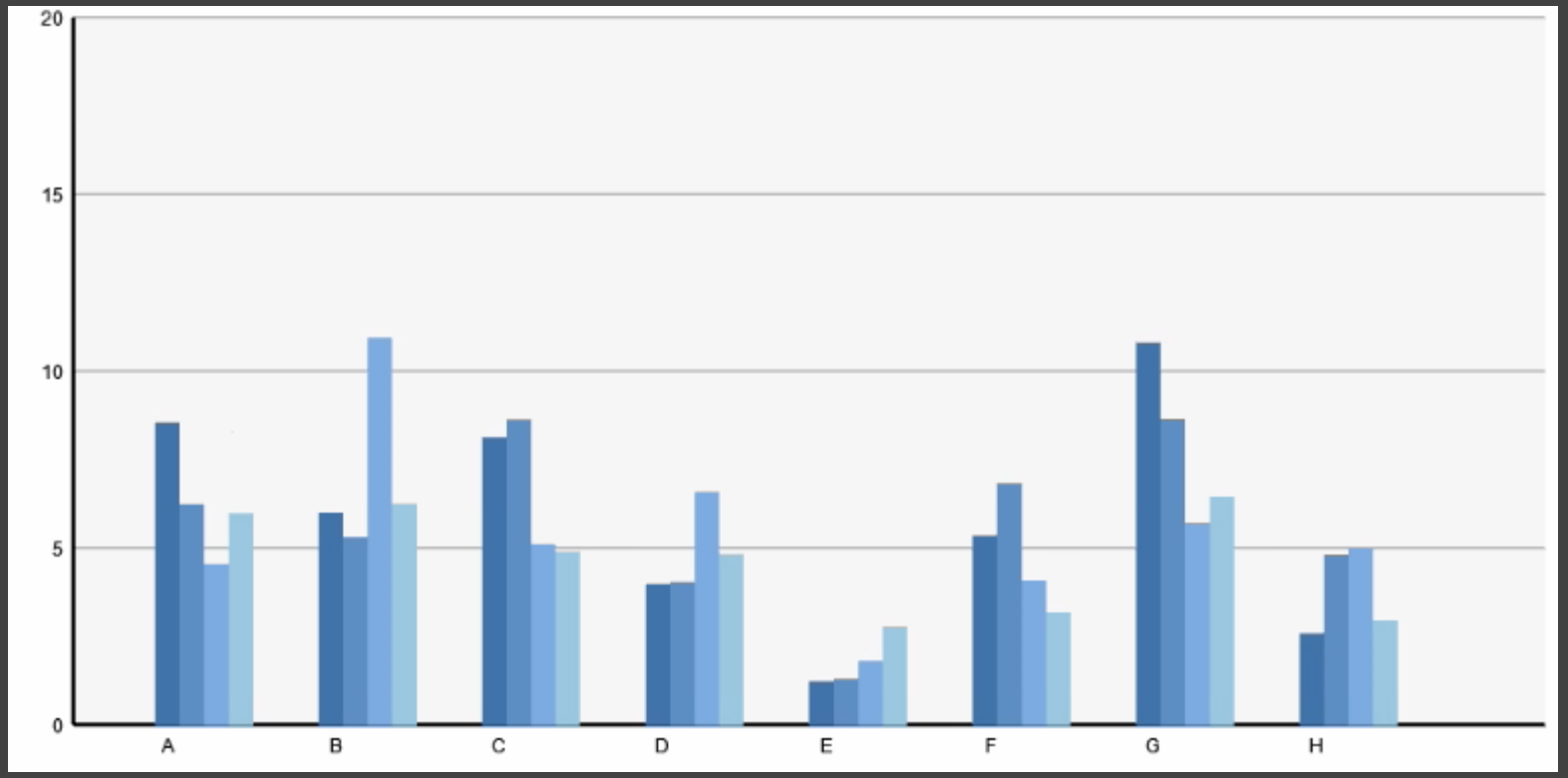
Change Data Dimensions



Change Data Dimensions



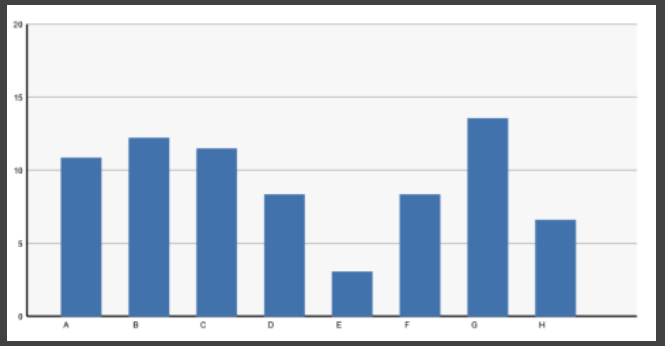
Change Encodings + Axis Scales



Data Graphics & Transitions

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

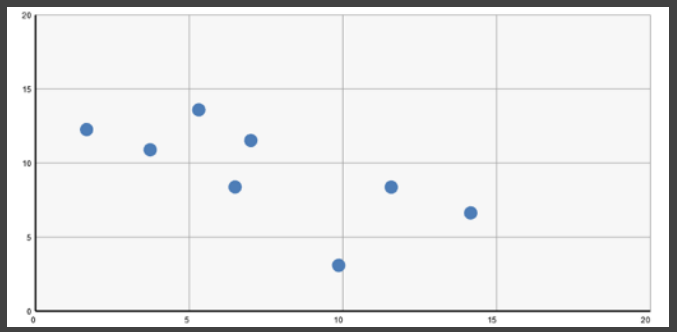
Visual Encoding



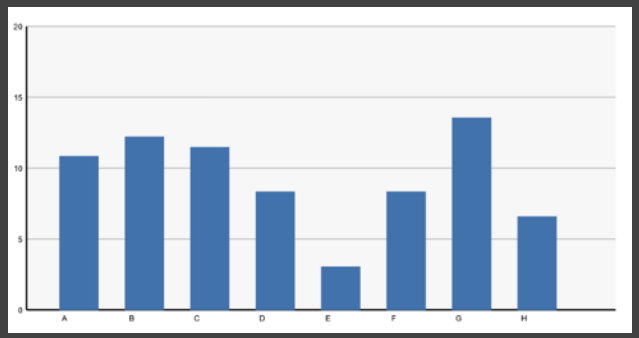
Change selected data dimensions or encodings

Animation to communicate changes?

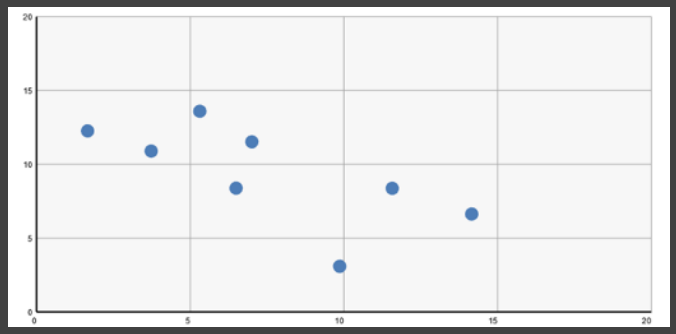
Category	Sales	Profit
A	11	7
B	13	10
C	12	6
D	8	5
E	3	1



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

Visual marks should always represent the same data tuple.

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

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

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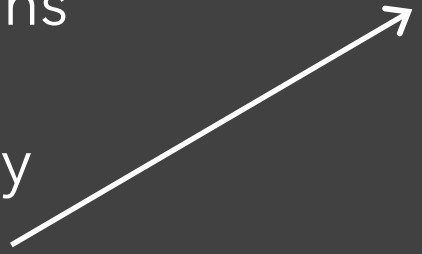


Keep animation as simple as possible. If complicated, break into simple stages.

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)

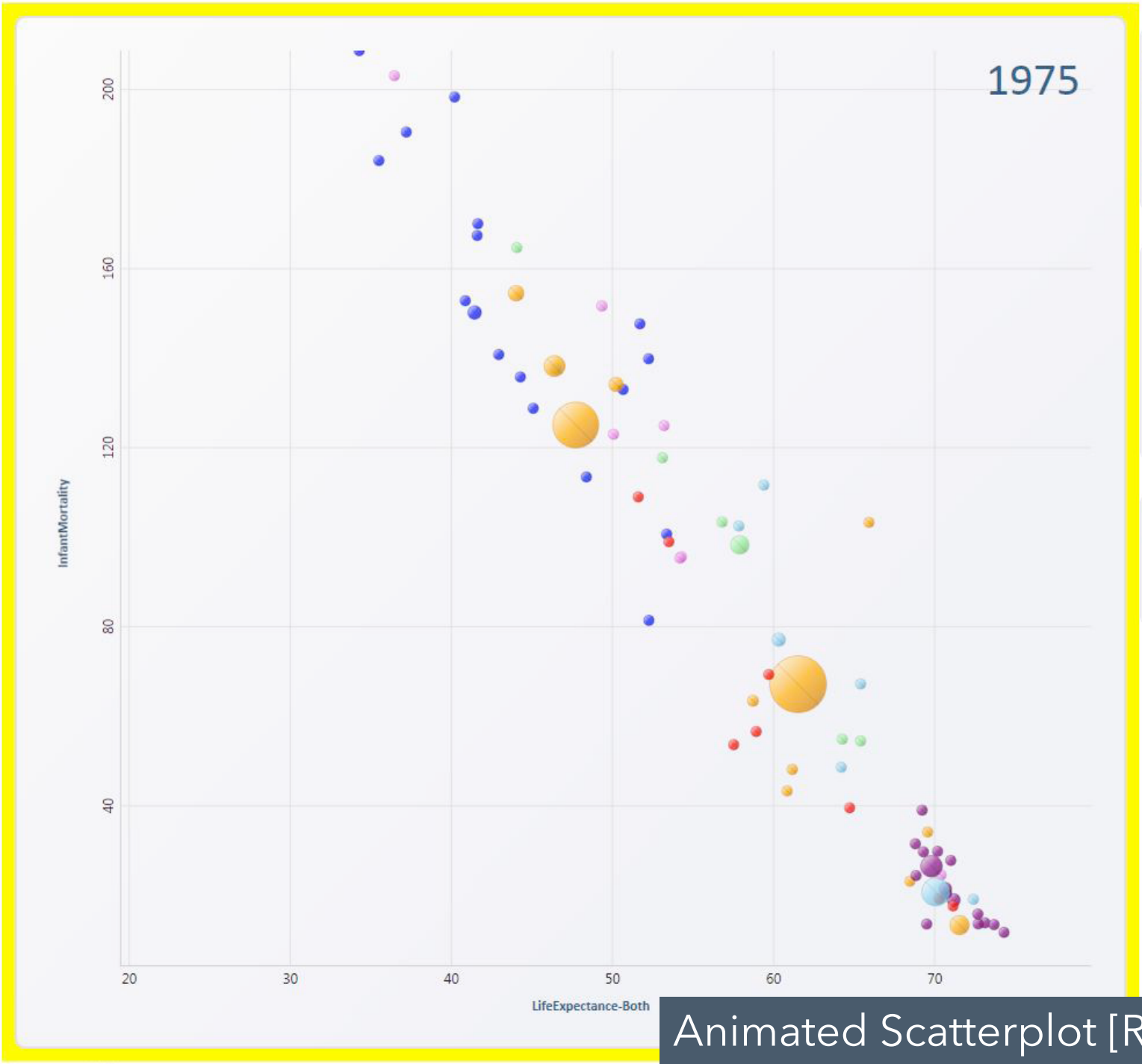
Subjects preferred animated transitions

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.

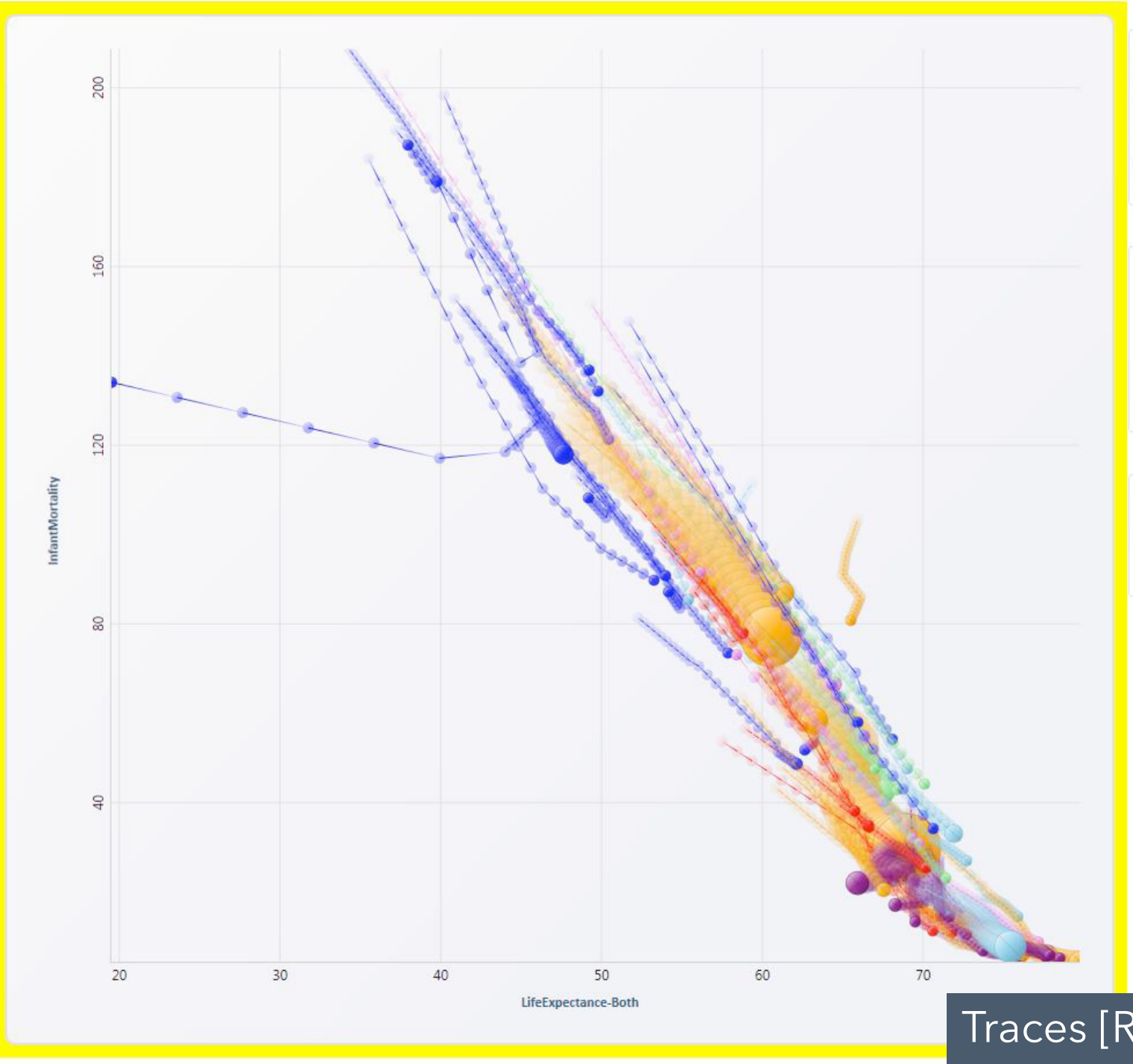
Answers set: 0/2

Next

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

Give Up | Next

Animated Scatterplot [Robertson 08]



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

Traces [Robertson 08]

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

Small Multiples [Robertson 08]

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**