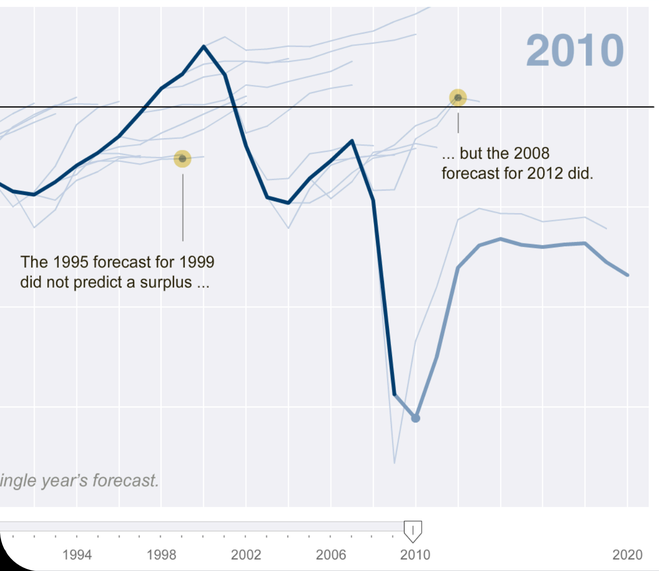
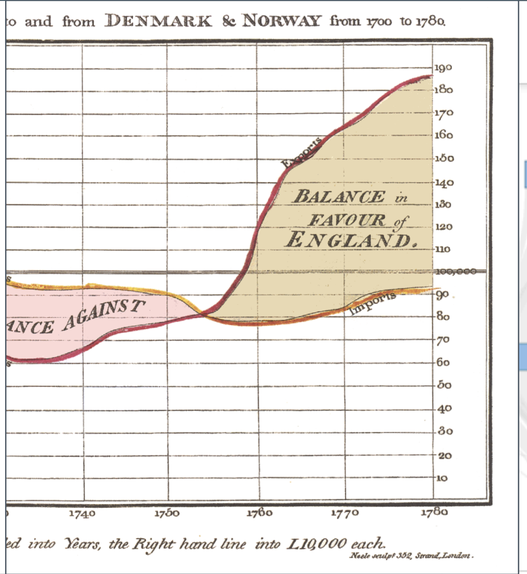
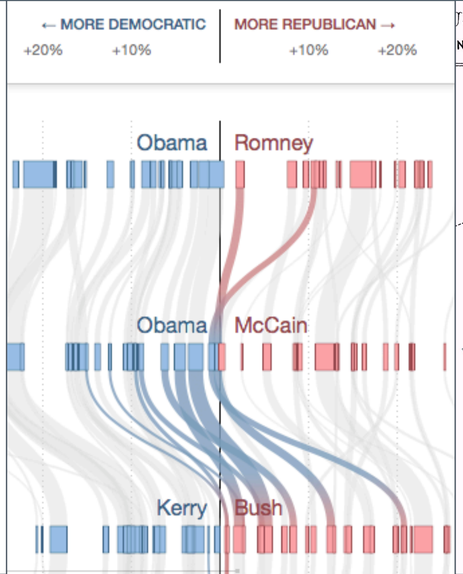
6.859: Interactive Data Visualization

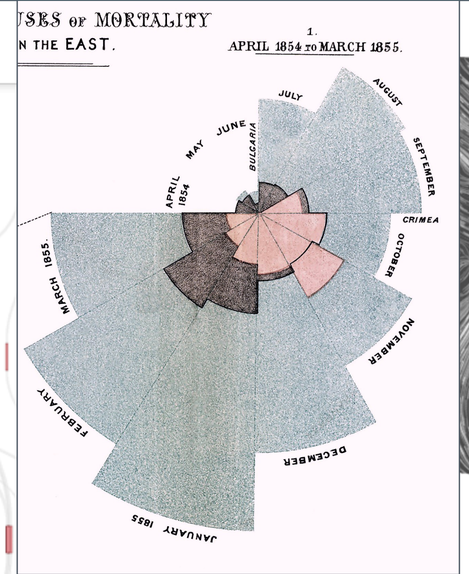
Animation

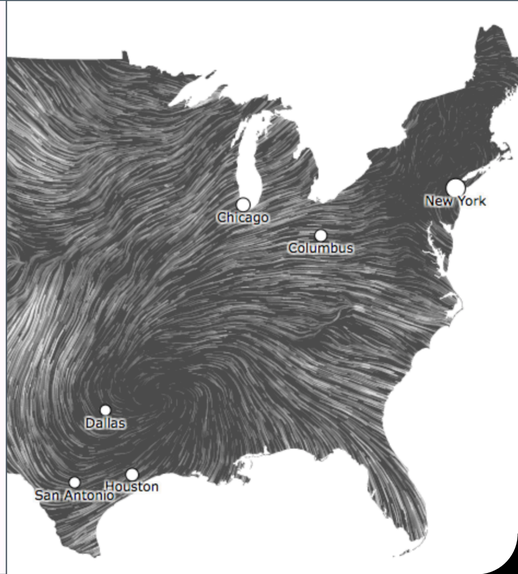
Arvind Satyanarayan





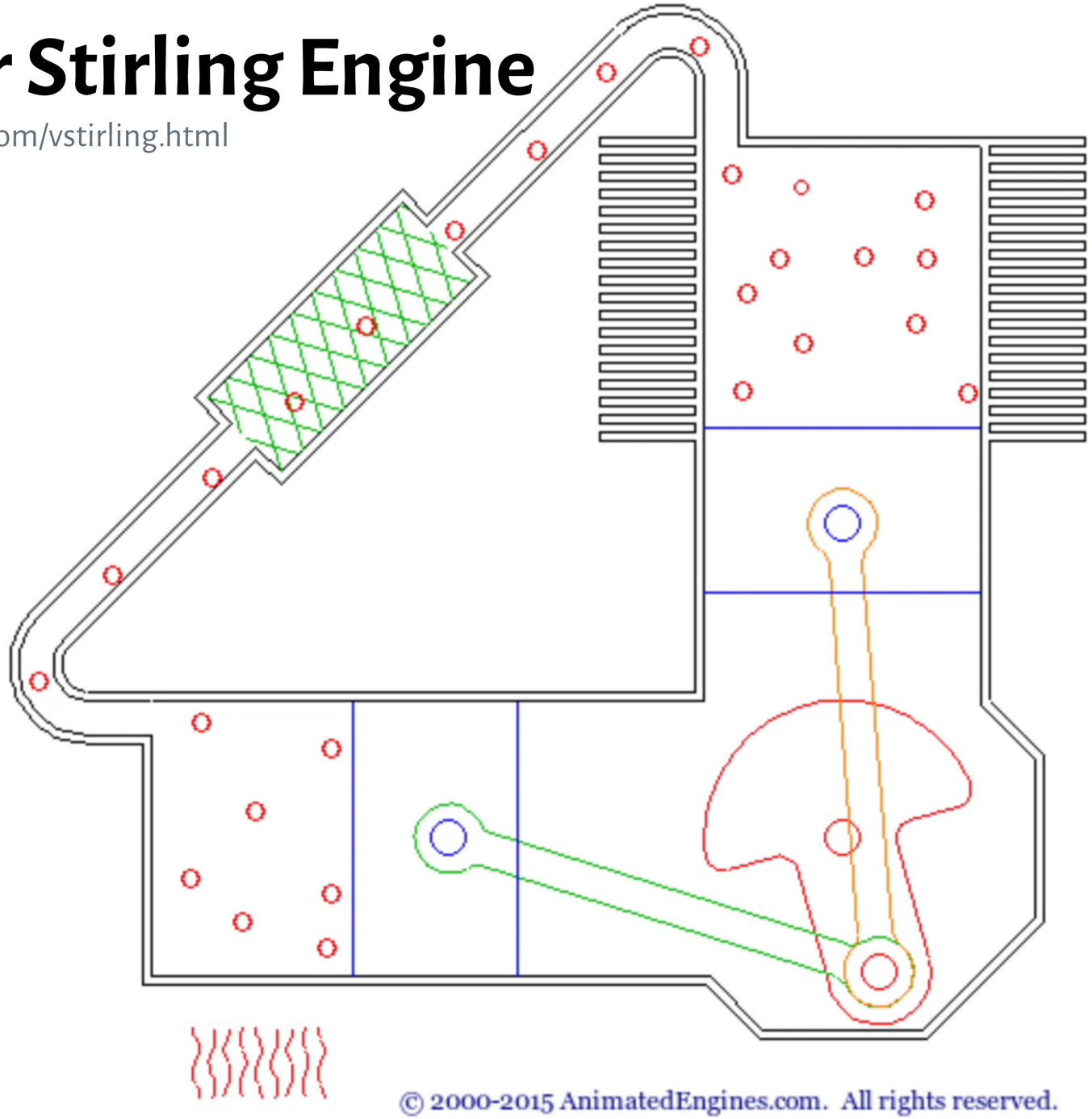






Two-cylinder Stirling Engine

http://www.animatedengines.com/vstirling.html

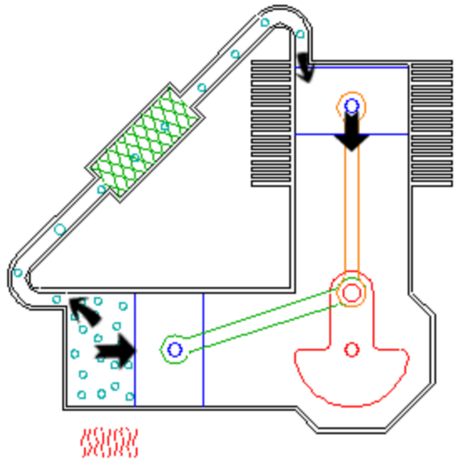


Two-cylinder Stirling Engine: In Static Steps

http://www.animatedengines.com/vstirling.html

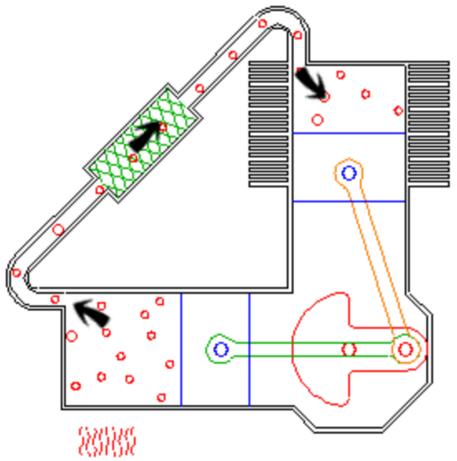
1 Expansion

Most of the gas in the system has just been driven into the hot cylinder. The gas heats and expands driving both pistons inward.



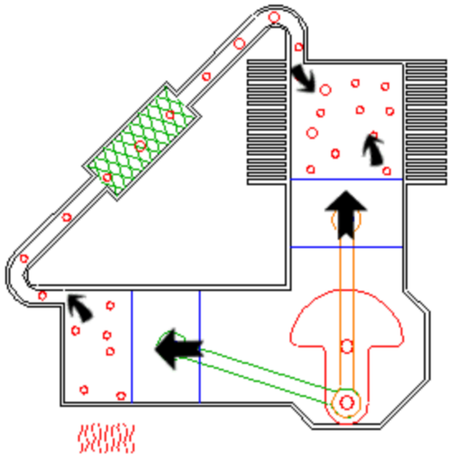
2 Transfer

The gas has expanded (about 3 times in this example). Most of the gas (about 2/3) is still located in the hot cylinder. Flywheel momentum carries the crankshaft the next 90 degrees, transferring the bulk of the gas to the cool cylinder.



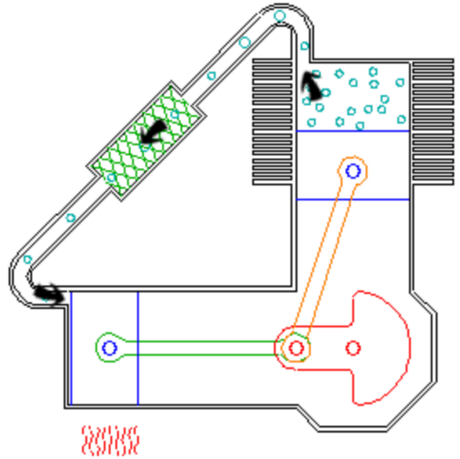
3 Contraction

The majority of the expanded gas has shifted to the cool cylinder. It cools and contracts, drawing both pistons outward.



4 Transfer

The contracted gas is still located in the cool cylinder. Flywheel momentum carries the crank another 90 degrees, transferring the gas to back to the hot cylinder to complete the cycle.



Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition

Animation Goals

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Understand a State Transition

Animation Goals

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Explain a Process

Understand a State Transition

Motion as a visual cue

Smooth motion is perceived at ~10 frames / sec (1 frame every 100ms).

7.5 fps

15 fps

30 fps

60 fps

60 fps

30 fps

15 fps

7.5 fps

Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition

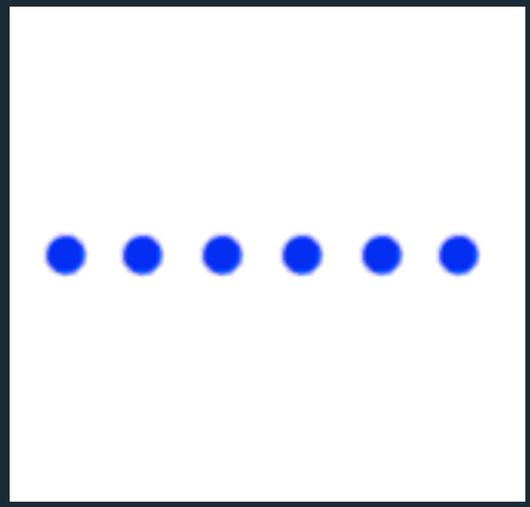
Motion as a visual cue

Smooth motion is perceived at ~10 frames / sec (1 frame every 100ms).

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

More sensitive to motion at our periphery.

Similar motions perceived as a group (gestalt principle of common fate).



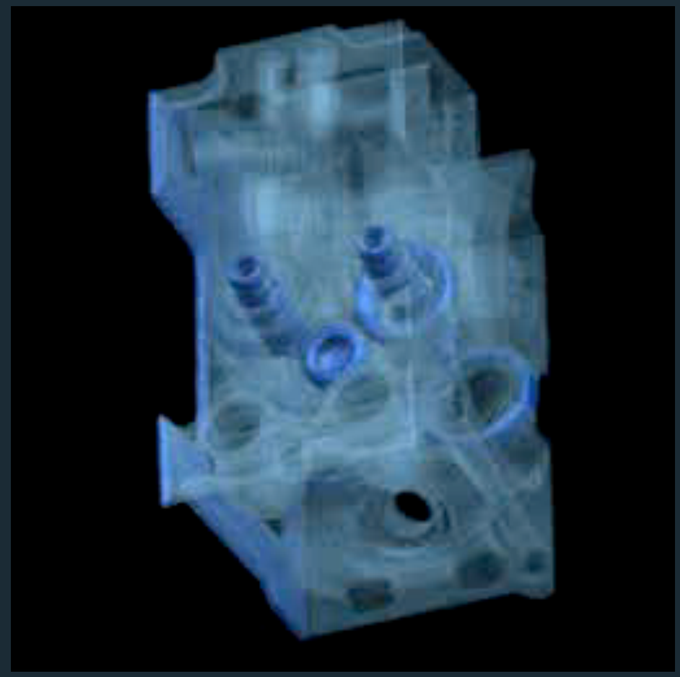
Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition



Volume Renderings. [Lacroute 95]

Animation Goals

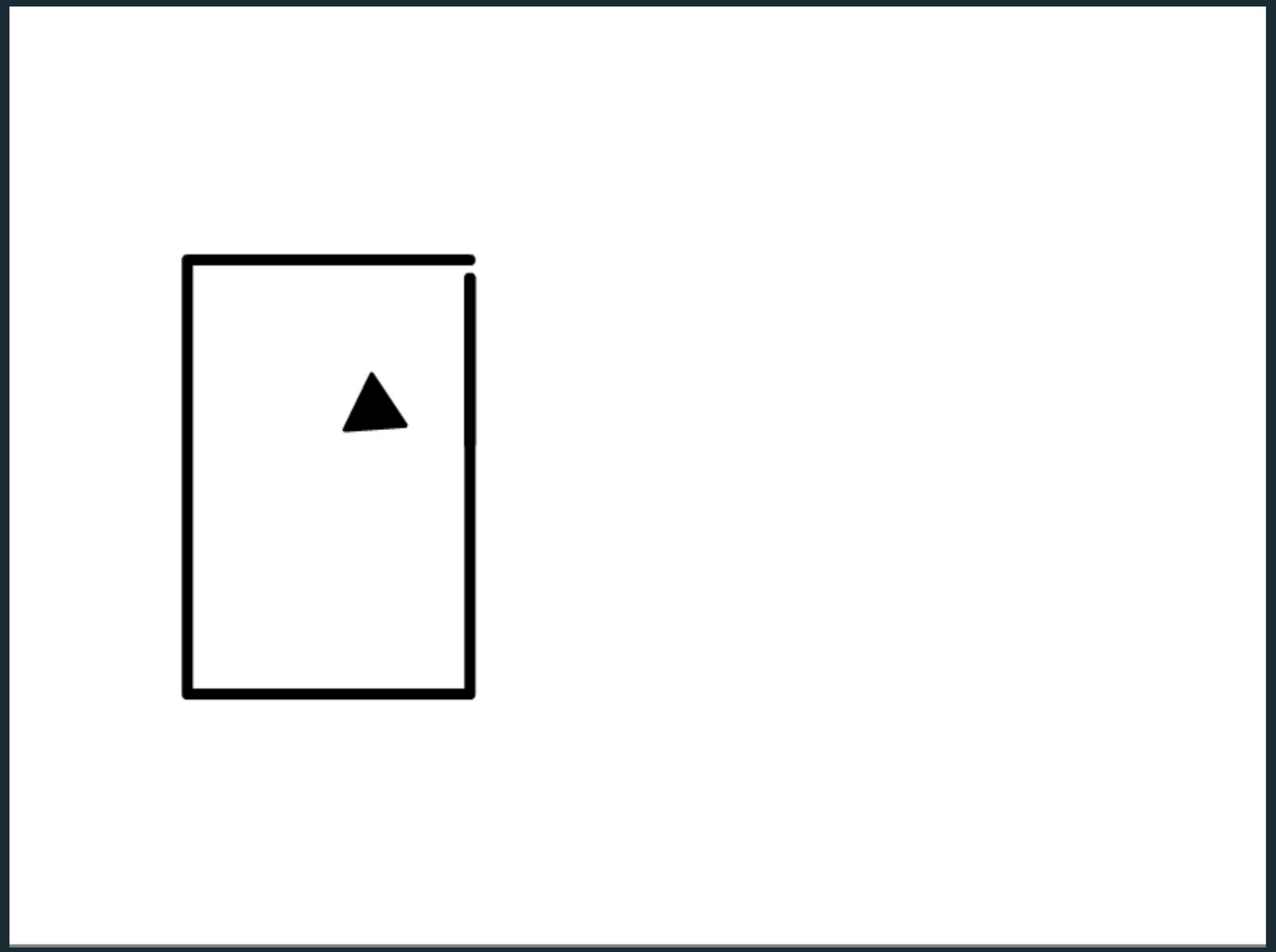
Direct Attention

Increase Engagement

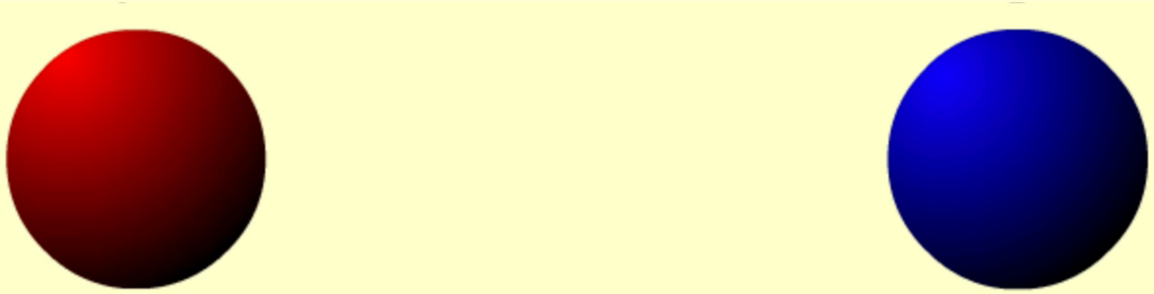
Explain a Process

Understand a State Transition

Constructing narratives & anthropomorphizing

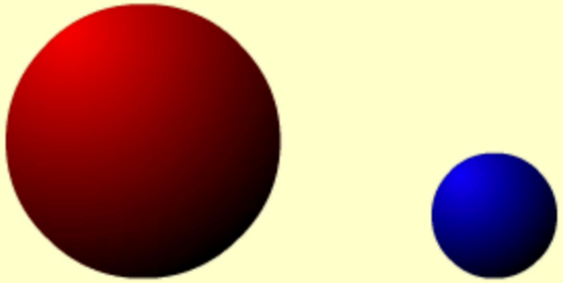


[Heider and Simmel 1944]

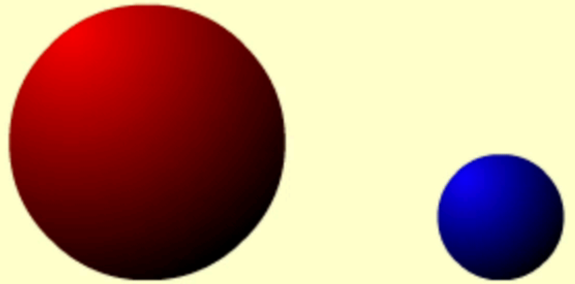


[Michotte 1946]

[Michotte 1946]



[Michotte 1946]



[Michotte 1946]

Animation Goals

Direct Attention

Increase Engagement

Explain a Process – the perception (or attribution) of causality.

Understand a State Transition

Animation Goals

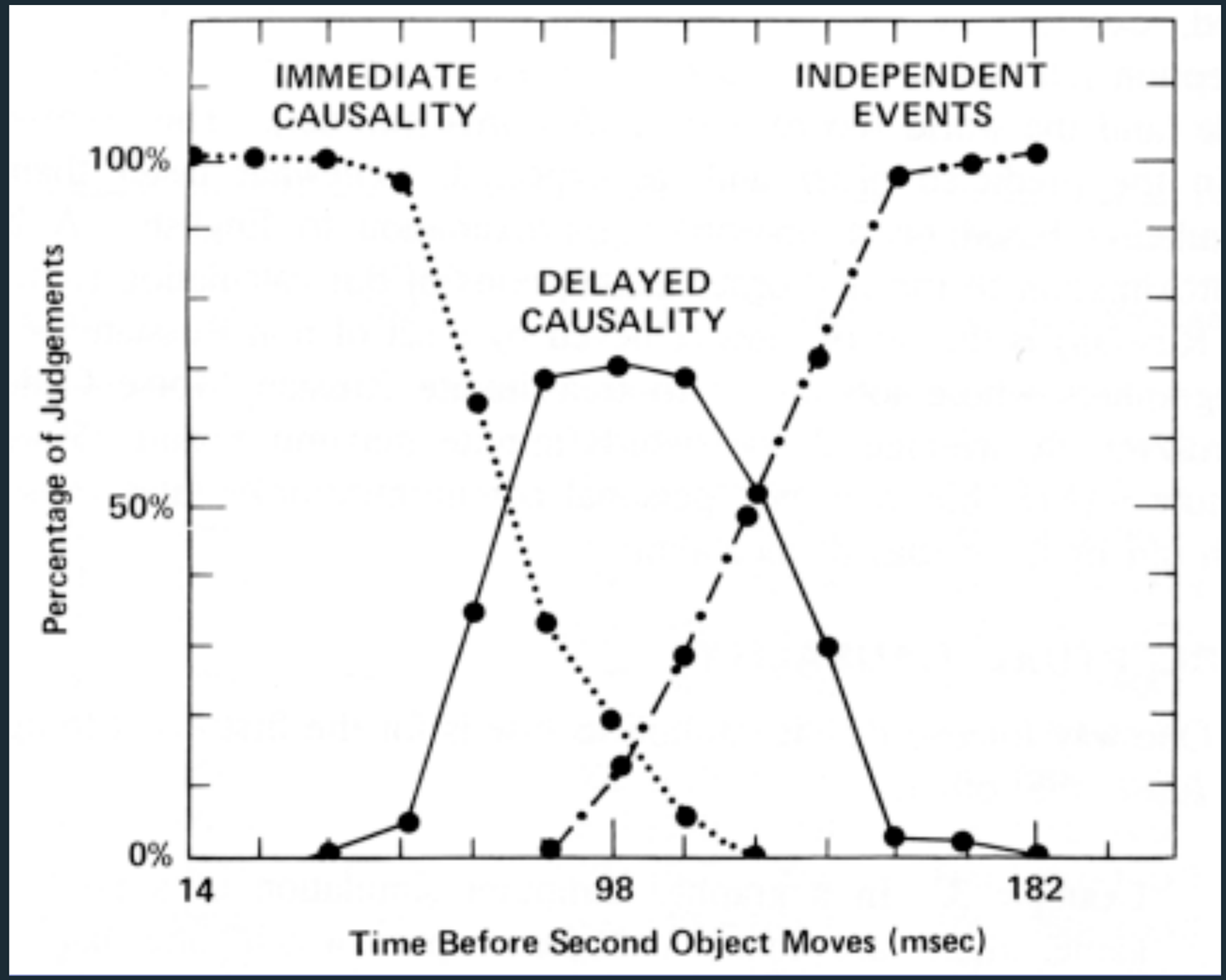
Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition

Attribution of Causality.



[Reprint from Ware 2004]

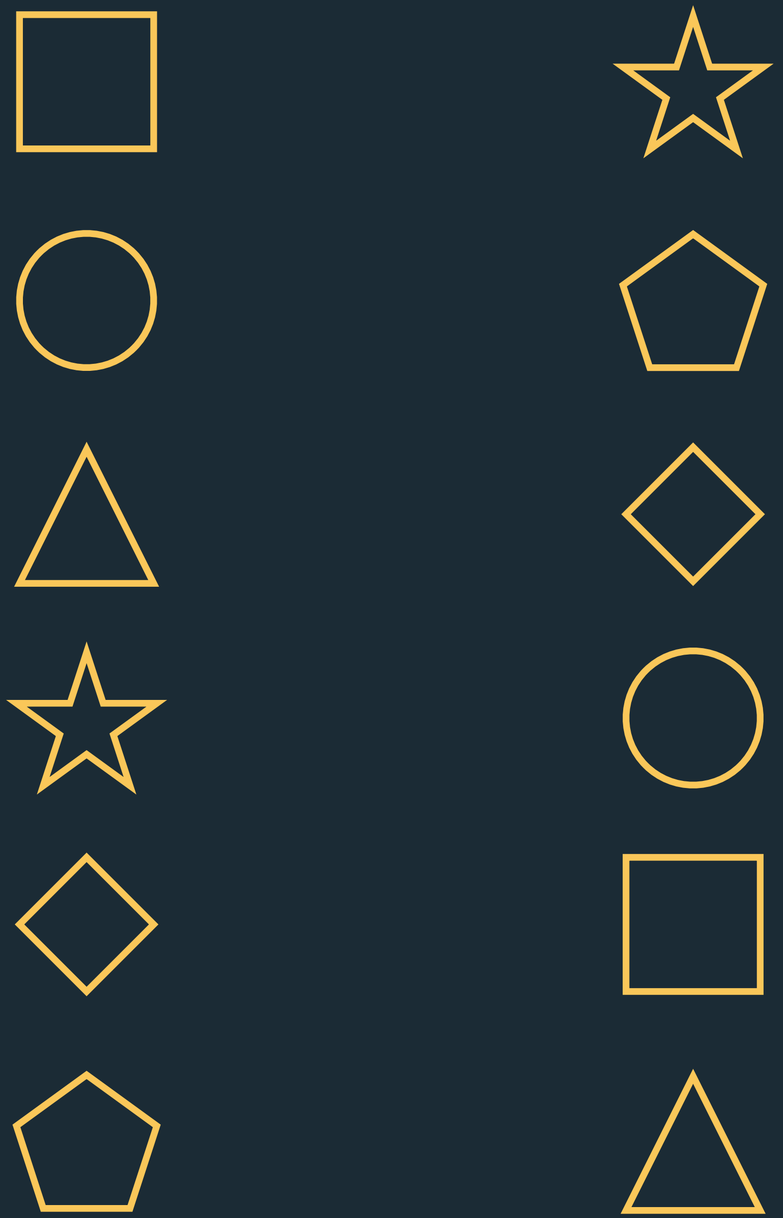
Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition



Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition

Start **End**

Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition

- Animation can show transition better, but...
  - May be too fast or too slow.
  - Too many objects may move at once.

End

Animation Goals

Direct Attention

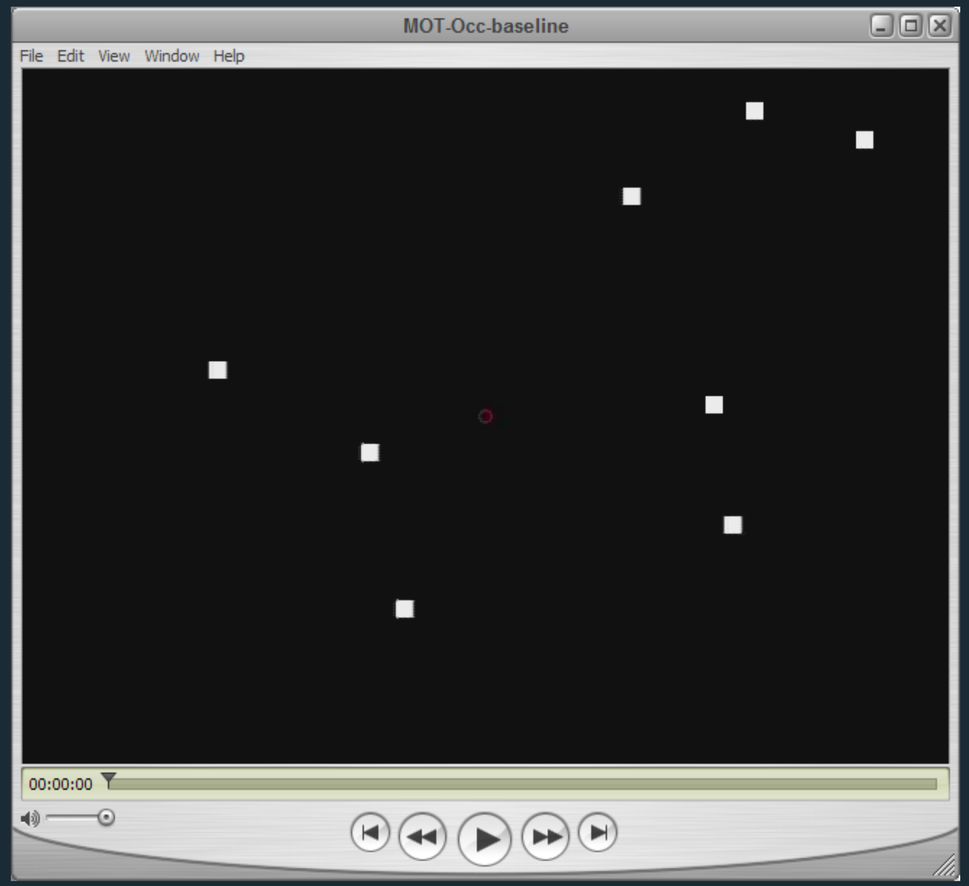
Increase Engagement

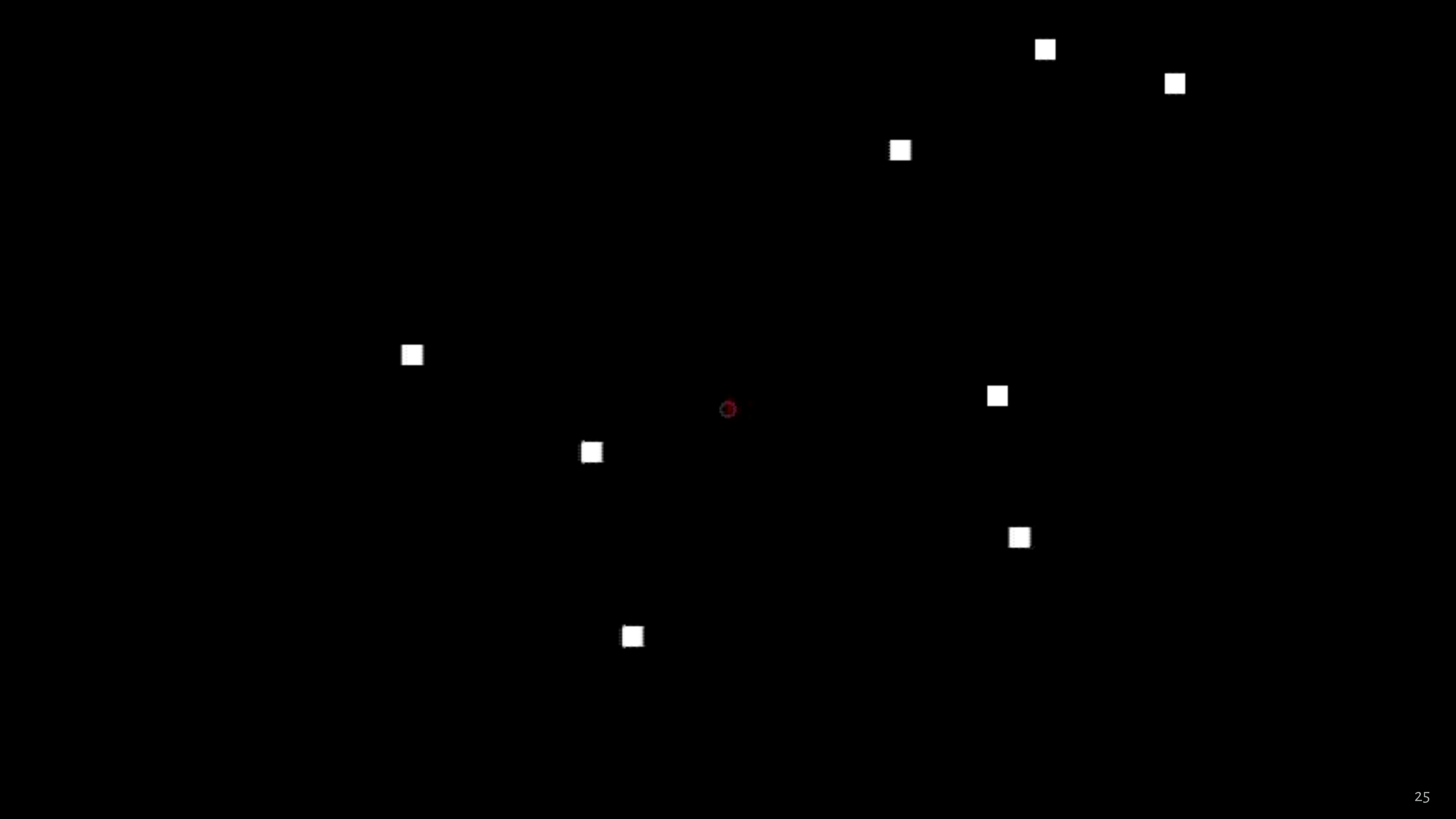
Explain a Process

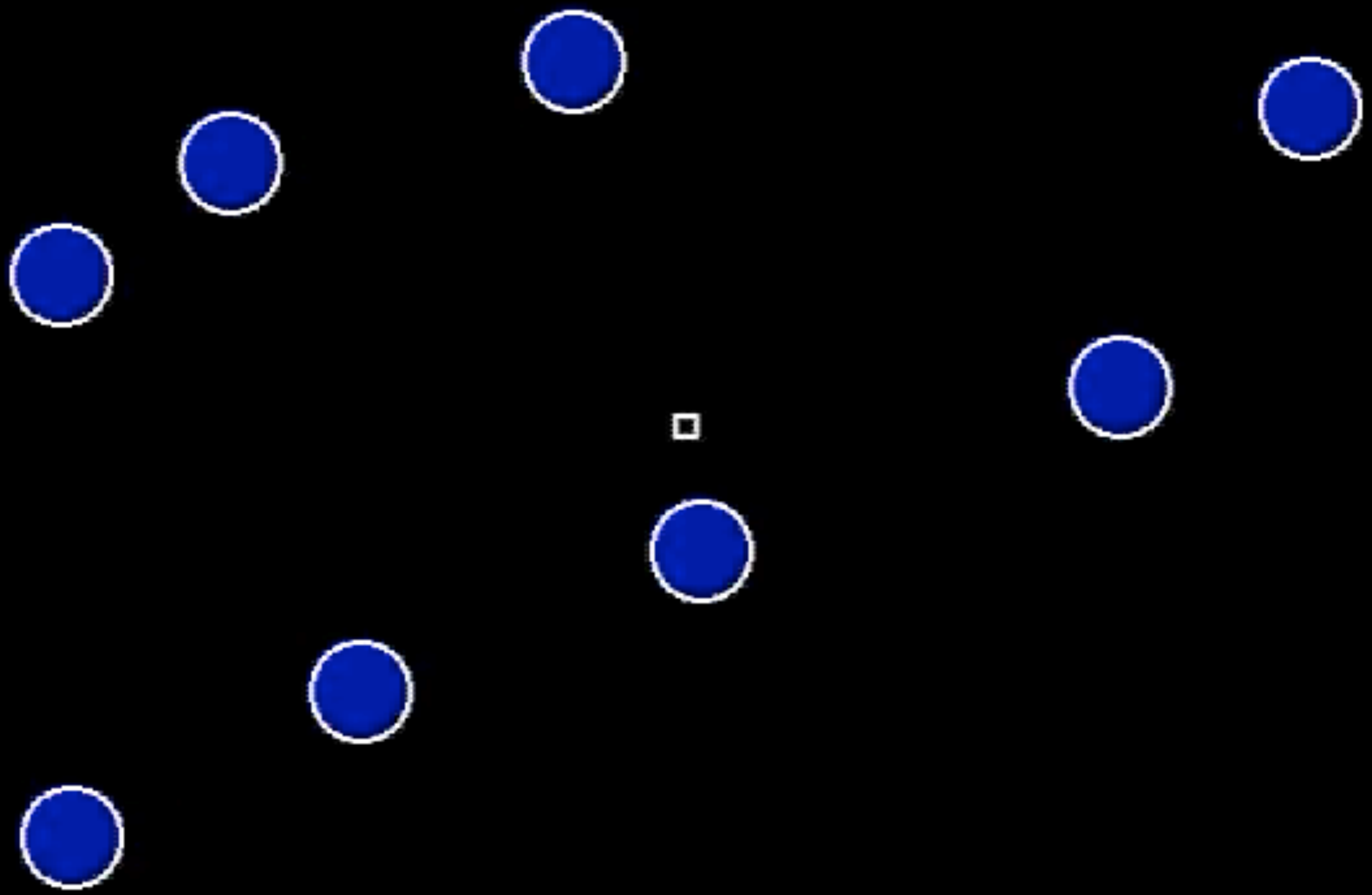
Understand a State Transition

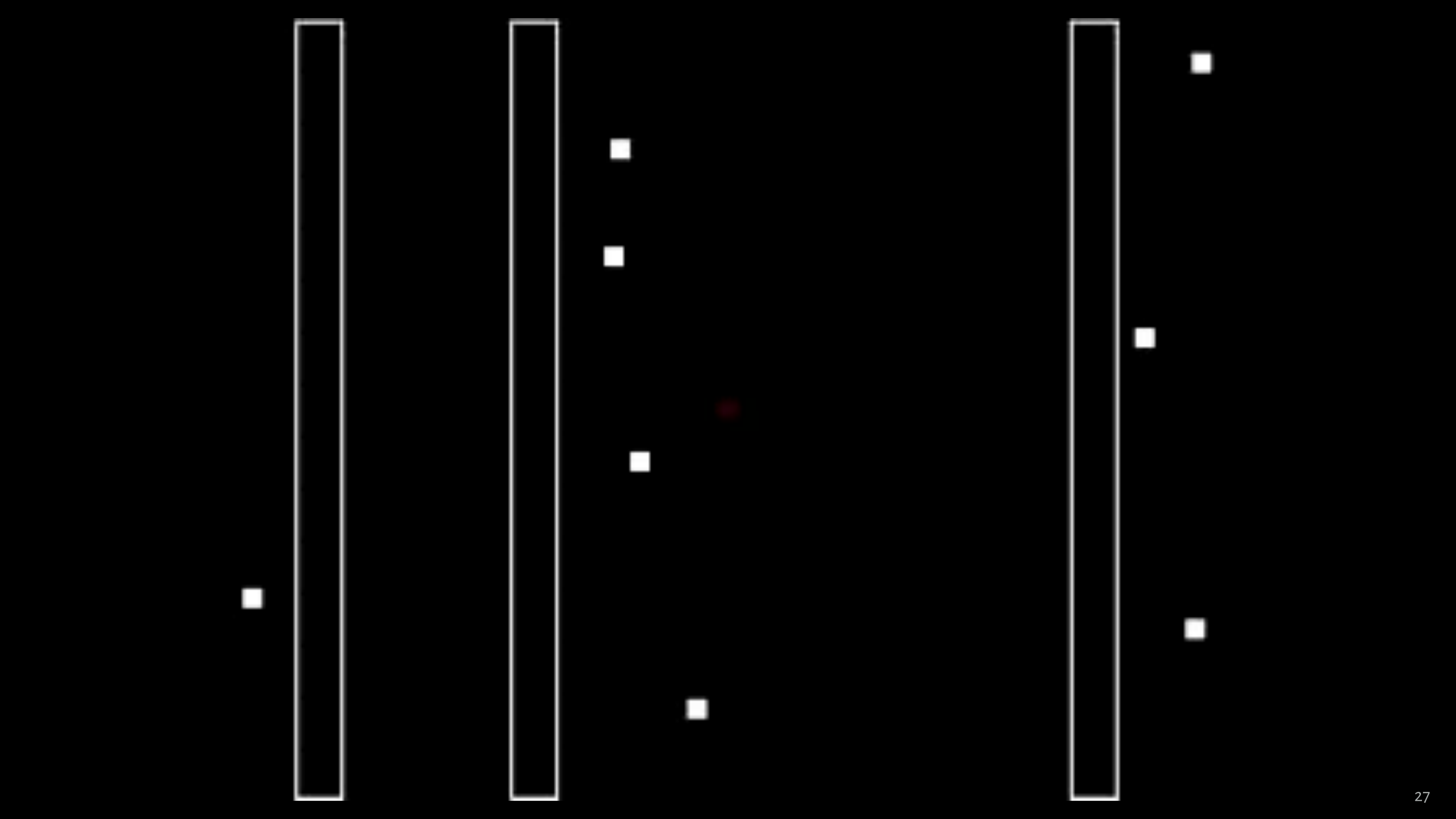
- Animation can show transition better, but...
  - May be too fast or too slow.
  - Too many objects may move at once.

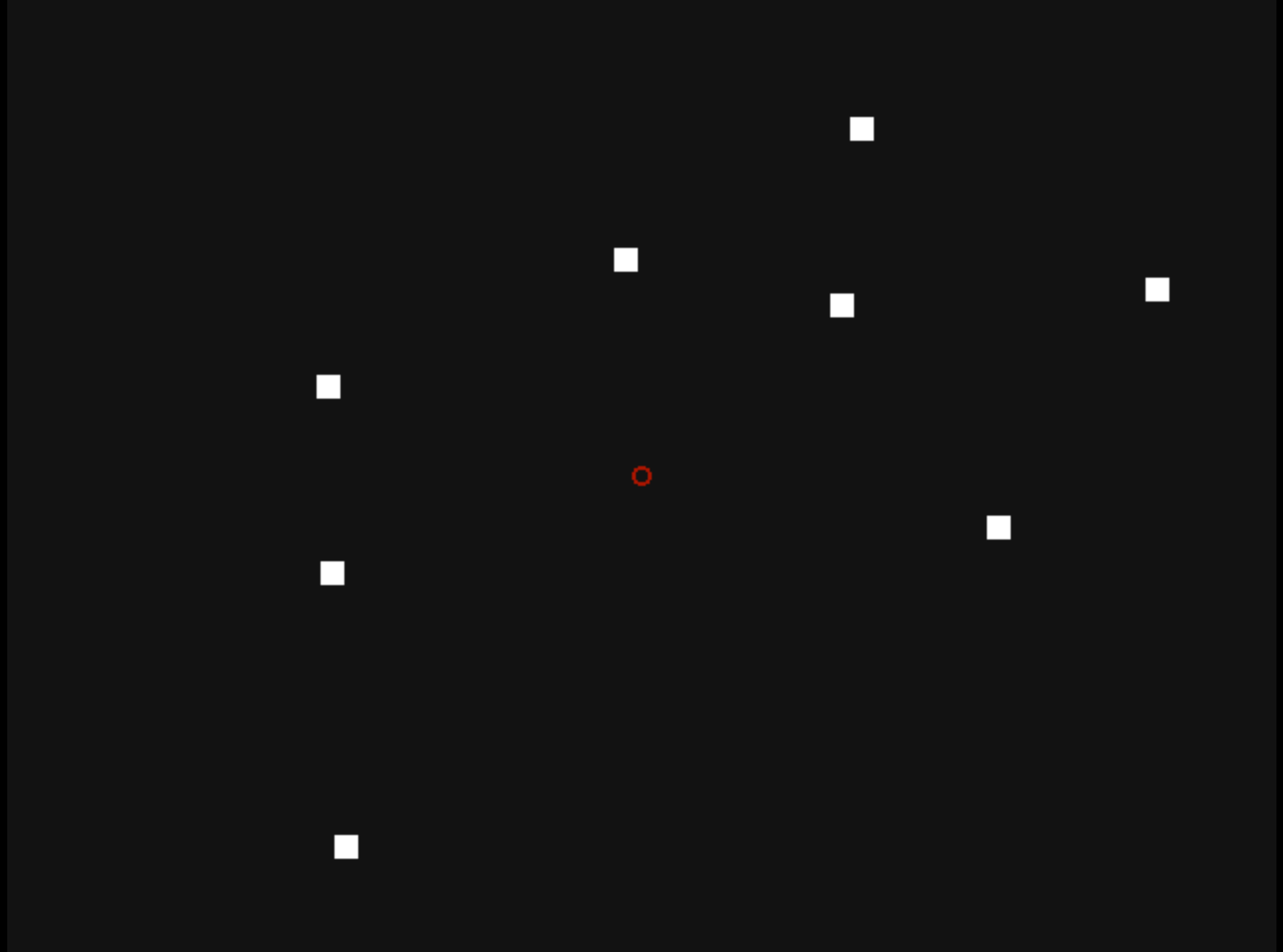
How many dots can we track at once?

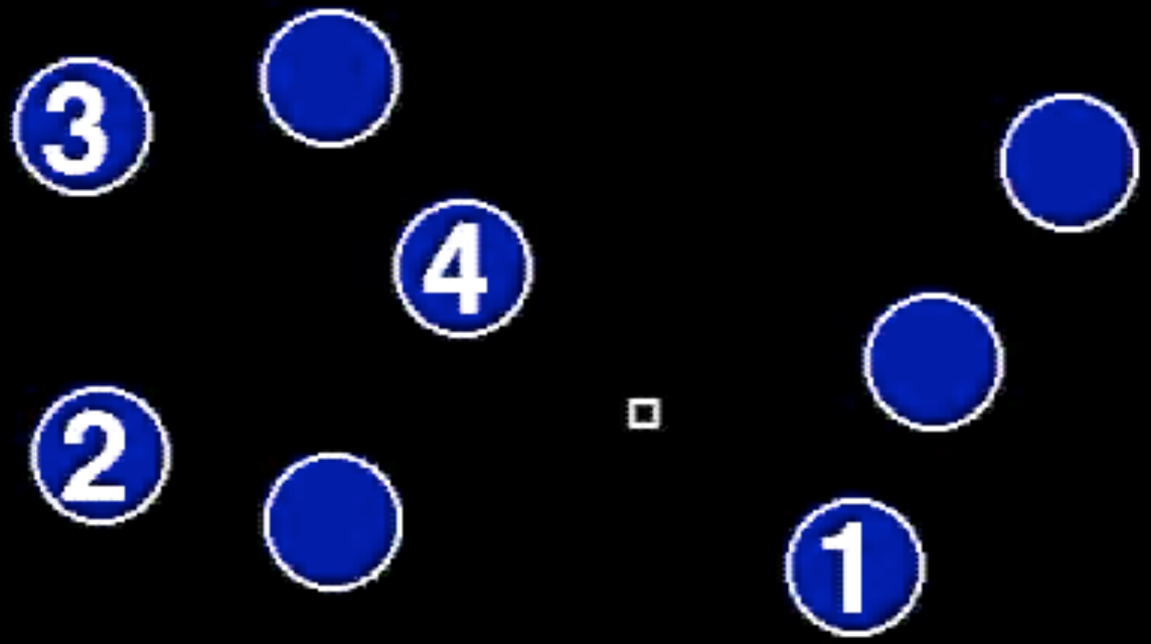











3
4
2
1

Animation Goals

Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition

- Animation can show transition better, but...
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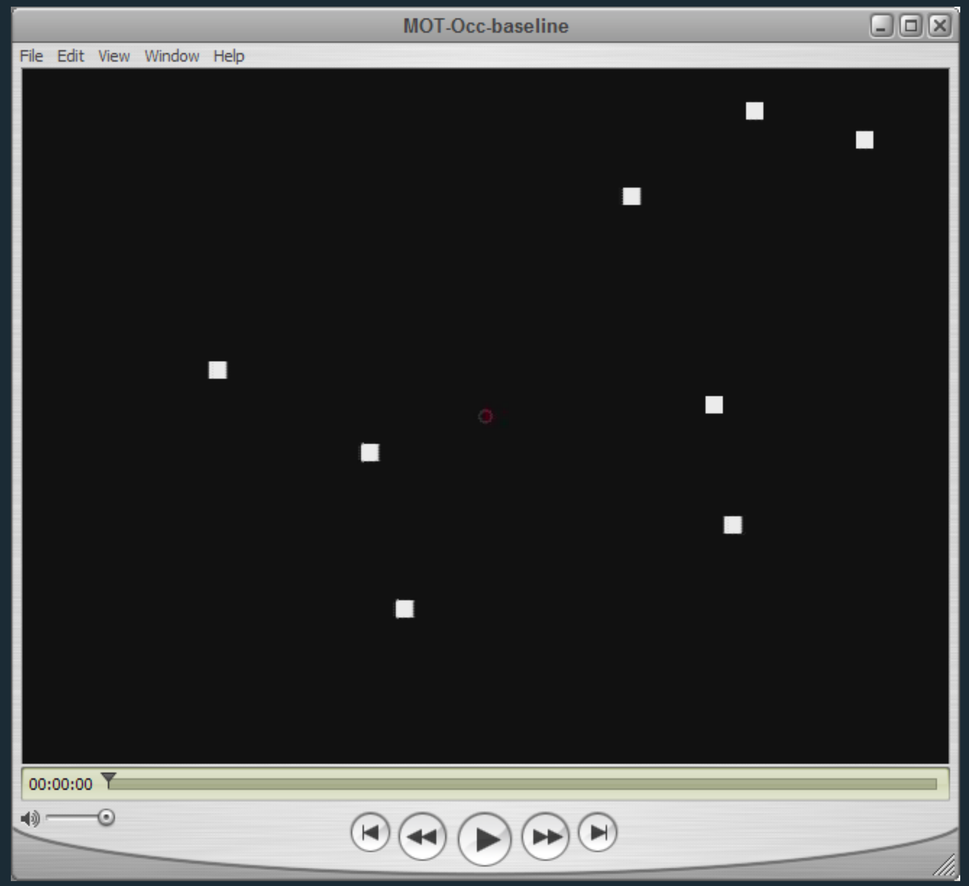


~4-6. Difficulty increases significantly at 6.

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)

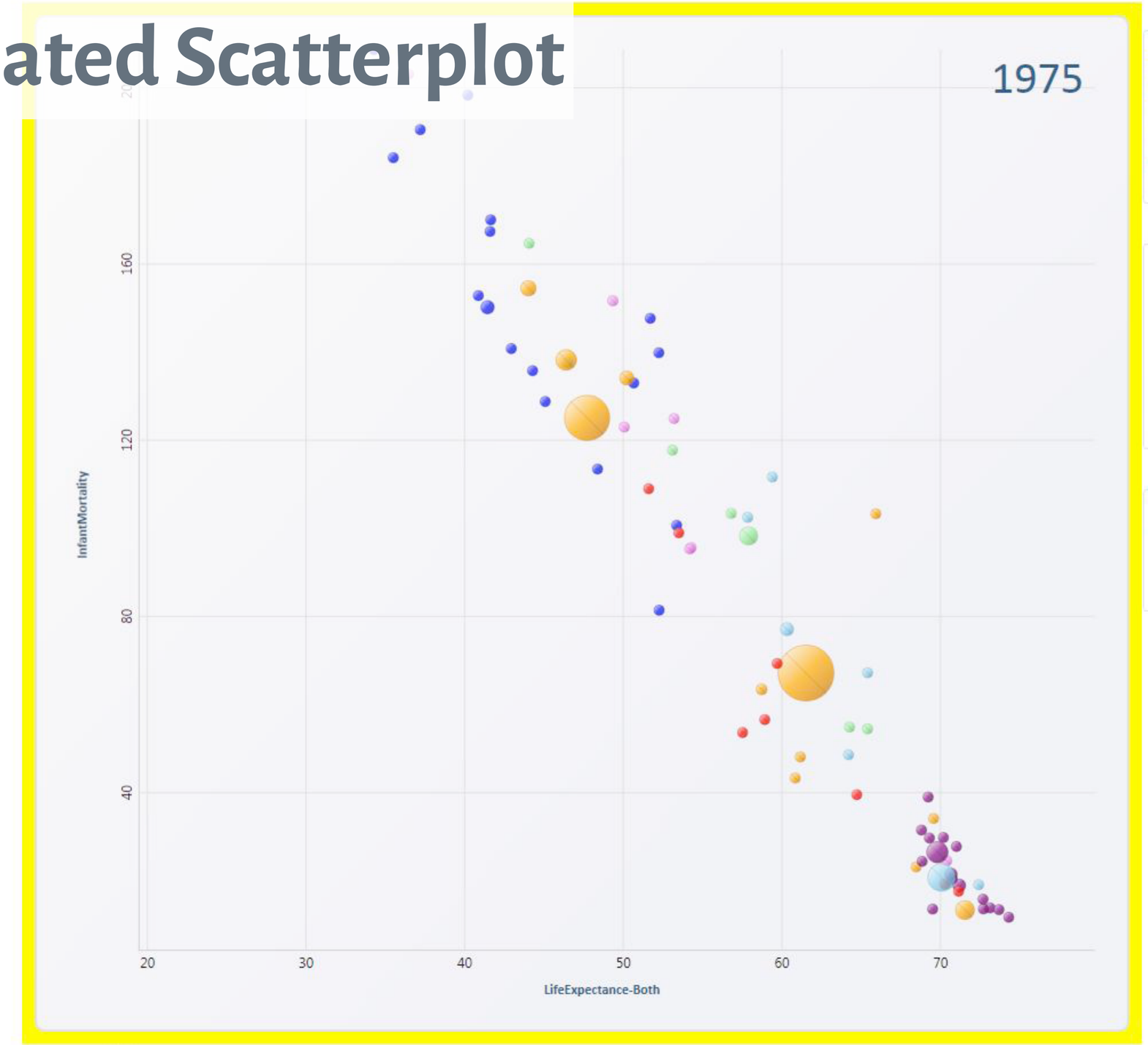
Subjects preferred animated transitions


2.5
3
3.5
6.5
7


1962
Life expectancy at birth, total
Fertility rate, total

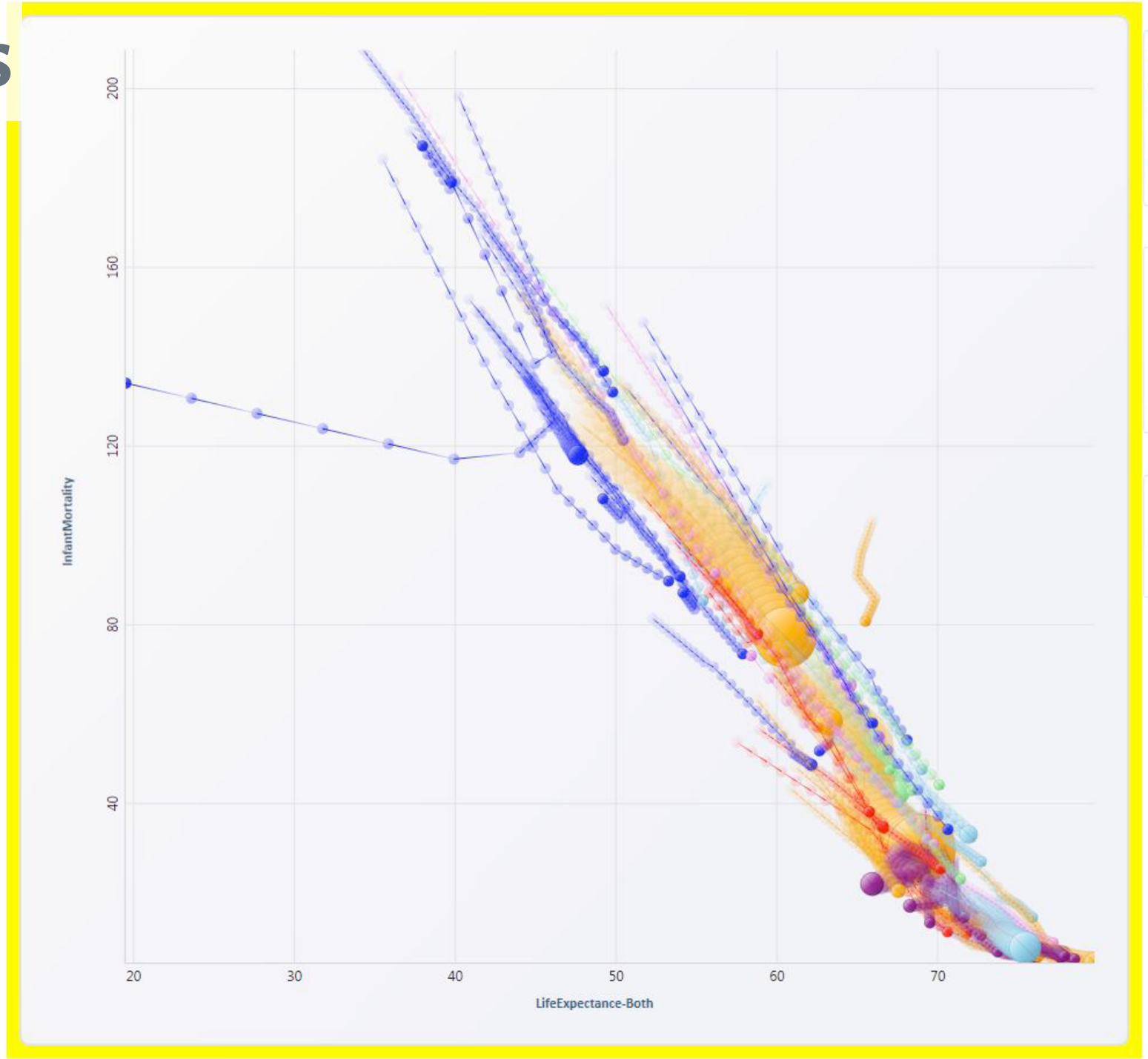

2.5
3
3.5
6.5
7

Animated Scatterplot



[Robertson et al. 2008]

Traces



[Robertson et al. 2008]

Small Multiples

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

[Robertson et al. 2008]

Study Conclusions

Subjects asked comprehension questions.
Presentation condition included narration.

Animated Scatterplot vs. Static Traces vs. Small Multiples

In which condition would participants:
be most accurate?
be faster?
prefer?

Raise your hand

Post in the chat

Study Conclusions

Subjects asked comprehension questions.
Presentation condition included narration.

Small multiples 10% more accurate than animation.

Presentation: Animation 60% faster than small multiples.

Analysis: Animation 82% slower than small multiples.

User preferences favor animation
(even though less accurate and slower for analysis!).

Animation Goals

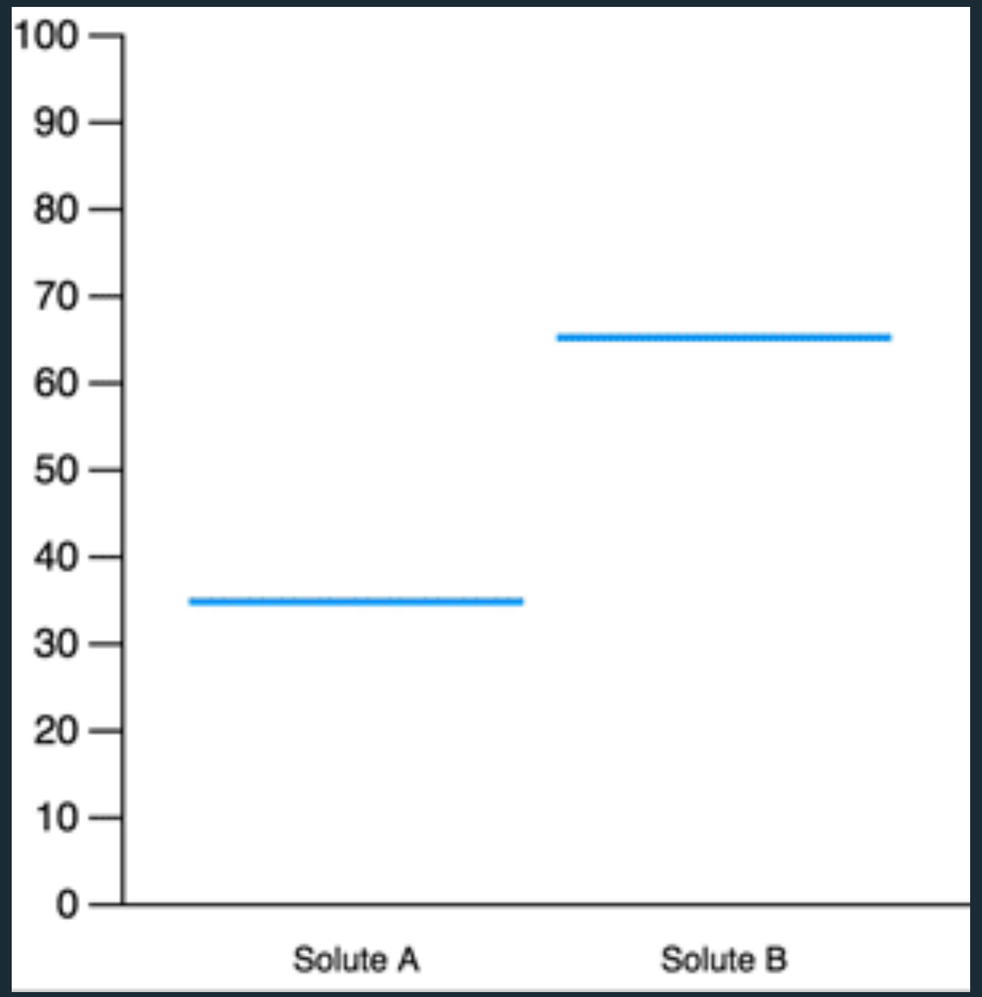
Direct Attention

Increase Engagement

Explain a Process

Understand a State Transition

Use to encode data



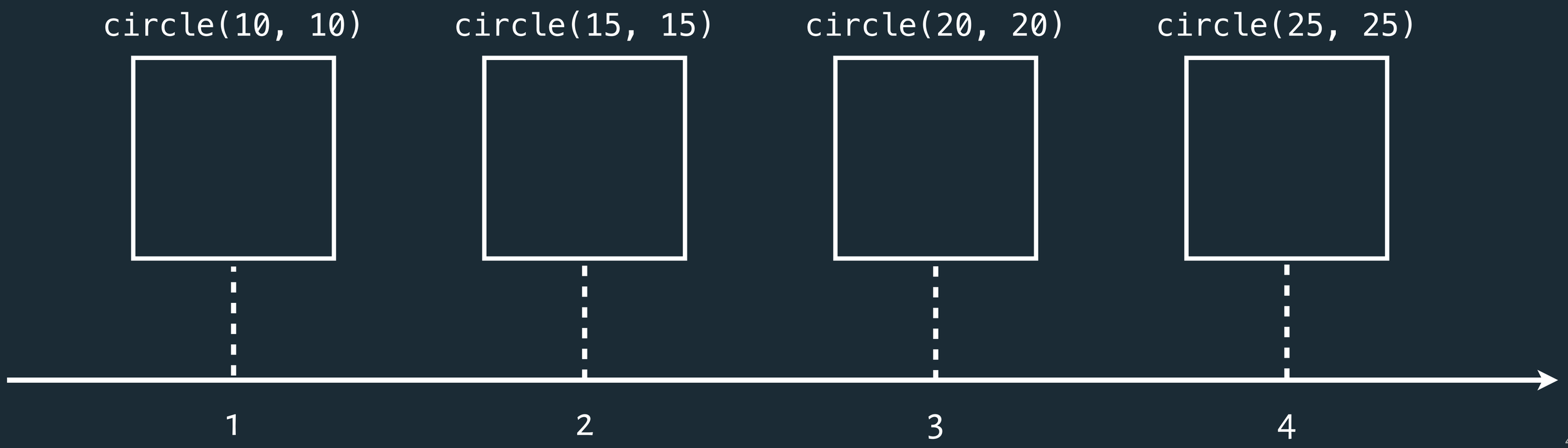
[Hullman et al. 2015]

Implementing Animation

Frame-Based Animation

Redraw the scene at regular intervals (e.g., 16ms).

Developer defines the redraw function (e.g., Processing, p5.js)



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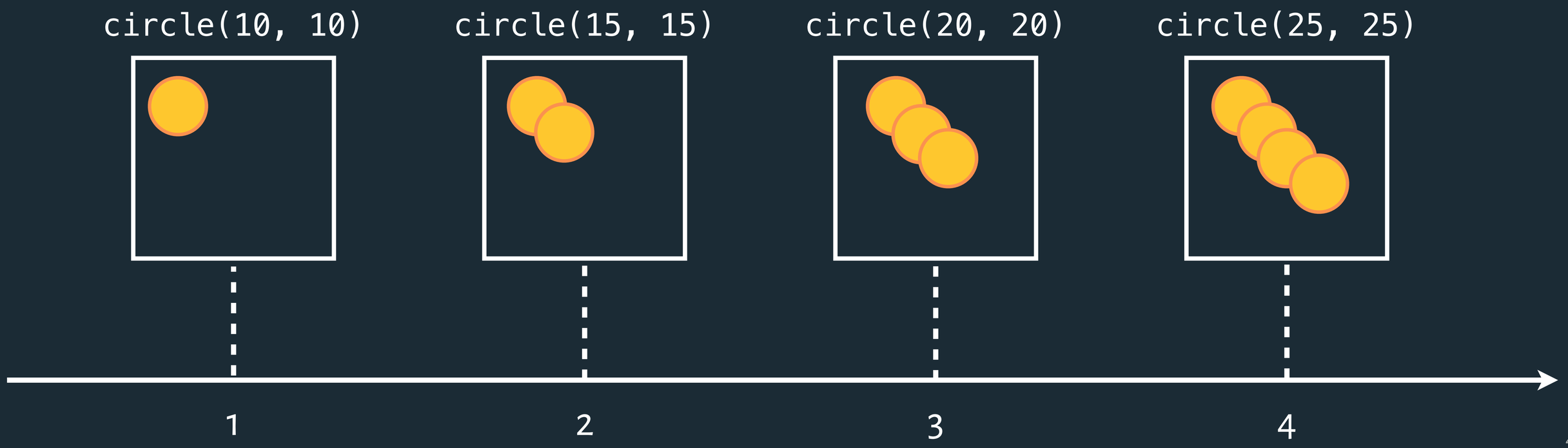
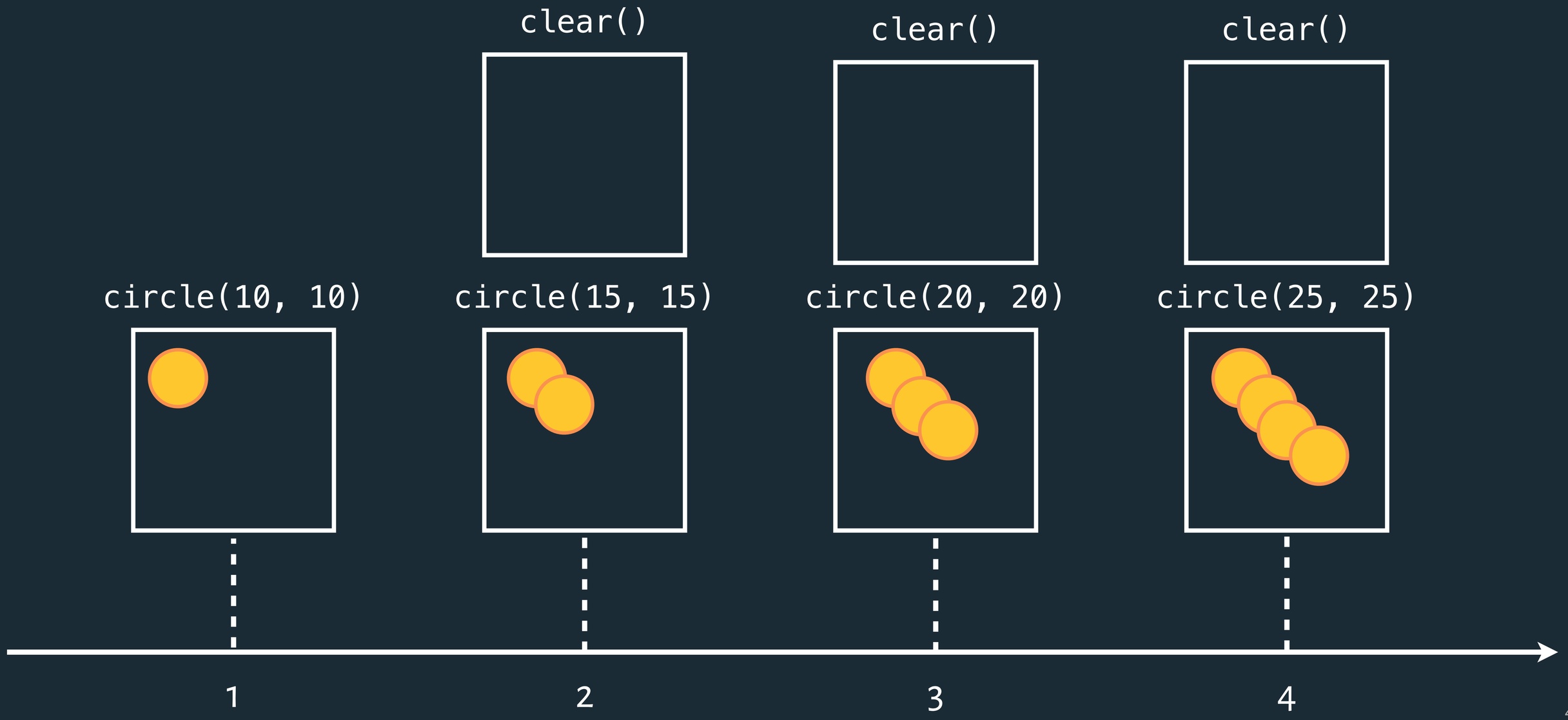
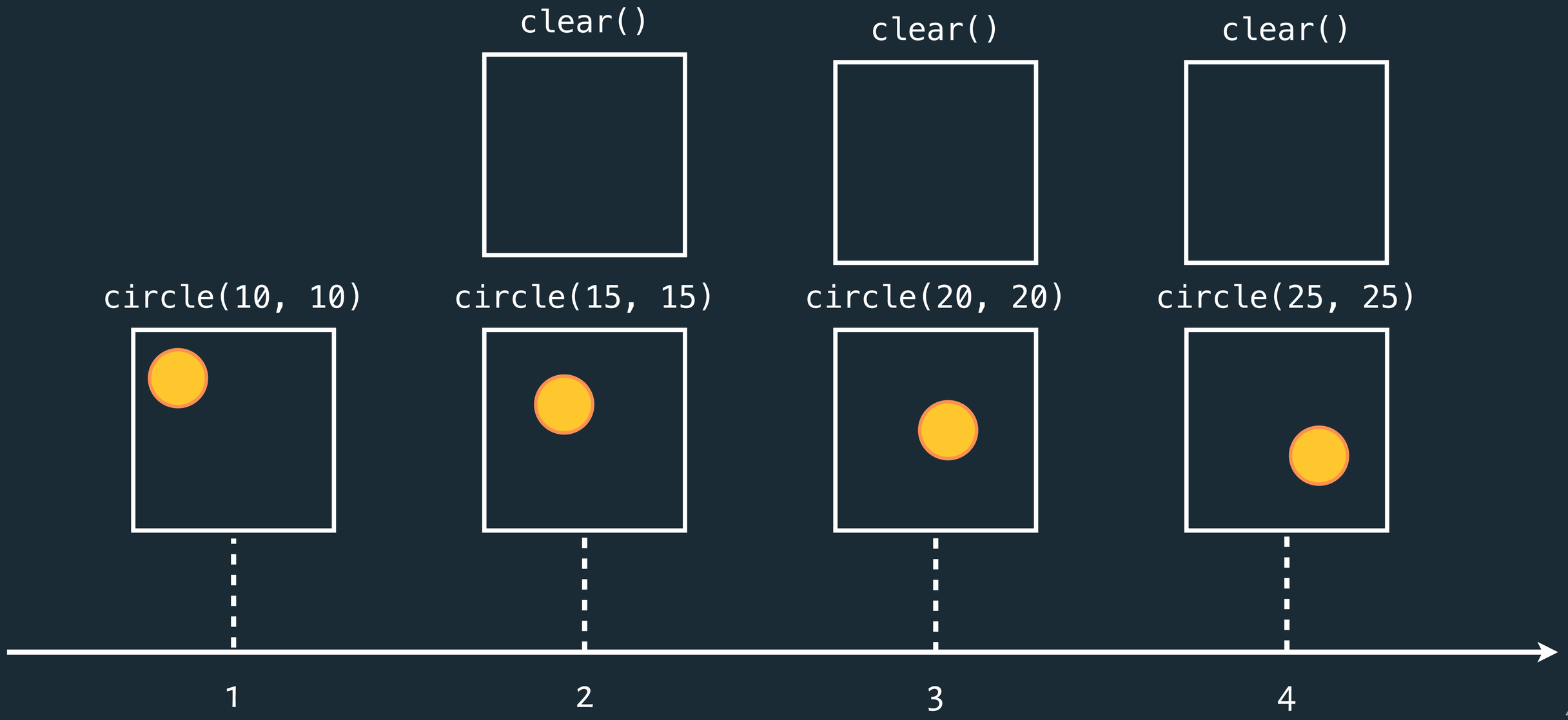


Implementing Animation



Implementing Animation



Implementing Animation

Frame-Based Animation

- Redraw the scene at regular intervals (e.g., 16ms).
- Developer defines the redraw function (e.g., Processing, p5.js)

Transition-Based Animation [Hudson & Stasko, 1993]

- Specify a property value, duration, and an "easing" function.
- Also called **tweening** (for "in-betweens").
- Steps computed via **interpolation**

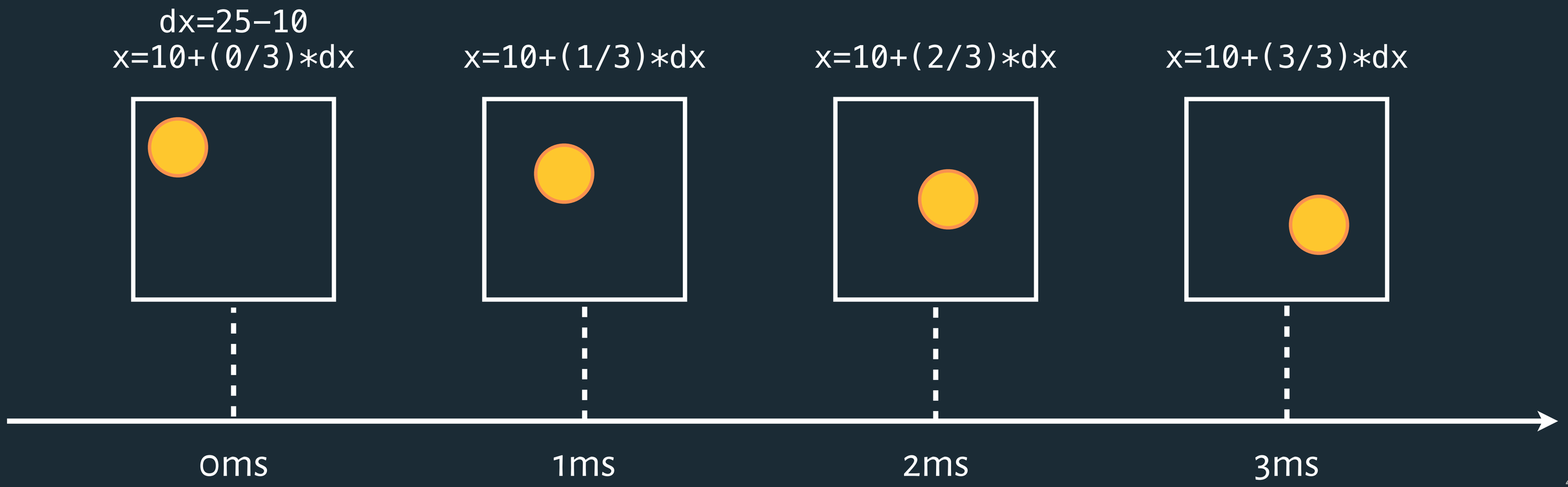
```
step (fraction) { val_now = val_start + fraction * (val_end - val_start); }
```

- Timing & redraw managed by UI toolkit.

Implementing Animation

```
From: (10, 10).
To: (25, 25).
Duration: 3 seconds.
```

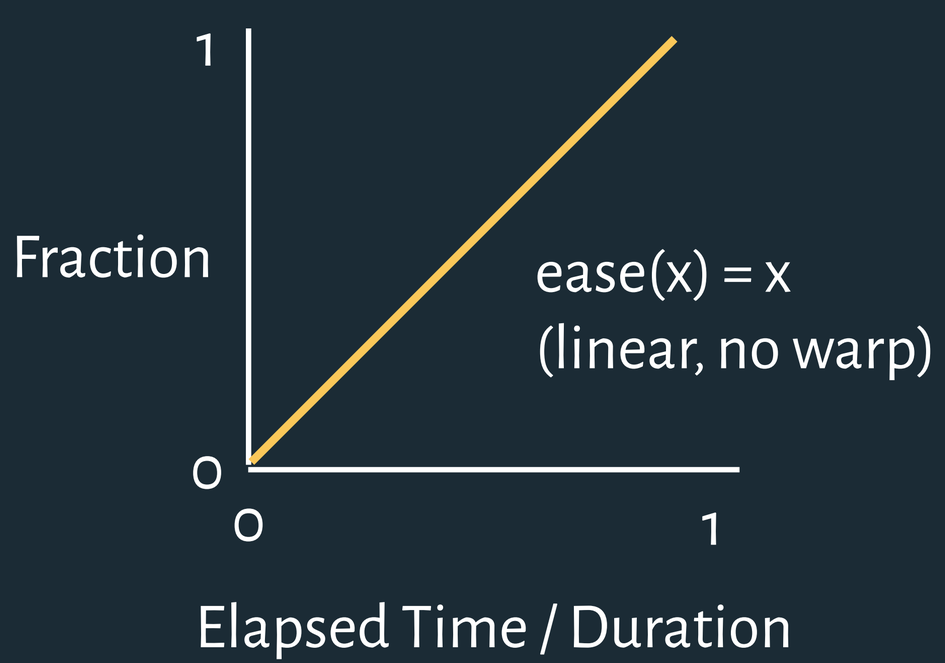
System handles the frame-by-frame updates!

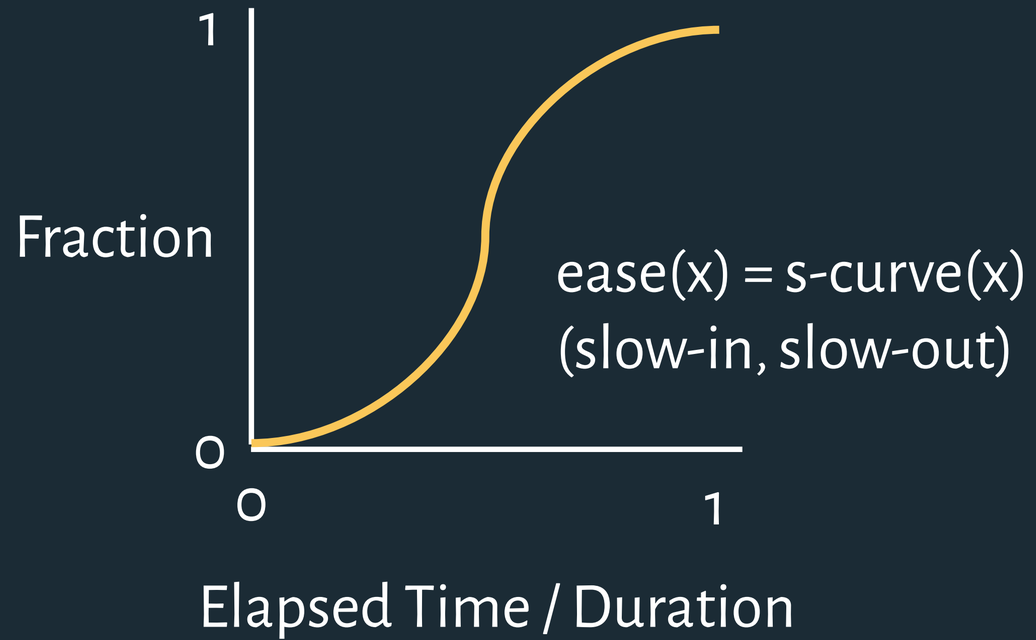


Easing/Pacing Functions

Goals: Stylize animation, improve perception.

Basic idea is to **warp time**: as *duration* goes from start (0%) to end (100%), dynamically adjust the *interpolation fraction* using an easing function.





https://easings.net