

Visual Narrative Flow: Exploring Factors Shaping Data Visualization Story Reading Experiences

Sean McKenna^{1,2}, Nathalie Henry Riche¹, Bongshin Lee¹, Jeremy Boy³, Miriah Meyer²

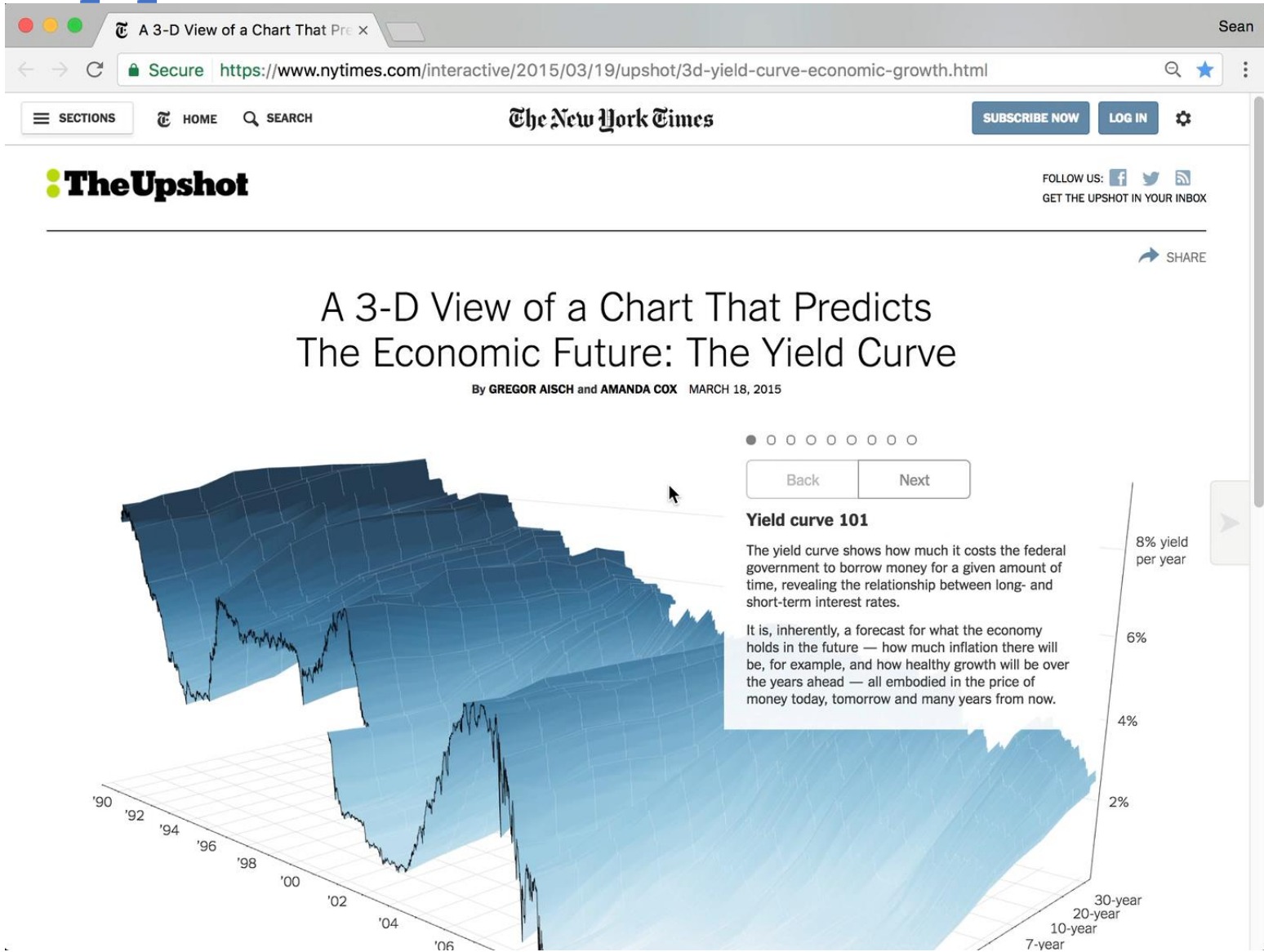
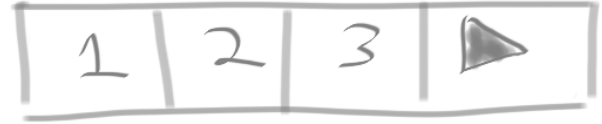
¹ Microsoft Research

² University of Utah

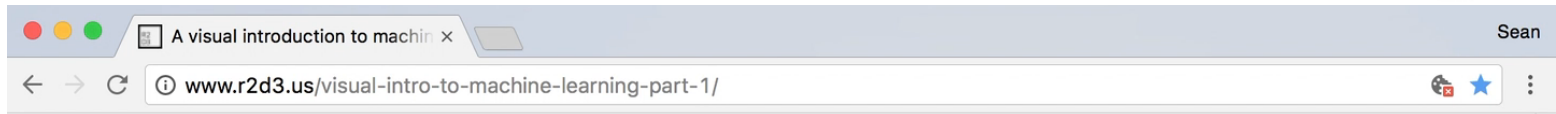
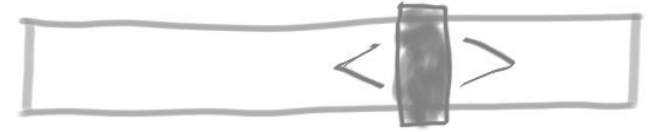
³ United Nations Global Pulse

Visual Narrative Flow

Stepper



Scroller

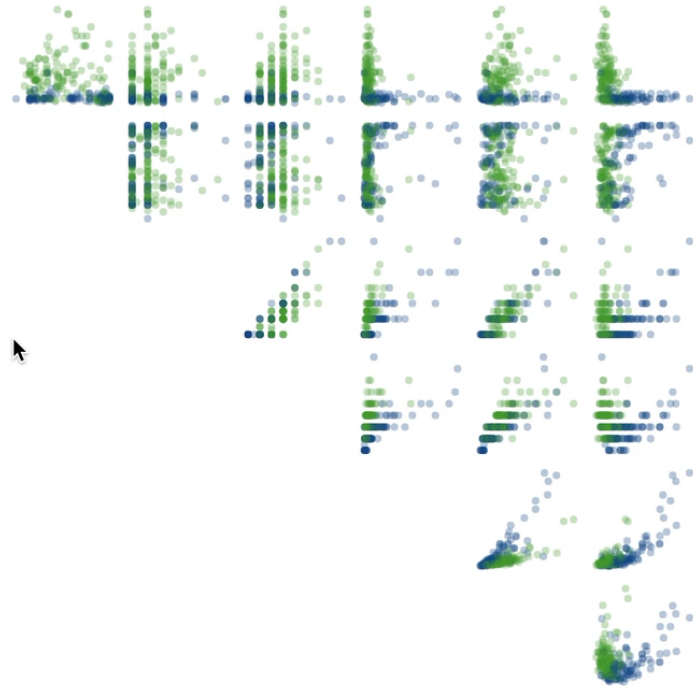


R2
D3

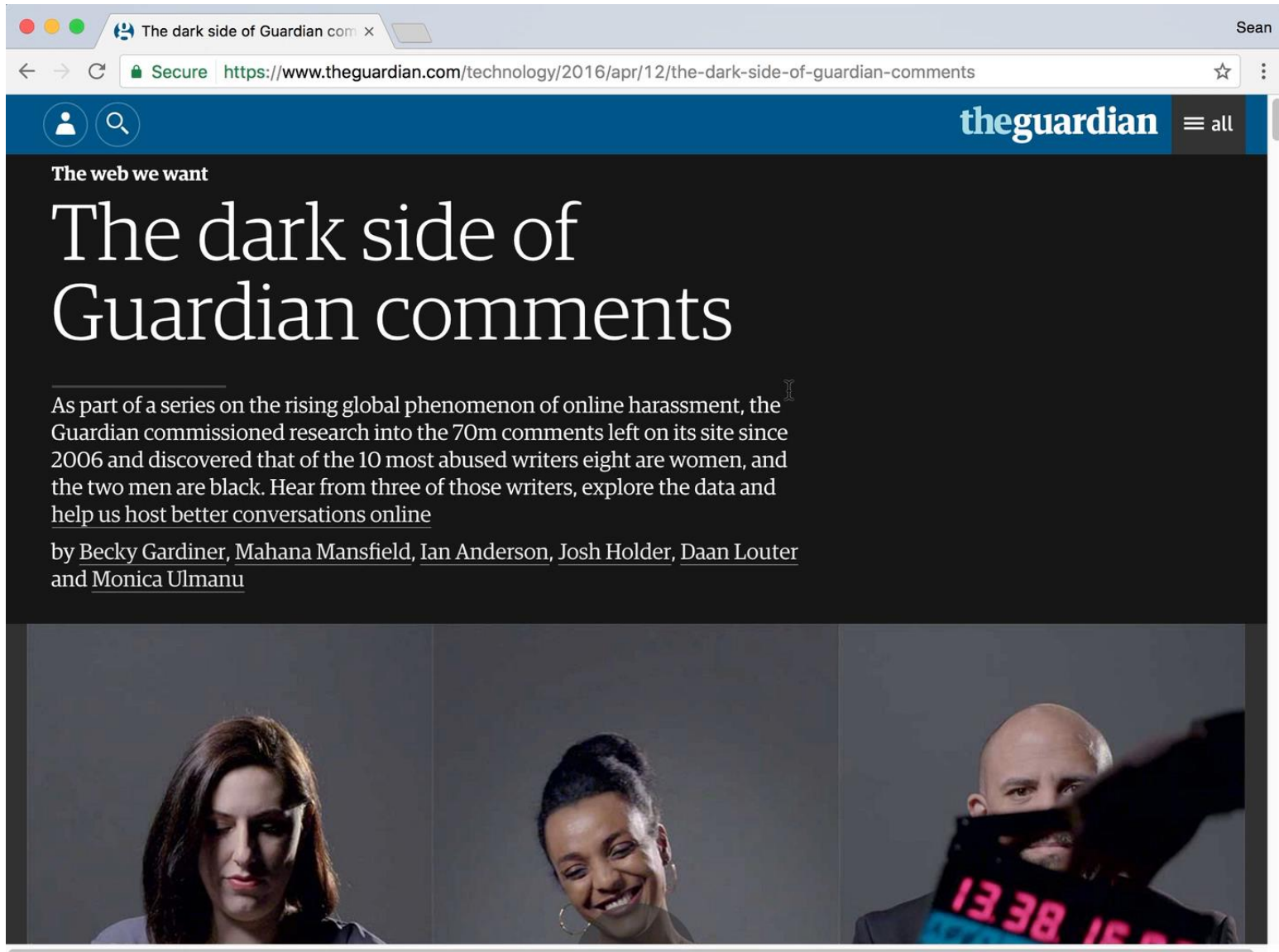
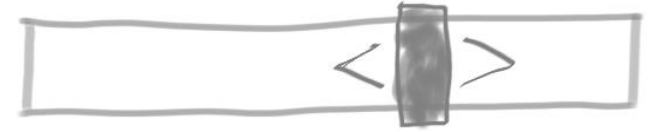
A visual introduction to machine learning

English

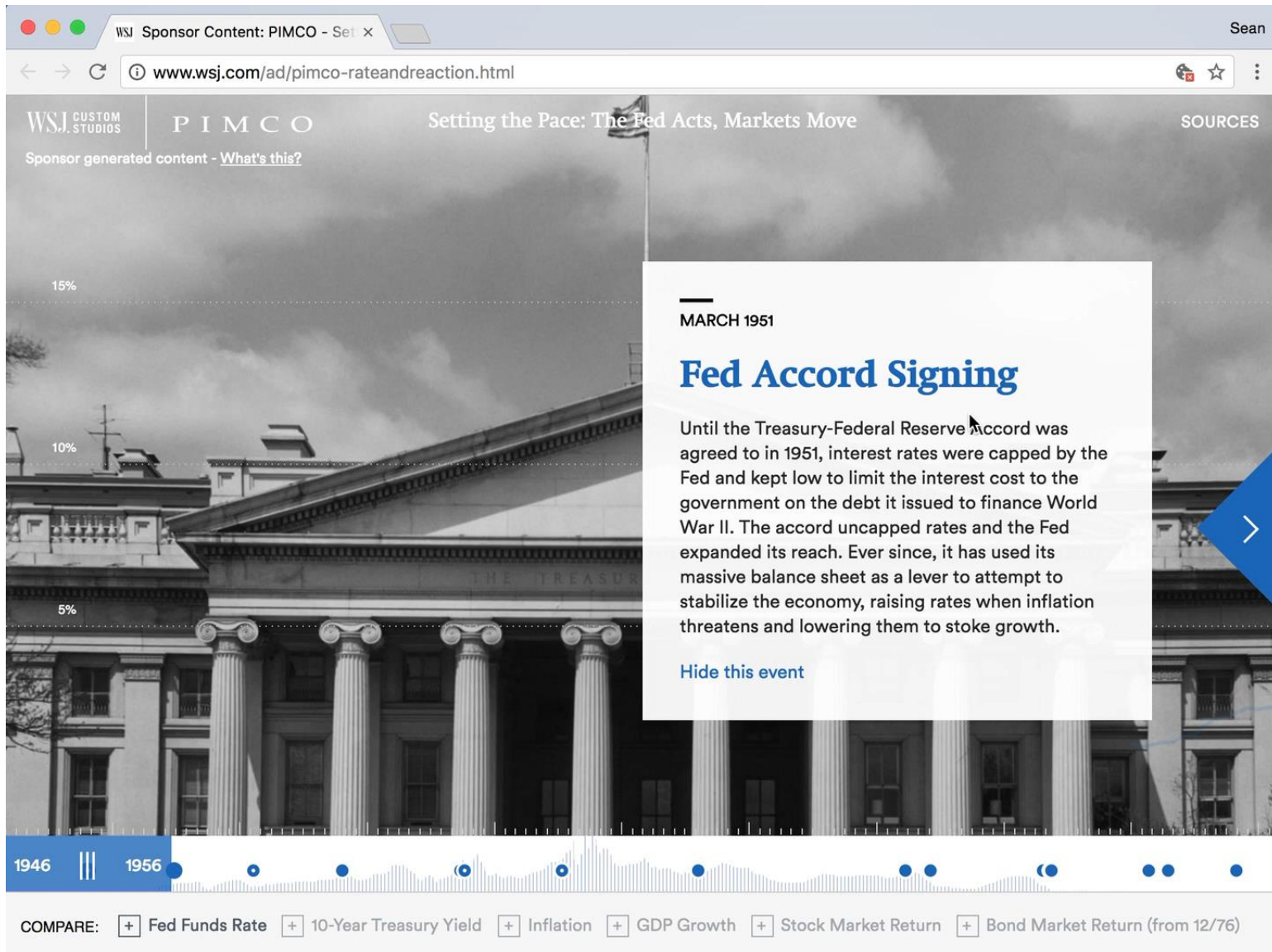
In machine learning, computers apply **statistical learning** techniques to automatically identify patterns in data. These techniques can be used to make highly accurate predictions.



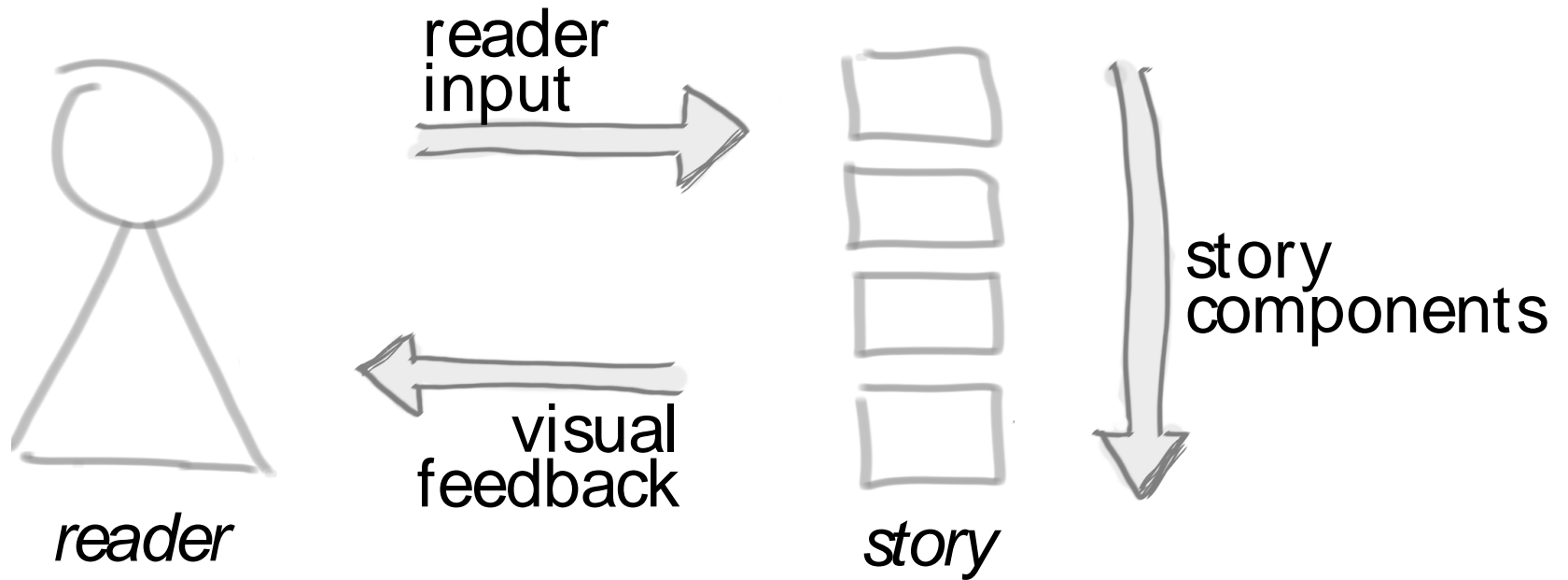
Discrete Scroller



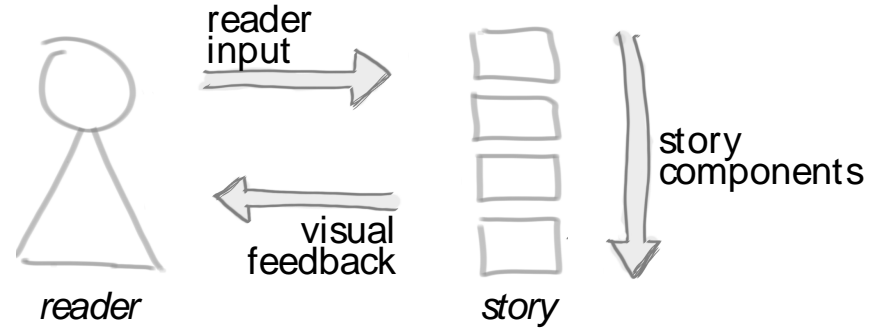
Slider



Visual Narrative Flow



Outline



- 7 factors of visual narrative flow
- analysis of 80 stories & authoring prototype
- 3 studies on preference, usability, and engagement

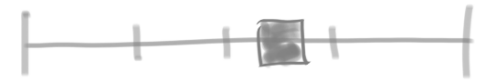
Navigation Input



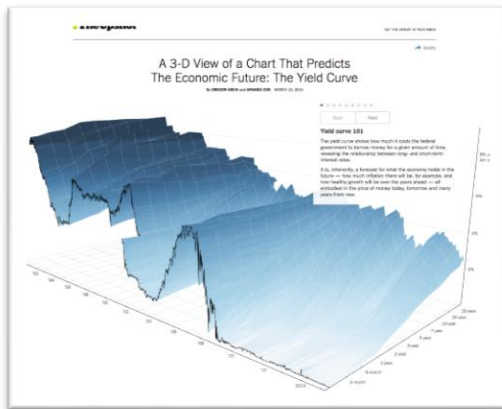
button



scroll



slider



Design Space

navigation input



button



scroll



slider

navigation progress



text



dots



vis

story layout



document



slideshow



hybrid

story progression



linear



linear skip



tree/graph

level of control



text



vis



transitions

over:

and how:



discrete



continuous

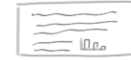


hybrid

role of visualization



equal



figure



annotated

navigation feedback



text



vis



widget

Corpus of Stories

- 80 stories
- iterative coding
- mapped out 7 factors

#	title	navigation input			level of control			navigation progress				story layout			role of visualization			story progression			navigation feedback			
		scroll	button	slider	text	vis	anim	text	dots	vis	other	doc	slide	cols	equal	figure	annot.	linear	skip	other	text	vis	widget	order
1	A Visual Introduction to Machine Learning	0			C	C	C					0	2	0				0			0			sync
2	Scientific Proof that Americans are Completely	0			C	C	D					0	2	0				0			0			sync
3	Fewer Helmets, More Deaths	0	0		C	C	D					0	2	0				0			0	0		vis
4	A 3-D View of a Chart That Predicts The Econ	0		0	D	D	D					0	1					0			0	0		sync
5	A Visual Analysis of Battle at the Berrics	0			C	C	D					0	1					0			0	0		sync
6	Budget Forecasts, Compared With Reality	0	0	0	D	D	D		0	0		0	1					0			0	0		sync
7	Human Development Trends, 2005	0			D	D	D		0			0	1					0			0	0		hyb
8	Diary of a Food Tracker	0	0		H	H	H					0	1					0			0	0		vis
9	How Americans Die	0			D	D	D		0			0	1					0			0	0		text
10	Visualizing MBTA Data: An Interactive Explor	0			C	C	C					0	1					0			0	0		vis
11	The World According to China	0			C	C	D					0	1					0			0	0		swap
12	How the U.S. and OPEC Drive Oil Prices	0			C	H	D					0	1					0			0	0		sync
13	Scaling Mt. Everest: A Scroll Up the Icy Path	0			C	C	C					0	3					0			0	0		sync
14	Stone Fall: The Deeper Reveal	0			C	C	D					0	2					0			0	0		sync
15	The Story of Joss & Ruth	0			C	C	C					0	1					0			0	0		sync
16	2014 Was the Hottest Year on Record	0			C	C	D					0	1					0			0	0		sync
17	The World's Ball	0	0		C	C	D					0	1					0			0	0		swap
18	The Russia Left Behind	0	0		C	C	C					0	2					0			0	0		sync
19	The Water We Eat	0			C	H	C					0	1-2					0			0	0		sync
20	9/11 Jumping	0	0		C	H	C					0	1					0			0	0		swap
21	The Great Wall: St. Catherine's Most Unlikely	0			C	C	C					0	2					0			0	0		sync
22	Russia's Evolving in Ukraine	0			C	C	-					0	1					0			0	0		swap
23	At Top Colleges, an Admission Gap for Minor	0	0		D	D	D					0	1					0			0	0		text
24	Geography is Making Sense	0	0		C	C	C					0	2					0			0	0		sync
25	How Different Groups Spend Their Day	0			D	D	D					0	1					0			0	0		sync
26	Deconstructing the Past: A New Look at Hist	0	0		D	D	D					0	1					0			0	0		sync
27	Dallas Day Schools	0	0		D	D	D					0	1					0			0	0		sync
28	ChapTat	0			H	C	-					0	1					0			0	0		sync
29	Neonic-Nectar: An Interactive Explanation	0	0		D	D	D					0	1					0			0	0		hyb
30	The Year Ahead 2018: 50 Comments to Wit	0	0		C	C	-					0	2					0			0	0		sync
31	The Museum of the World	0	0		-	C	C					0	1					0			0	0		sync
32	Worldwide Carbon Check	0			D	D	D					0	1					0			0	0		vis
33	Interactive, Global Emission	0	0		-	D	D					0	1					0			0	0		vis
34	A Map of Olympic Markets	0	0		-	D	D					0	1					0			0	0		sync
35	Shane White's Double McTwin	0			D	D	D					0	1					0			0	0		vis
36	Robbie in Suit to Resonance	0			D	D	D					0	1					0			0	0		vis
37	A Nation Divided	0	0		D	C	D					0	1					0			0	0		sync
38	342,000 Savings Later, Deak-Jones Calls It a C	0			C	D	C					0	1					0			0	0		sync
39	52 Photos to See in 2015	0			C	C	-					0	2					0			0	0		sync
40	A Walk Through the Challenge	0			D	D	C					0	2					0			0	0		text
41	Bumblin' North Korea	0			C	C	-					0	1					0			0	0		sync
42	Walking New York	0	0		C	D	-					0	2					0			0	0		vis
43	My Jobless Relative Are Winning	0			C	D	D					0	1					0			0	0		text
44	Real and Fake Winter	0	0		H	D	D					0	1-2					0			0	0		text
45	Eisenstein's and Eisenstein's	0			C	C	-					0	1					0			0	0		sync
46	Elm Delays from 2,000 Screenplay, Bate	0			C	C	D					0	1					0			0	0		sync
47	Urban Decay: Urban Decay in the World	0	0		D	D	D					0	1					0			0	0		sync
48	If the Moon Were Only One Planet	0			C	C	-					0	1					0			0	0		sync
49	State of the Gadget Union	0			C	C	-					0	1					0			0	0		text

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7	Human Development Trends, 2005	0			D	D	D	0				0	1					0			0	0		hyb
8	Diary of a Food Tracker	0	0		H	H	H					0	0	1				0			0	0		vis
9	How Americans Die	0			D	D	D					0	1					0			0	0		text
10	Visualizing MBTA Data: An Interactive Explor	0			C	C	C					0	1					0			0	0		vis
11	The World According to China	0			C	C	D					0	1					0			0	0		swap
12	How the U.S. and OPEC Drive Oil Prices	0			C	H	D					0	0	1	0			0			0	0		sync
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Design Space

navigation input



button



scroll



slider

navigation progress



text



dots



vis

story layout



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hybrid

story progression



linear



linear skip



tree/graph

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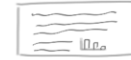


hybrid

role of visualization



equal



figure



annotated

navigation feedback



text

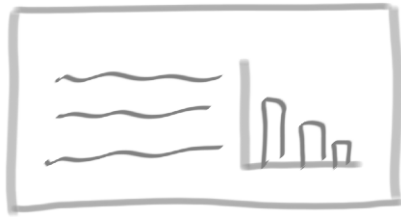


vis

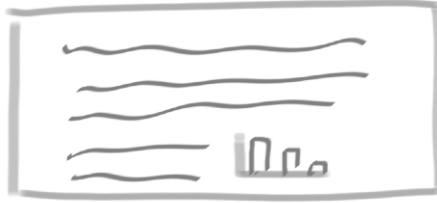


widget

Role of Visualization



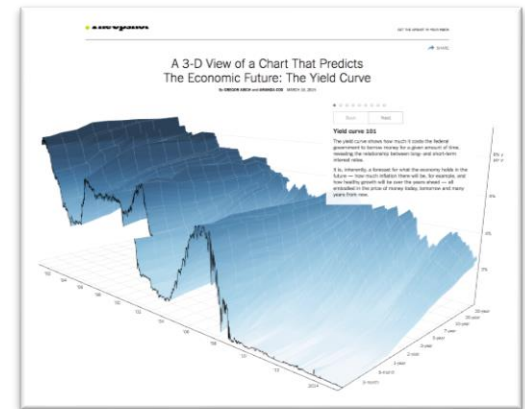
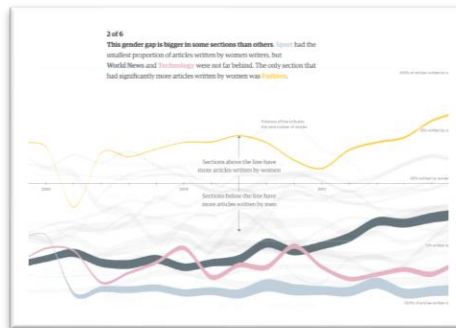
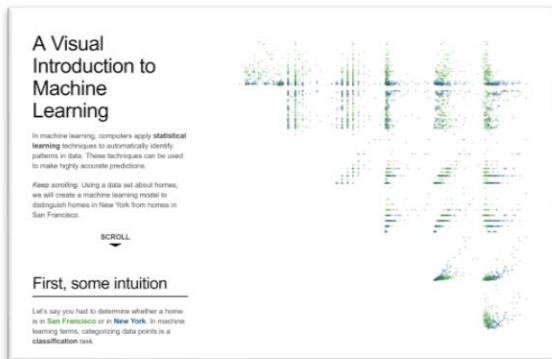
equal



figure

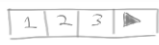


annotated



Design Space

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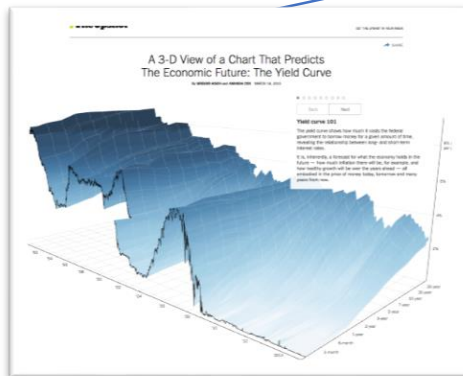
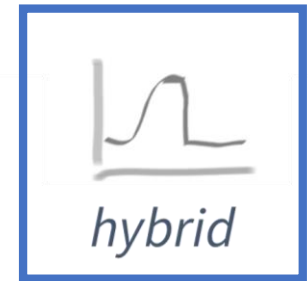
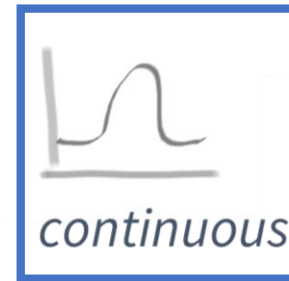
widget

Level of Control

- components:



- & controlled:



Design Space

navigation input



navigation progress



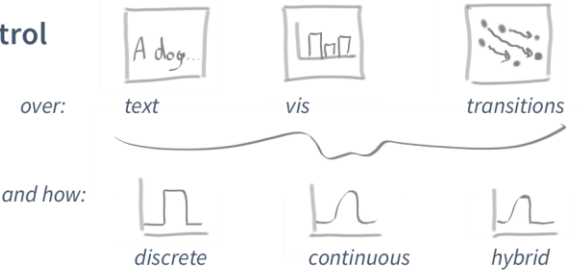
story layout



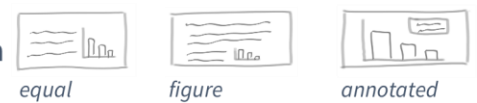
story progression



level of control



role of visualization



navigation feedback



Authoring Prototype



[previous](#) [next](#)

Teaching Bar Charts through Data Visualization

showing the raw data

Data enables us to better understand the world around us.

Take this list of a few characters from the TV show, The Simpsons. It includes their names, genders, and their ages.

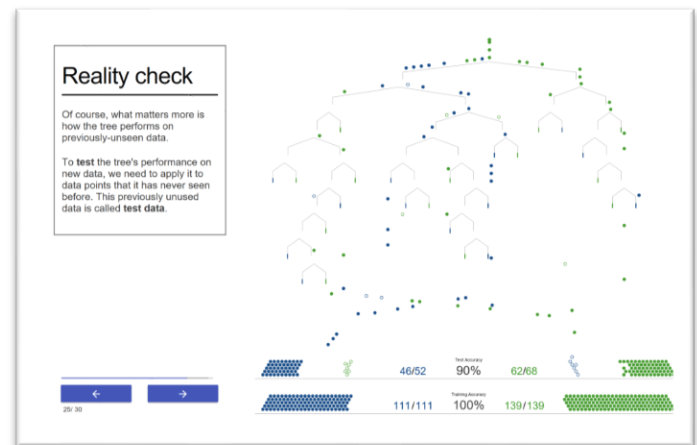
Let's start with just the 5 main Simpson family characters.



	Gender	Adult
Lisa	F	N
Bart	M	N
Homer	M	Y
Marge	F	Y
Maggie	F	N

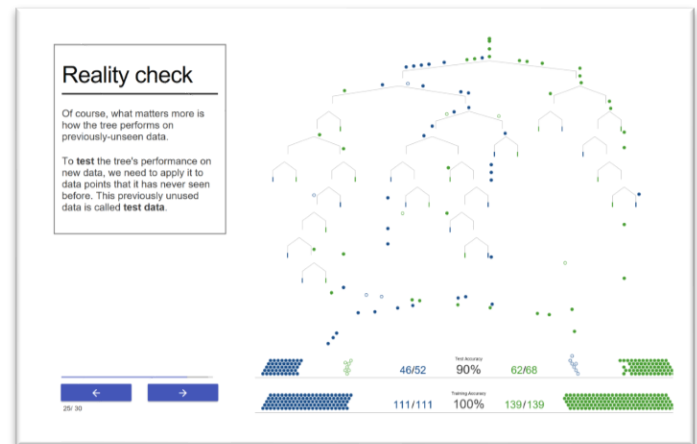
Overview of Studies

- mimic real-world stories
 - scrollers and steppers
 - machine learning story
- 3 studies to measure:
 - preference
 - usability [Brooke 1986]
 - engagement [O'Brien, Toms 2010]



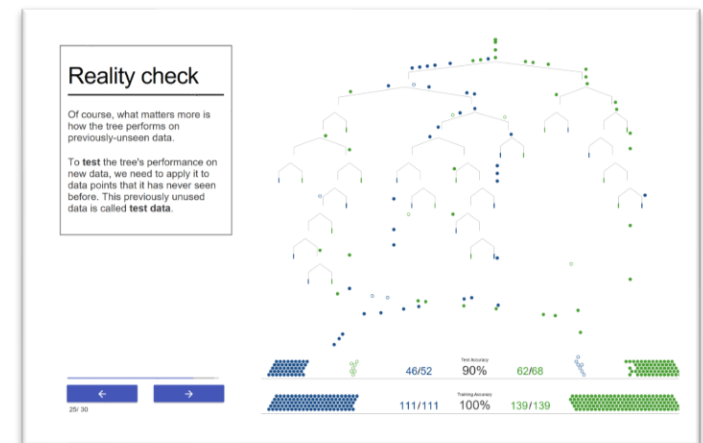
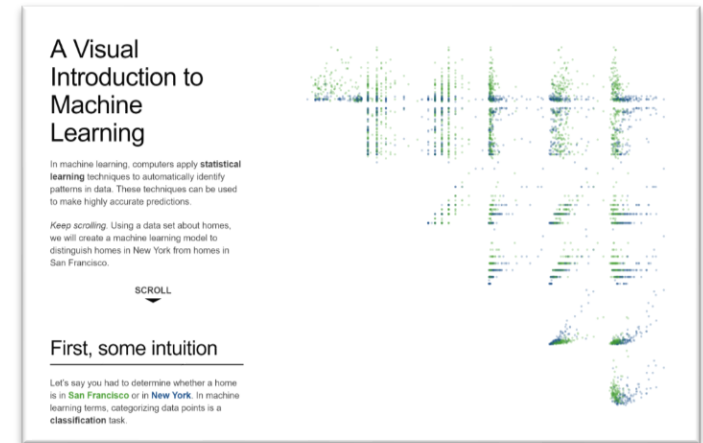
Web Survey

- methodology
 - 8 participants, free to explore
 - measured usability & preference
- mixed preferences
 - 3 stepper, 5 scroller
- similarly usable
- qualitatively
 - stepper: progress bar, arrow keys
 - scroller: less effort to scroll



Observations & Interviews

- methodology
 - 10 participants, 3 chapters, tablet
 - measured usability & preference
- results
 - above average usability [Sauro 2011]
 - 2/10 steppers
- “scrolling allowed me to see the transformations more fluidly”
- “scrolling is sexier in some ways, it is unique ... and just more fun”



Crowdsourced Study

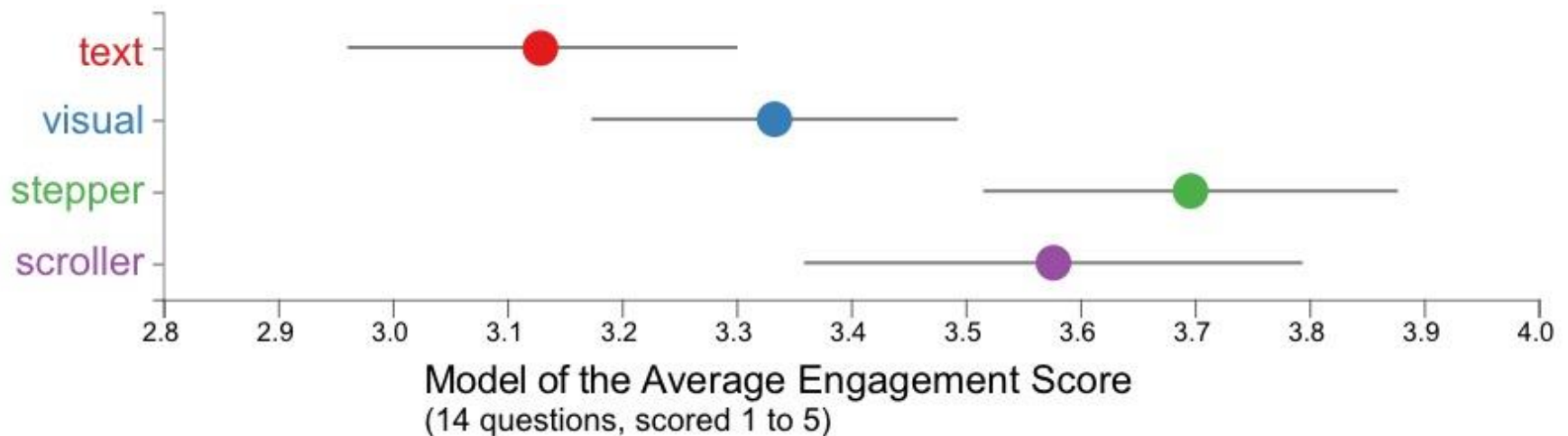
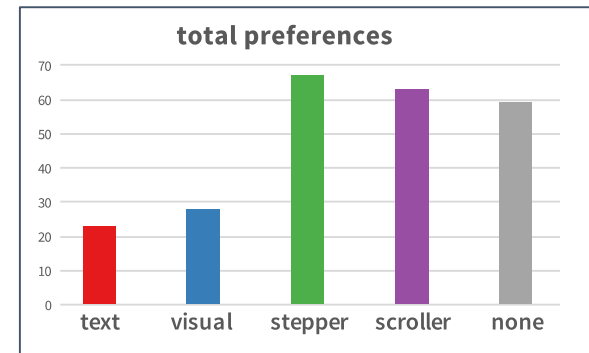
- 4 conditions:



- which conditions are most engaging?

Crowdsourced Study Results

- linear mixed effects analysis
- visualizations & animations engage
- no significance: steppers & scrollers

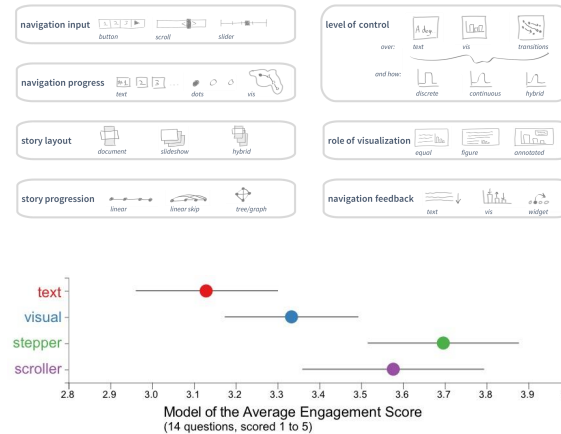
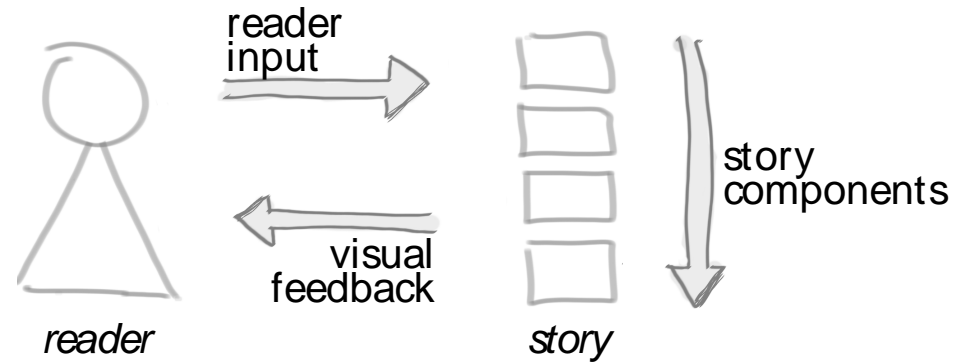


Discussion & Future Work

- choice of flow factors may need to vary
- results of study may not generalize
- explore other metrics for engagement
- compare against comprehension, time, completion, or attention

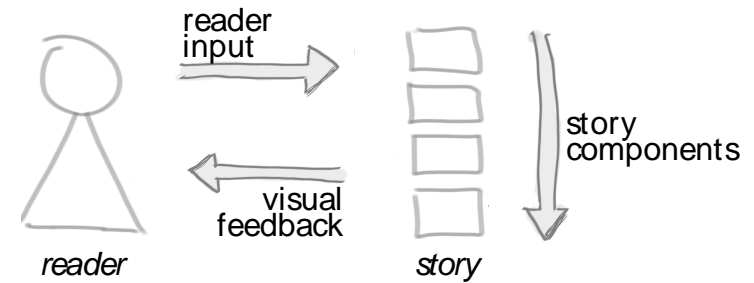
Visual Narrative Flow

- reader input, story components, visual feedback
- design space of 7 flow-factors
- corpus of 80 stories & authoring prototype
- 3 studies on usability, preference, and engagement



A table representing a corpus of 80 stories. Each row corresponds to a story, and the columns represent various attributes or components of the story, such as title, author, and content details.

Thank You!



<http://narrative-flow.github.io>

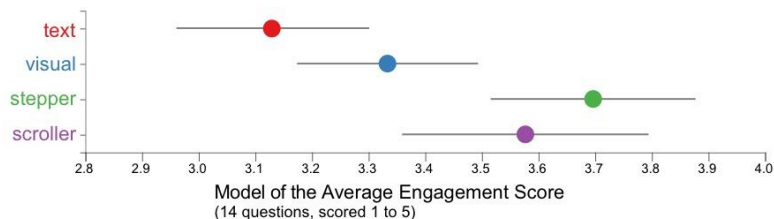
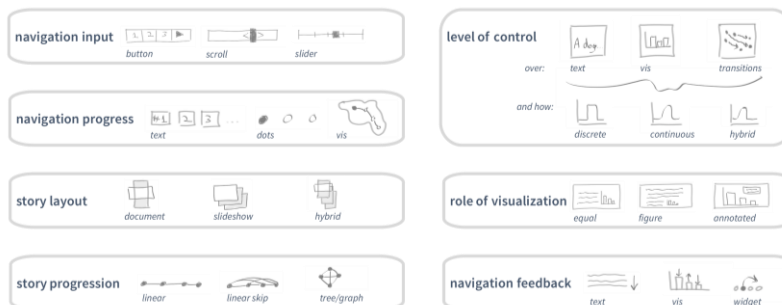
sean@cs.utah.edu @mckennapsean (.com)



Microsoft



visualization
design lab



id	question	text	visual	stepper	scroller	total
1	How easy is it to navigate through the story?	4	4	4	4	16
2	How easy is it to understand the story?	4	4	4	4	16
3	How easy is it to interact with the story?	4	4	4	4	16
4	How easy is it to find information in the story?	4	4	4	4	16
5	How easy is it to follow the story?	4	4	4	4	16
6	How easy is it to remember the story?	4	4	4	4	16
7	How easy is it to share the story?	4	4	4	4	16
8	How easy is it to explore the story?	4	4	4	4	16
9	How easy is it to learn from the story?	4	4	4	4	16
10	How easy is it to enjoy the story?	4	4	4	4	16
11	How easy is it to use the story?	4	4	4	4	16
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25	How easy is it to interact with the story?	4	4	4	4	16
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27	How easy is it to follow the story?	4	4	4	4	16
28	How easy is it to remember the story?	4	4	4	4	16
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31	How easy is it to learn from the story?	4	4	4	4	16
32	How easy is it to enjoy the story?	4	4	4	4	16
33	How easy is it to use the story?	4	4	4	4	16
34	How easy is it to navigate through the story?	4	4	4	4	16
35	How easy is it to understand the story?	4	4	4	4	16
36	How easy is it to interact with the story?	4	4	4	4	16
37	How easy is it to find information in the story?	4	4	4	4	16
38	How easy is it to follow the story?	4	4	4	4	16
39	How easy is it to remember the story?	4	4	4	4	16
40	How easy is it to share the story?	4	4	4	4	16
41	How easy is it to explore the story?	4	4	4	4	16
42	How easy is it to learn from the story?	4	4	4	4	16
43	How easy is it to enjoy the story?	4	4	4	4	16
44	How easy is it to use the story?	4	4	4	4	16
45	How easy is it to navigate through the story?	4	4	4	4	16
46	How easy is it to understand the story?	4	4	4	4	16
47	How easy is it to interact with the story?	4	4	4	4	16
48	How easy is it to find information in the story?	4	4	4	4	16
49	How easy is it to follow the story?	4	4	4	4	16
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59	How easy is it to find information in the story?	4	4	4	4	16
60	How easy is it to follow the story?	4	4	4	4	16
61	How easy is it to remember the story?	4	4	4	4	16
62	How easy is it to share the story?	4	4	4	4	16
63	How easy is it to explore the story?	4	4	4	4	16
64	How easy is it to learn from the story?	4	4	4	4	16
65	How easy is it to enjoy the story?	4	4	4	4	16
66	How easy is it to use the story?	4	4	4	4	16
67	How easy is it to navigate through the story?	4	4	4	4	16
68	How easy is it to understand the story?	4	4	4	4	16
69	How easy is it to interact with the story?	4	4	4	4	16
70	How easy is it to find information in the story?	4	4	4	4	16
71	How easy is it to follow the story?	4	4	4	4	16
72	How easy is it to remember the story?	4	4	4	4	16
73	How easy is it to share the story?	4	4	4	4	16
74	How easy is it to explore the story?	4	4	4	4	16
75	How easy is it to learn from the story?	4	4	4	4	16
76	How easy is it to enjoy the story?	4	4	4	4	16
77	How easy is it to use the story?	4	4	4	4	16
78	How easy is it to navigate through the story?	4	4	4	4	16
79	How easy is it to understand the story?	4	4	4	4	16
80	How easy is it to interact with the story?	4	4	4	4	16
81	How easy is it to find information in the story?	4	4	4	4	16
82	How easy is it to follow the story?	4	4	4	4	16
83	How easy is it to remember the story?	4	4	4	4	16
84	How easy is it to share the story?	4	4	4	4	16
85	How easy is it to explore the story?	4	4	4	4	16
86	How easy is it to learn from the story?	4	4	4	4	16
87	How easy is it to enjoy the story?	4	4	4	4	16
88	How easy is it to use the story?	4	4	4	4	16
89	How easy is it to navigate through the story?	4	4	4	4	16
90	How easy is it to understand the story?	4	4	4	4	16
91	How easy is it to interact with the story?	4	4	4	4	16
92	How easy is it to find information in the story?	4	4	4	4	16
93	How easy is it to follow the story?	4	4	4	4	16
94	How easy is it to remember the story?	4	4	4	4	16
95	How easy is it to share the story?	4	4	4	4	16
96	How easy is it to explore the story?	4	4	4	4	16
97	How easy is it to learn from the story?	4	4	4	4	16
98	How easy is it to enjoy the story?	4	4	4	4	16
99	How easy is it to use the story?	4	4	4	4	16
100	How easy is it to navigate through the story?	4	4	4	4	16

Design Space

navigation input



button



scroll



slider

navigation progress



text



dots



vis

story layout



document



slideshow



hybrid

story progression



linear



linear skip



tree/graph

level of control

over:



text



vis



transitions

and how:



discrete



continuous



hybrid

role of visualization



equal



figure



annotated

navigation feedback



text



vis



widget

Navigation Progress



text



dots



vis

Story Layout



document



slideshow



hybrid

Story Progression



linear



linear skip



tree/graph

Navigation Feedback



text



vis



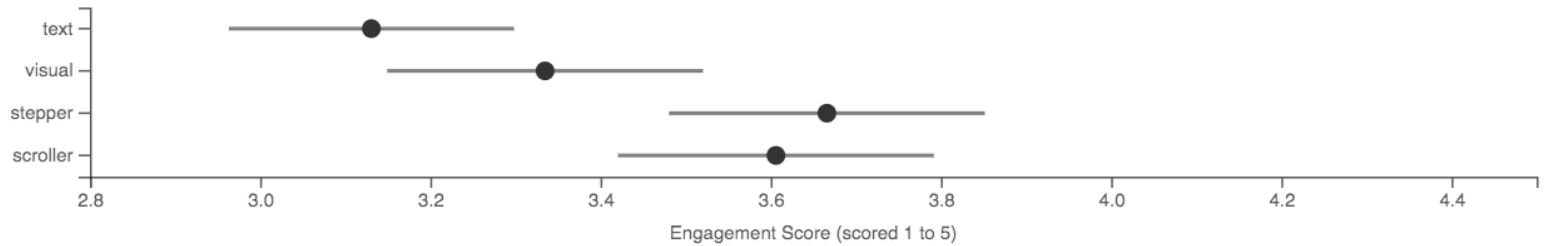
widget

Crowdsourced Study Analysis

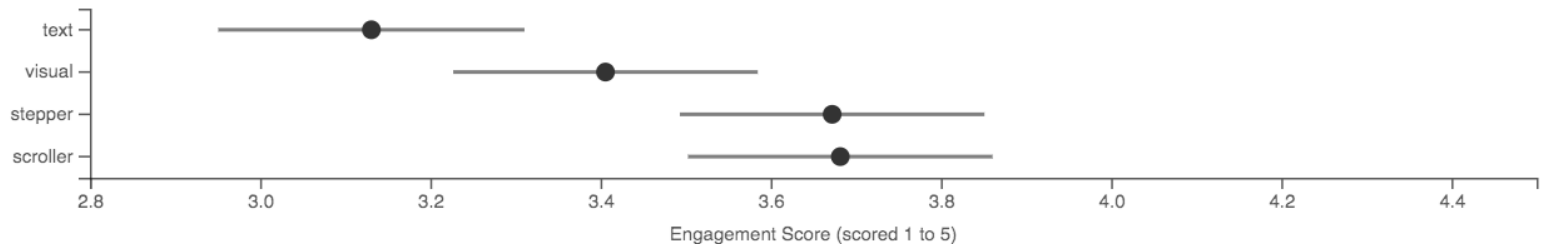
- linear mixed effects model
- fixed effects
 - four narrative flows
 - two chapters used
- random effects: intercepts and slopes
 - participants
 - engagement questions

Engagement Models

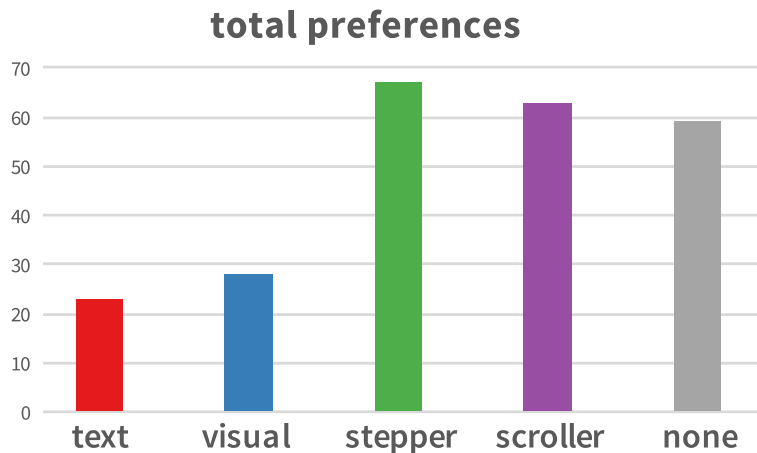
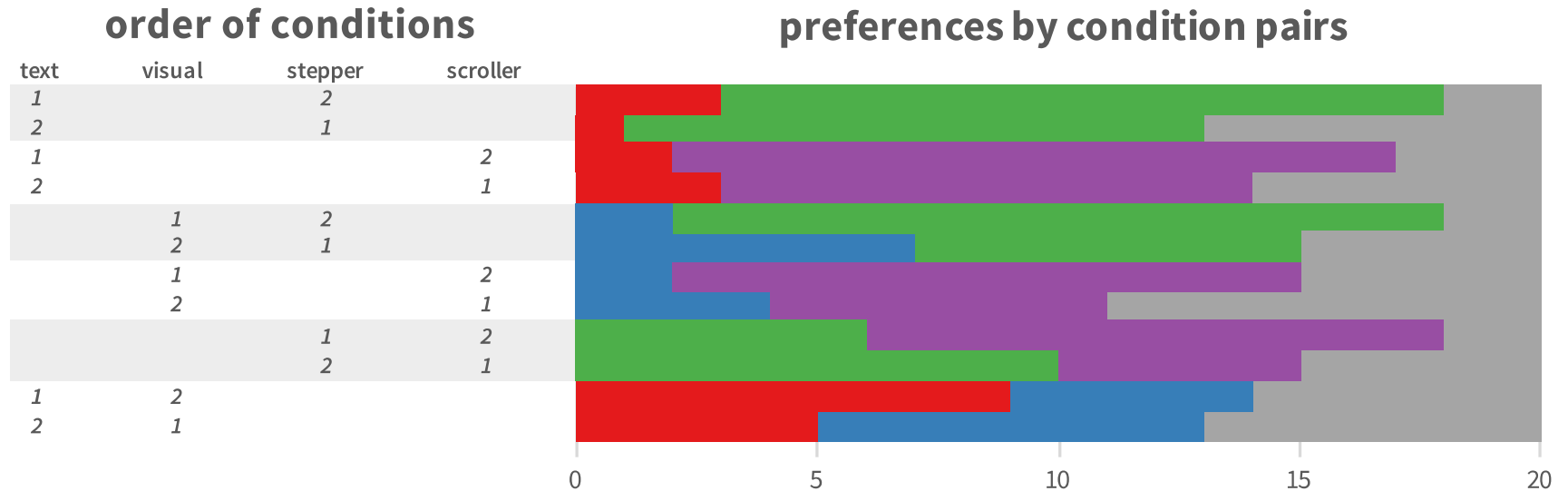
1. I was absorbed in reading the story.



2. I forgot about my immediate surroundings while reading through this story.



Crowdsourced Preferences



Hybrid Example

(video)