

WHAT MAKESA VISUALIZATION MEMORABLE?



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 - Aude Oliva, and Hanspeter Pfister





Cleveland & McGill (198⁴ graph, and the lower panel displays Shart Note the Liner panel displays a conveyed by the graphic constituents



Pinker (1990)

PERCEPTION







Bateman, et al. (2010)





legends to optimize



Cawthon & Vande Moere (2007) Vande Moere, et al. (2012)





AESTHETICS

MEMORY

PERCEPTION



COMPREHENSION

ENGAGEMENT



MPACT

AESTHETICS

MEMORY

PERCEPTION

Perception

MEMORY

WHAT MAKESA VISUALIZATION MEMORABLE?



MEMORY

PERCEPTION

WHAT MAKESA VISUALIZATION MEMORABLE?







Massive database with 1000s of real visualizations

Online game with 100s of people

Statistically significant results





"Single" visualizations (2,070 images)



"single"



Visualization Database (5,693 images)







Englehardt (2002)





Harris (1999)

Robert L. Harris



Cleveland & McGill (1984)



Area Bar Circle Diagram Distribution Tree & Network Grid / Matrix Line Map Point





See "Supplemental Material" PDF





"Single" visualizations (2,070 images)



"single"



Visualization Database (5,693 images)











Visualization Database (5,693 images)







Visualization Database (5,693 images)





"Single" visualizations (2,070 images)



"single"



EXPERIMENT

"Single" visualizations (2,070 images)



EXPERIMENT

- Conducted on amazon mechanical turk[™]
- 261 participants
- Game with 17 levels
 - 120 visualizations per level
 - up to 2,040 visualizations per game
 - over 57% of participants played whole game

Artificial Artificial Intelligence

Memory game

Welcome back! You may try the practice again, or skip right on to the game.

Start Practice

Skip Practice

By making judgments about these images, you are participating in a study being performed by cognitive scientists in the Computer Science and Artificial Intelligence Laboratory at MIT. If you have questions about this research, please contact Dr. Oliva at oliva@mit.edu. Your participation in this research is voluntary. You may decline further participation, at any time, without adverse consequences. Your anonymity is assured, the researchers who have requested your participation will not receive any personal info@ation about you.



Memory game

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Welcome back! You may try the practice again, or skip right on to the game.

art Practice

kip Practice



EXPERIMENT

- Visualizations presented for 1 second
- I.4 second break ('dot') between visualizations
- Measurements:
 - "Hit rate" = number of correct IDs of repeated viz
 - "False alarm rate" = number of premature responses

Press the 'r' key any time you see an image you saw before!

Annual net* income by education level 25-64 year-olds, 2009 or latest, \$'000 at purchasing-power parity Luxembo United St Austria Ireland Netherlan Australia Britain Canada South Kore Germany Italy Sweden Denmark France Spain Israel Estonia Source: DEC Less taxes and social contribution

Progress



RESULTS

Top I2 (w/o 'objects')

Top 12



































Bottom 12

















G – Countries projected to achieve ≥75% decrease in case incidence by 2015



| Line IV | Frankrige in Pro- | | PR7-201120307 | | The four the case of the | | - | 10.0 APR 1999 (10) |
|--|-------------------|--------|---------------|-----------------------|--------------------------|------|--------|--|
| | 5-00 | 100 | 1.00 | 54. 101 - 202 | 81. | 1.00 | | |
| PV 1914 | | | | | | | | |
| | 1.54 | 100 A | 1000 | 244 | 1.04 | | 10.700 | 200 |
| lines. | 10 | 107 | 10.0 | 100. | 100 | 2.25 | 76 | and a second sec |
| and show the second sec | . 12 | | 125 | 100 | 112 | 1.22 | 213 | 100000000000000000000000000000000000000 |
| No. of Concession, Name | 1.01 | | 1000 | | | | | 100 100 100 |
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| | | | | | 114 | 100 | | 10000 |
| | 1.87 | 100 | 100 | 100 | | 3.0 | 4.54 | |
| Report P | | - | 1000 | | 1.00 | | | |
| M Management | 1.14 | | 200 | 2.04 | 1.14 | | 0.001 | 111111418 |
| No. of Concession, Name | 1.52 | 2.4 | 5.14 | A.1.0 | 10 | 1.44 | 4.54% | 100.010.000 |
| Romanus Automation | 125 | | 125 | 111 | 15 | 100 | 227 | 101210 |
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| Real future and | | | | | | | | |
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| No.cos | 10,000 | 11,210 | - C | - | 1.64 | 1.81 | 10.54 | 11110-00-005 |
| Residence of the other | +04 | -949 | | | | | 3.00 | 111000-118 |
| | 10.041 | 10.000 | | a constant in | | | 1.00 | |
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| Number of Contract | 5.654 | 1.001 | | | | | 5.64 | 500 |
| es sourcestations | 10,000 | 1000 | | 12 | 100 | 1.00 | 3.05 | 10000-100 |
| | 10.000 | 1400 | | | 100 | 140 | - 50 | 101004-109 |
| Contraction of the loter | 8.79 | 8.75 | 418 | 45 | | | 19.87 | 10000001110 |

REDESIGN YOUR PLACE



Uttatailed Facad stantied

Figure 3.2 System of mode and by main times well-and/Opene et al. 2000



10:37716 <u>pr. pr. pr. pr. pr. pr. pr. pr.</u>







D - Percentage change in case incidence, 2000-2011



F – Countries projected to achieve <75% decrease in case incidence by 2015 or with insufficent data to assess trends



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| 1.871 | 14 | 10.00 |
| 11.00 | | 10.05 |
| 1,840 | 1.044 | 40.08 |
| 1.000 | 100 | 8.00 |
| | 18 | 15.75.0 |
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| 004 | 3005 | 2006 | 2007 | 2008 | 2019 | 200 | 201 |

Infographic





News media

Scientific Journals

Government Reports







| n Flows | including SOMA) | \$ Billion | 5 |
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| | 2 | 49 | |
| | 5 | 38 | |
| | 21 | 59 | |
| | 5 | 37 | |

Memorability? **#2 Scientific Journals**

#1 Infographic



#3 News media

#4 Government Reports







| Coupon Flows | \$ Billio | |
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| 57 | 27 | 84 |
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| 15 | 1 | 16 |
| 32 | 5 | 37 |
| 47 | 2 | 49 |
| 33 | 5 | 38 |
| 38 | 21 | 59 |
| 32 | 5 | 37 |

A visualization was more memorable if... it contains humanie with the sense of the football sense of the fo



A visualization was more memorable if...



A visualization was more memorable if... it is a distinct visualization type.





A visualization was more memorable if... it is colorful.





The battle over which North American city is the best for biking is fierce and most likely-unresolveable. We can tell you which cities' residents make the largest percentage of their commutes by bike.





A visualization was more memorable if... it is visually dense.



Shaded area indicates contribution of undernutrition to each cause of death. Source: World Health Organization.³



Pneumonia

18%

66%

69%

7%

Measles

4%

A visualization was more memorable if... it has a low data-to-ink ratio.



the eventual cost to fall to \$28b by fiscal year 2022. This estimate however could change materially depending on future changes in home prices, enterprise market share, and other

** Treasury estimates. Based on the President's FY2013 Budget, the Federal Reserve has already remitted \$82 billion in excess earnings – above what would be expected in normal

Note: Estimates are most recently available as of publication and are subject to revision based on future market conditions. Chart includes income and costs for the financial stability



A FEW MORE RESULTS...

Visualization memorability is consistent and intrinsic





Top I2 (w/o 'objects')

Top 12



































Bottom 12

















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| | _ | | | | | | |
| 004 | 3005 | 2006 | 2007 | 2008 | 2019 | 200 | 201 |

Distinct visualizations are more memorable.









The Wall Street Journal



60° W 50° W 40° W 30° W 20° W 10° W

Memorability varies across publication type.



News media #3

#4 Government Reports





12

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009 2010 2011









Source: NASA

Figure 21. DALYs lost attributable to 10 leading risk factors for the age group 15–59 years in the world, 2004









1956 60

Source: NASA

65

70 75 80



85 90 95 2000 05 10



FOR MORE INFORMATION...

On this paper/project: http://bit.ly/vizmemory

On my other research: http://bit.ly/mborkin

Special thanks to Krzysztof Gajos, the Harvard SEAS IT team, Sean Yeh, Chelsea Yeh, the Department of Defense through the NDSEG Fellowship Program, the NSF through the NSF Graduate Research Fellowship and grant #1016862, Google, and Xerox.

