What Does Eye-Tracking Teach Us About Dashboard Design?

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 Agenda & Objectives

• How did this all come about?
• What is eye-tracking?
  • History, biology and technology
• Our eye-tracking studies
• Conclusions: and what you can do to improve your dashboards today
Why do Eye-tracking Studies?
Andy’s Mantra: Copy The F-pattern When Making Dashboards
Beyond Memorability: Visualization Recognition and Recall

Michelle A. Borkin*, Member, IEEE, Zoya Byliniski*, Nam Wook Kim, Constance May Bainbridge, Chelsea S. Yeh, Daniel Borkin, Hanspeter Pfister, Senior Member, IEEE, and Aude Oliva

**EXPERIMENT DESIGN**

**Labeled Visualization Database**
- Visualizations are taken from [5], and the label taxonomy described in Table I is applied.

**Encoding**
- 100 "targets" visualizations
- 393 visualizations
- 100% fixation locations and durations

**Recognition**
- Some 100 targets + 100 "fillers"

**Recall**
- Correctly recognized blurred targets

Fig. 1: Illustrative diagram of the experiment design. From left to right: the elements of the visualizations are labeled and categorized, eye-tracking fixations are gathered for 10 seconds of "encoding"; eye-tracking fixations are gathered while visualization recognizability is measured, and finally participants provide text descriptions of the visualizations based on blurred representations to gauge recall.

**Abstract**—In this paper we move beyond memorability and investigate how visualizations are recognized and recalled. For this study we labeled a dataset of 393 visualizations and analyzed the eye movements of 33 participants as well as thousands of participant-generated text descriptions of the visualizations. This allowed us to determine what components of a visualization attract people’s attention, and what information is encoded into memory. Our findings qualitatively support many conventional qualitative design guidelines, including that (1) titles and supporting text should convey the message of a visualization, (2) if used appropriately, pictograms do not interfere with understanding and can improve recognition, and (3) redundancy helps effectively communicate the message. Importantly, we show that visualizations memorable “at a glance” are also capable of effectively conveying the message of the visualization. Thus, a memorable visualization is often also an effective one.

**Index Terms**—Information visualization, memorability, recognition, recall, eye-tracking study

1 Introduction

Understanding the perceptual and cognitive processing of a visualization is essential for effective data presentation as well as communication, such as color, visual complexity, and recognizable objects increase a
Fig. 21. The apparatus used in recording eye movements.
US economy: statistics at a glance

The FT's one-stop overview of key US economic data and trends, including GDP, inflation, unemployment, consumer indicators, and the outlook for US interest rates and mortgage rates.

By Sam Flemming, Emily Cadman, Steven Bernard and Tom Pearson

GDP growth
The US economy ended the year on a stronger footing than expected, providing some reassurance as the global outlook falters. The recovery though remains steady rather than spectacular.

Annualised Q1 GDP growth
0.5%

Growth rates

US GDP growth
Quarter on quarter per cent change

A robust jobs market and still rising house prices are providing the ballast for an economy that is facing weaker growth overseas, a sharp contraction in its manufacturing sector and retrenchment in the once booming oil industry.

The size of the US economy
$tr. constant prices

While the US economy returned to its pre-recession size in 2011, three years ahead of the UK, the pace of acceleration has been slower than in previous recoveries.

US GDP per person
Purchasing power parity, EU28=100

However the US remains one of the richest countries in the world, on most metrics including when measured per head of population.
The Anatomy
How Do We Measure Eye-tracking Data?
2015 Workers Compensation Regional & Industry Analysis

Primary KPI: Amount Incurred

Regional Analysis

<table>
<thead>
<tr>
<th>Region</th>
<th>Percentage</th>
<th>Incurred Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>South</td>
<td>33%</td>
<td>$50M</td>
</tr>
<tr>
<td>Northeast</td>
<td>27%</td>
<td>$41M</td>
</tr>
<tr>
<td>West</td>
<td>27%</td>
<td>$40M</td>
</tr>
<tr>
<td>Midwest</td>
<td>13%</td>
<td>$19M</td>
</tr>
</tbody>
</table>

Avg Recovery Time: 17.3 Days

# of Cases: 10,661

Incurred Amount: $150M

Area of Injury by Amount Incurred

Top 10 Nature of Injuries

- Strain: 47% [67M]
- Fracture: 11% [51M]
- Other: 11% [51M]
- Contusion: 7% [10M]
- Sprain: 7% [10M]
- Laceration: 5% [4M]
- Inflammation: 3% [2M]
- Puncture: 1% [250K]
- Carpal Tunnel Synd: 1% [180K]
- Hemia: 1% [150K]
2015 Workers Compensation Regional & Industry Analysis

Primary KPI: Amount Incurred

Agriculture: $2.0M, +135%
Construction: $1.3M, +25%
Finance & Real Estate: $1.6M, +25%
Manufacturing: $4.3M, +9%
Retail Trade: $8.2M, -16%
Services: $4.0M, -2%
Transportation: $3.8M, +21%
Wholesale Trade: $2.0M, -17%

Regional Analysis

South: 33%, $522M
Northeast: 27%, $411M
West: 22%, $420M
Midwest: 14%, $192M

Avg Recovery Time: 17.3 Days
# of Cases: 10,661
Incurred Amount: $150M

Area of Injury by Amount Incurred

Recovery Time (Weeks)

Top 10 Nature of Injuries

- Strain: 47%, $67M
- Fracture: 11%, $1.6M
- Other: 11%, $1.5M
- Contusion: 7%, $1.0M
- Sprain: 7%, $1.0M
- Laceration: 5%, $0.6M
- Inflammation: 3%, $0.4M
- Dislocation: 1%, $0.3M
- Carpal Tunnel: 1%, $0.1M
- Hemisection: 1%, $0.1M

MAP: Male: $80M, 40%; Female: $90M, 40%
Study #1
The Results
Was Andy Wrong?
A robust housing market and still rising house prices are providing the ballast for an economy that is facing weaker growth overseas, a sharp contraction in its manufacturing sector and retrenchment in the once booming oil industry.

While the economy returned to its pre-recession levels in 2014, three years ahead of the UK, the pace of acceleration has been slower than in previous recoveries.

However, the US remains one of the richest countries in the world; on most metrics, including when measured per head of population.
US economy: statistics at a glance

The FT's one-stop overview of key US economic data and trends, including GDP, inflation, unemployment, consumer indicators, and the outlook for US interest rates and mortgage rates.

By Sam Fleming, Emily Cadman, Steven Bernard and Tom Pearson.

GDP growth

The US economy ended the year on a stronger footing than expected, providing some reassurance as the global outlook falters.

The recovery through remains steady, rather than spectacular.

Annualised Q1 GDP growth: 0.5%

US GDP growth

Quarter-on-quarter annualised

Source: Thomson Reuters Datastream, April 2023.

A robust jobs market and rising house prices are providing the basis for an economy that is facing weaker growth overseas, a sharp improvement in its current account balance and a boost to consumer spending.

The size of the US economy

In constant prices


While the US economy returned to growth, however, the US remains the world's largest economy. The US economy grew by 0.3% in 2019, three years after the start of the last recession, in line with expectations. The pace of acceleration has been modest, and the US economy is still measured in trillions of dollars.
US economy: statistics at a glance

The FT's one-stop overview of key US economic data and trends, including GDP, inflation, unemployment, consumer indicators, and the outlook for US interest rates and mortgage rates.

By Sam Fleming, Emily Cadman, Steven Bernard and Tom Pearson

GDP growth
The US economy ended the year on a stronger footing than expected, providing some reassurance as the global outlook falters.

The recovery, though remains steady, rather than spectacular.

Annualised Q1 GDP growth
0.5%

Growth rates
US GDP growth
Quarter-on-quarter rate, annualized

Source: Thomson Reuters Datastream, April 28

A robust jobs market and still rising house prices are providing the ballast for an economy that is facing weaker growth overseas, a sharp contraction in its manufacturing sector and retrenchment in the once booming oil industry.

Size of the economy
The size of the US economy
$tr, constant prices

Source: BLS/Bloomberg, 21 Jan 2015

While the US economy returned to its pre-recession size in 2011, three years ahead of the UK, the pace of acceleration has been slower than in previous recoveries.

Growth per head
US GDP per person
Purchasing power parity, EU28=100

Source: Bloomberg, 21 Jan 2015

However the US remains one of the richest countries in the world, on most metrics, including when measured per head of population.
FORM IS PART OF FUNCTION
HUMANS LIKE HUMANS
BIG NUMBERS MATTER
Study #2
## Agency Utilization Rollup

### Target vs Billable vs Non-Billable

<table>
<thead>
<tr>
<th>Category</th>
<th>Target</th>
<th>89%</th>
<th>48%</th>
<th>40%</th>
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</thead>
<tbody>
<tr>
<td>Creative</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Account Management</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Executive/Admin</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Biz</td>
<td>100%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Non-Billable vs Billable Hours

<table>
<thead>
<tr>
<th>Category</th>
<th>2015</th>
<th>2014</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative</td>
<td>1,760</td>
<td>1,674</td>
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</tr>
<tr>
<td>Account Management</td>
<td>34</td>
<td>35</td>
<td>36</td>
</tr>
<tr>
<td>Project Management</td>
<td>10</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Technology</td>
<td>14,404</td>
<td>14,314</td>
<td>14,224</td>
</tr>
<tr>
<td>Operations</td>
<td>414</td>
<td>414</td>
<td>414</td>
</tr>
<tr>
<td>Executive/Admin</td>
<td>37</td>
<td>37</td>
<td>37</td>
</tr>
<tr>
<td>New Biz</td>
<td>2,483</td>
<td>2,501</td>
<td>2,519</td>
</tr>
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</table>

### Utilization Trend

- **% Potential**: [Data not provided]
- **% Billable**: [Data not provided]
BANs on the TOP OR BOTTOM
BANs on the TOP OR BOTTOM
BANs on the TOP OR BOTTOM

BANs on the LEFT OR RIGHT
BANs on the TOP OR BOTTOM

BANs on the LEFT OR RIGHT

BANs in HIGH OR LOW CONTRAST
BANs on the TOP OR BOTTOM

BANs on the LEFT OR RIGHT

BANs in HIGH OR LOW CONTRAST

BANs in MEDIUM OR LARGE FONT
TIME TO FIRST FIXATION (seconds)

1.9

6.1
TIME TO FIRST FIXATION

2.7

4.0
TIME TO FIRST FIXATION

1.1

1.0
TIME TO FIRST FIXATION

3.7

2.7
FIXATION DURATION

0.4

0.8

Fixation Duration (sec)
TOP OR BOTTOM MATTERS!

LEFT OR RIGHT DOESN’T MATTER

HIGH OR LOW CONTRAST DOESN’T MATTER

MEDIUM OR LARGE FONT MATTERS!
Fig. 21. The apparatus used in recording eye movements.
Condition 1 - Static
Condition 2 - Dependent
Condition 3 - Independent
Condition 1 – Static Viewing
Condition 2 – Dependent
Condition 3 – Independent
Conditions with SD

- Dependent: 8.38
- Independent: 9.51

SD:
- 1.932
- 2.500
- 3.000
- 3.500
- 4.000
- 4.375

Average of Mean for each Condition. Color shows details about Condition. Size shows standard deviation of SD. The view is filtered on Condition, which keeps Dependent and Independent.
Summary
Limitations
Where They LOOK, Not What They See
10 seconds?
Recommendations
Think About Form First
Don’t Be Repetitive
BANs

Agency Utilization Rollup

$3.8M  $3.4M  $1.3M  $2.6M  +12.2
Fees       Potential       New Biz + Opportunity       Internal Projects       FTE Overstaffed

Target vs Billable vs Non-Billable %

<table>
<thead>
<tr>
<th>Category</th>
<th>Target</th>
<th>Billable</th>
<th>Non-Billable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative</td>
<td>90%</td>
<td>53%</td>
<td>46%</td>
</tr>
<tr>
<td>Account Management</td>
<td>105%</td>
<td>47%</td>
<td>53%</td>
</tr>
<tr>
<td>Project Management</td>
<td>104%</td>
<td>39%</td>
<td>61%</td>
</tr>
<tr>
<td>Technology</td>
<td>102%</td>
<td>25%</td>
<td>75%</td>
</tr>
<tr>
<td>Operations</td>
<td>4%</td>
<td>10%</td>
<td>90%</td>
</tr>
<tr>
<td>Executive/Admin</td>
<td>57%</td>
<td>57%</td>
<td>43%</td>
</tr>
<tr>
<td>New Biz</td>
<td>100%</td>
<td>100%</td>
<td>0%</td>
</tr>
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Non-Billable vs Billable Hours

<table>
<thead>
<tr>
<th>Category</th>
<th>Non-Billable</th>
<th>Billable</th>
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</thead>
<tbody>
<tr>
<td>Creative</td>
<td>5,749</td>
<td>8,743</td>
</tr>
<tr>
<td>Account Management</td>
<td>10,070</td>
<td>8,020</td>
</tr>
<tr>
<td>Project Management</td>
<td>6,996</td>
<td>6,974</td>
</tr>
<tr>
<td>Technology</td>
<td>16,454</td>
<td>5,408</td>
</tr>
<tr>
<td>Operations</td>
<td>10,33</td>
<td></td>
</tr>
<tr>
<td>Executive/Admin</td>
<td>2,179</td>
<td>16</td>
</tr>
<tr>
<td>New Biz</td>
<td>2,850</td>
<td>1</td>
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Cost | Fees | Potential

<table>
<thead>
<tr>
<th>Category</th>
<th>Cost</th>
<th>Fees</th>
<th>Potential</th>
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<tbody>
<tr>
<td>Creative</td>
<td>$1,069K</td>
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</tr>
<tr>
<td>Account Management</td>
<td>$2,199K</td>
<td>$795K</td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td>$608K</td>
<td>$208K</td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>$819K</td>
<td>$3,762K</td>
<td></td>
</tr>
<tr>
<td>Operations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Executive/Admin</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>New Biz</td>
<td></td>
<td></td>
<td></td>
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</tbody>
</table>

New Biz + Opp

<table>
<thead>
<tr>
<th>Category</th>
<th>Hours</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creative</td>
<td>1,456 hrs</td>
<td>25%</td>
</tr>
<tr>
<td>Account Management</td>
<td>4,524 hrs</td>
<td>29%</td>
</tr>
<tr>
<td>Project Management</td>
<td>3,455 hrs</td>
<td>17%</td>
</tr>
<tr>
<td>Technology</td>
<td>363 hrs</td>
<td>2%</td>
</tr>
<tr>
<td>Operations</td>
<td>0 hrs</td>
<td>0%</td>
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<tr>
<td>Executive/Admin</td>
<td>0 hrs</td>
<td>0%</td>
</tr>
<tr>
<td>New Biz</td>
<td>4 hrs</td>
<td>0%</td>
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Internal Projects

<table>
<thead>
<tr>
<th>Category</th>
<th>Hours</th>
<th>%</th>
</tr>
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<tbody>
<tr>
<td>Creative</td>
<td>1,301 hrs</td>
<td>8%</td>
</tr>
<tr>
<td>Account Management</td>
<td>1,579 hrs</td>
<td>10%</td>
</tr>
<tr>
<td>Project Management</td>
<td>2,283 hrs</td>
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</tr>
<tr>
<td>Technology</td>
<td>9,608 hrs</td>
<td>50%</td>
</tr>
<tr>
<td>Operations</td>
<td>0 hrs</td>
<td>0%</td>
</tr>
<tr>
<td>Executive/Admin</td>
<td>4 hrs</td>
<td>0%</td>
</tr>
<tr>
<td>New Biz</td>
<td>40 hrs</td>
<td>2%</td>
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Internal Admin

<table>
<thead>
<tr>
<th>Category</th>
<th>Hours</th>
<th>%</th>
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</thead>
<tbody>
<tr>
<td>Creative</td>
<td>2,552 hrs</td>
<td>24%</td>
</tr>
<tr>
<td>Account Management</td>
<td>4,667 hrs</td>
<td>25%</td>
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<tr>
<td>Project Management</td>
<td>4,659 hrs</td>
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<tr>
<td>Technology</td>
<td>4,485 hrs</td>
<td>23%</td>
</tr>
<tr>
<td>Operations</td>
<td>5 hrs</td>
<td>0%</td>
</tr>
<tr>
<td>Executive/Admin</td>
<td>2,170 hrs</td>
<td>50%</td>
</tr>
<tr>
<td>New Biz</td>
<td>546 hrs</td>
<td>20%</td>
</tr>
</tbody>
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Utilization Trend

Utilization vs Potential

Utilization vs % Billable
Think about Form First (a.k.a. Andy was wrong)

Avoid repetition

Use BANs
Thank you!

Amy Alberts
User Research Manager
Tableau

Andy Cotgreave
Technical Evangelist
Tableau

Dashboards from “The Big Book of Dashboards” available in the Tableau Store
www.bigbookofdashboards.com