How to develop a designer's instinct: A study on eye tracking

By Amy Alberts, User Research Manager

Introduction

Dashboards are a very visual mode for communicating data insights. However, in order to deliver the most key information effectively, you want to make sure your audience is drawn to the right areas of your dashboard. To do this, we need to understand what catches the eye, whether it's color, placement, size, or some other factor.

The Tableau Research and Design team took advantage of Tableau Conference, where thousands of our customers gather to learn about analytics, to run a study that sought to understand how the eye tracks visual data analysis.

The outcome of this work seeks to take advantage of how knowing where people look at dashboards first affects their interpretation of the information. Can we predict what viewers are drawn to when exposed to a dashboard they've never seen before? In other words: How do I, as data analyst, design visually compelling dashboards?

Hypotheses were developed using concepts from cognitive psychology and established UX design principles. There was an expectation that certain design elements would draw visual attention over others, but the Research and Design team was also interested in uncovering the unknowns.

Study design

As in any good study, there were a number of expectations and assumptions made in regards to how people consume different dashboards, as outlined below:

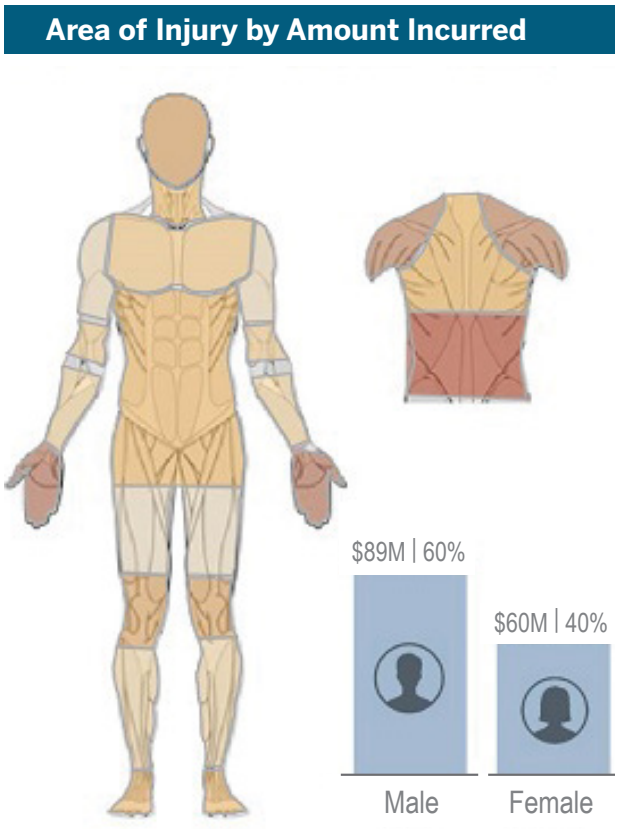
Assumption #1

People would be compelled to look at certain design elements on the screen:

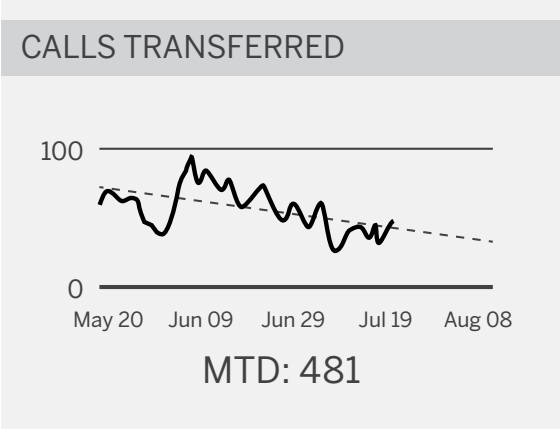
Big numbers: Given that participants in the study care about data, big numbers (as in the size of the font) should draw lots of attention. Plus, big numbers are easy to spot on a dashboard and usually hold a lot of meaning.

High contrast elements: The human visual system is built to react to high contrast. We rely heavily on this difference in color for a number of visual tasks, such as reading traffic signals or checking the ripeness of a banana.

Human-like representations (faces, body forms): Another thing the human visual system likes: other humans. Parts of our brain are solely dedicated to the detection of human faces and form. It's a safe bet that humans are going to draw visual attention if they are present on a dashboard.



"Volatile," jagged lines: Volatile lines infer trajectory and indicate movement. Since our eyes are particularly good at spotting movement, it seemed like a valid expectation to assume viewers would be drawn to these shapes on a dashboard.



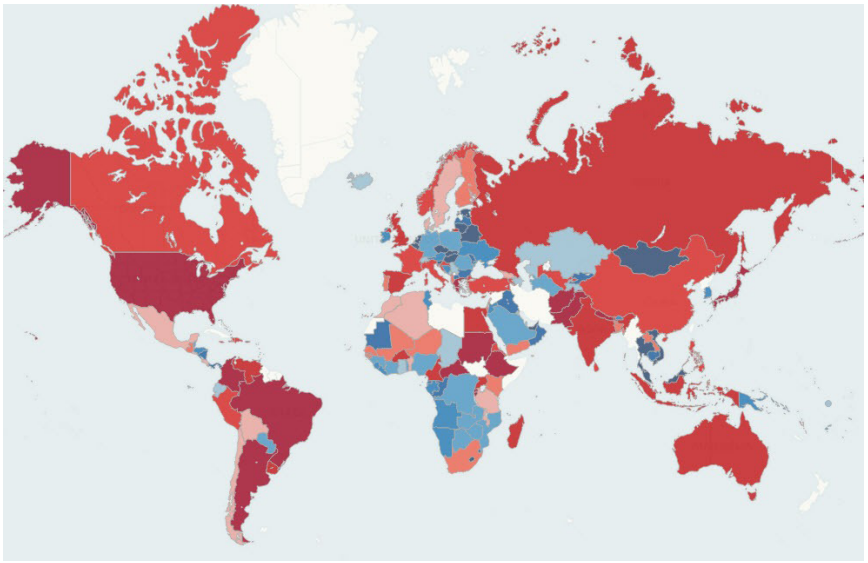
Icons: There was a chance that icons, especially highly recognizable ones, would draw visual attention. Pictures (versus text) tend to be visually appealing and may catch the eye.

Logos: Similar to icons and pictures, we expected that logos may be successful in drawing attention.

alteryx

interworks

Maps: Maps are interesting, familiar, and tend to be high contrast (they include many lines and are visually distinct from other things). Plus, they're packed with dense data. Our suspicion was they would get attention, but how and why wasn't clear.



Titles: Titles ground the dashboard and communicate its intent to the audience. Similar to reading behavior, we expect that people might have a habitual reaction to titles, and will be almost compelled to look at them. Or, they will ignore them because titles aren't as fun to look at as a big number. (As user researchers, this is why we do these studies.)

Net Promoter Score Analysis

Sales Performance

Assumption #2

People would display a propensity to "read" a dashboard like a document:

- Eye movements would be concentrated on the upper-left corner of the dashboard.
- Fewer eye movements would be detected in the bottom (specifically bottom-right) part of the screen.

Assumption #3

Eye movement patterns would change over the duration of the viewing period:

- Eye movements early on in the viewing period would be more concentrated on the compelling design elements.
- Eye movements later in the viewing period would be more distributed and harder to predict.

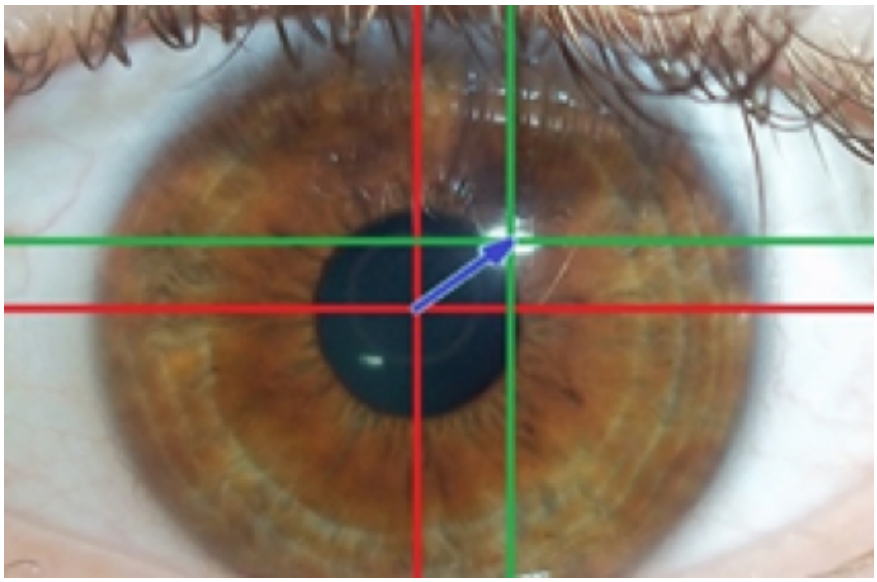
Understanding eye tracking

Eye tracking is associated with two components: (1) eye trackers, which are hardware and/or software collecting eye movement data, and (2) eye tracking, which is research methodology.

Eye trackers

Learn more about eye trackers with **Eye Tracking: The Ultimate Pocket Guide**

There are many types of eye trackers. The one we used for this study was the Tobii X2-30. This eye tracker uses lenses and cameras to track where someone is looking on a computer screen. The tracker beams infrared light into the participant's eyes. This light is reflected off the front (cornea) and back (retina) of the eye.



Check out this 10-second **gaze plot video.**

The tracker can detect this reflection. Based on the angles of the reflection—and the awareness of your head position and the computer screen— the tracker can determine where the participant is placing visual attention. The software that runs the tracker (in this case Tobii Studio) samples the eye position at 30 htz (30 times a second). The data comes in as X-Y coordinate data and is visually overlaid on top of the image.

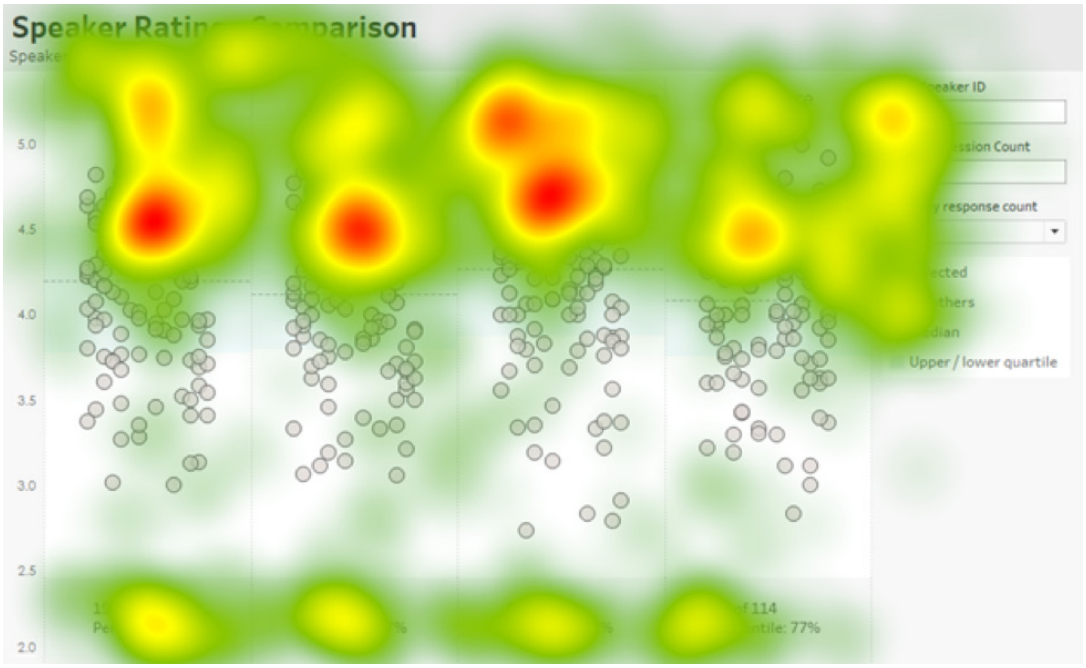
Eye tracking data can be viewed on a per-session level or can be analyzed in aggregate. Per-session data is commonly shown as a video of eye movements tracking over images.

Generally speaking, the analysis conducted for this study was at the aggregate level. Eye tracking data in aggregate is often visualized as a heatmap or bee swarm (depending on the research question).

Watch **this video** for a preview of the "bee swarm" method.

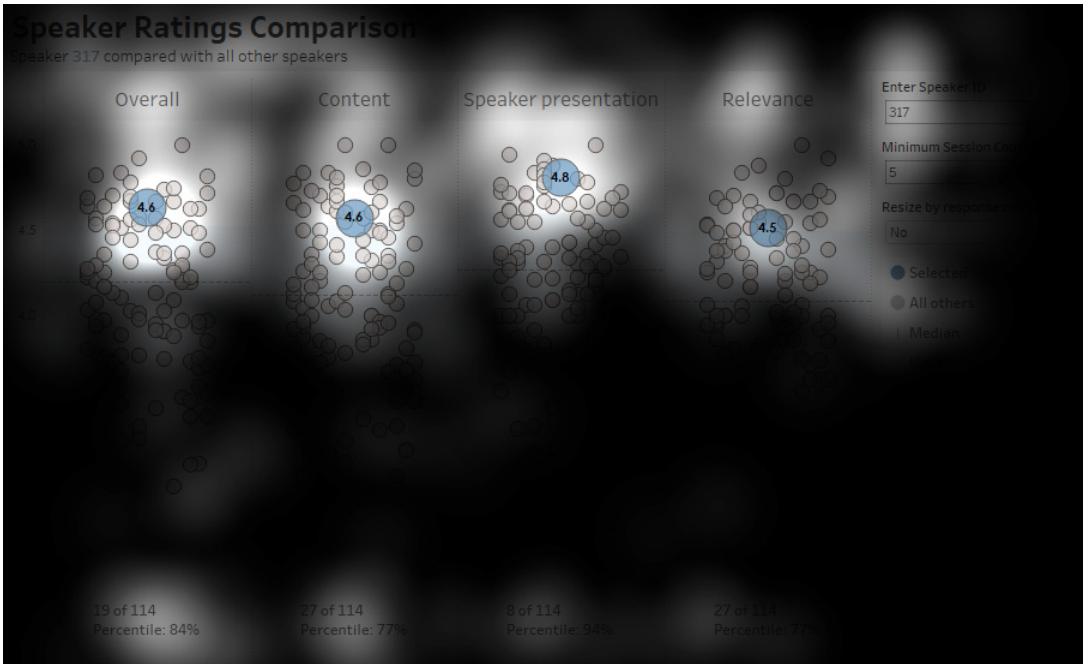
The bee swarm is an aggregate view of the gaze plot. In the video linked above, all participants' gaze plots are played together, each denoted by a different color. The bee swarm is a good way to look at "agreement" across participants. In other words, the more participants agree, the more their respective gaze plots will overlap. You can see the agreement early on in this example: Almost everyone is looking at the top of the dashboard. As the viewing time increases, eye movements become more dispersed and you see less agreement.

The heatmap visualization uses the concept of hot (red) or cold (green) to illustrate areas that have the most visual attention across all participants in the study. The heatmap and gaze opacity map are static representations of the bee swarm.



Much more attention was paid to the top of this dashboard and very little in the middle. Hence, the top areas are very "hot" and the middle is very "cold."

Because we were most interested in patterns of visual attention, we found that the gaze opacity map was a better illustration for our research. Essentially, the gaze opacity map is an inverse of the heatmap. Like a dirty window getting wiped clean, the gaze opacity map, as seen on the next page, visualizes where eye movements concentrate by increasing the opacity of the area in attention.



Most of the visual attention was at the top of this dashboard which explains why it has the lowest level of opacity. In contrast, the fully opaque areas (in black) illustrate little to no visual attention.

Eye tracking

Eye tracking is a research methodology where knowledge about where the eyes are looking is central to the research question. Eye tracking research is quite varied, ranging from modern polygraphy to medical diagnostics. Another common use of eye tracking is in user experience (UX) research. Eye trackers are used to help determine where people are looking when performing tasks with an application. Eye tracking can be incredibly exciting because it feels like you're watching someone think.

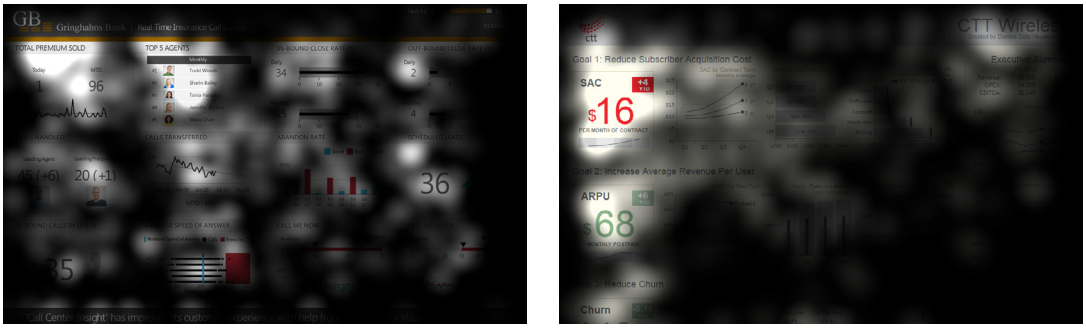
However, you must be careful when looking at eye tracking data in isolation of other data. Although eye tracking data is correlated with a person seeing something, the correlation is not perfect. How many times have you looked at something and not seen it? e.g. "Where are my keys that are right in front of my face?" How many times have you noticed something out of the corner of your eye, but not actually shifted your gaze to that object? e.g. "I see my phone just lit up with a call, but I'm going to ignore it for now."

The point is, you can look at something and not see it, and you can not look directly at something and see it. So although eye tracking by itself tells a fascinating story of the human experience, it must be triangulated with other data, such as considering what the person says while observing something or the outcome of their associated tasks. Therefore, in this study, we talk about "visual attention," not the act of seeing something.

Results

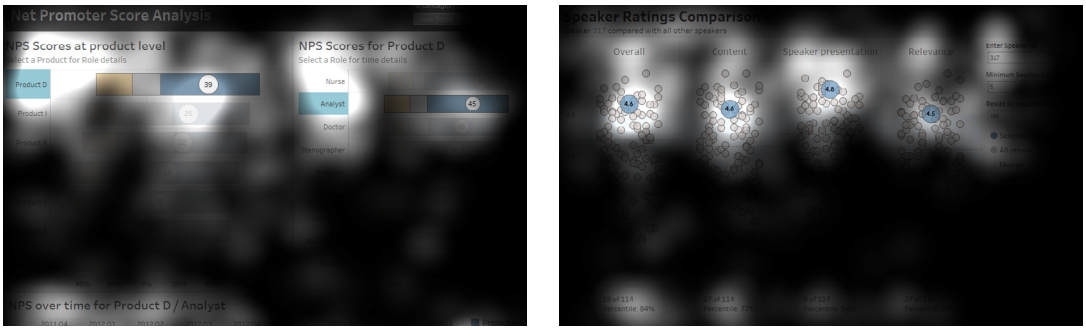
Before we get into the details of the results, it's important to note that some of these conclusions are not surprising. People who have studied design would be able to predict that high contrast elements and large fonts have a big effect on where people look. **However, what's special about what we found is there seems to be a hierarchy to the things we are inclined to look at.**

Our data suggests, above all else, that a human-like figure (a graphic of a torso, a picture of a human face) will always get the first visual attention. After human-like figures, we saw big numbers pulling visual attention early on in the viewing period. There are a few examples when elements like the title got the early attention. But in those cases, it appeared to be a result of the lack of other compelling things for the eyes to consider. So, simply put, a human face or a large number are the magnets of dashboard design.



The dashboard on the left shows the eye being drawn to the title of each visualization. The dashboard on the right shows how big numbers really gain the eye's focus.

Another interesting (but logical) phenomenon was the effect of repetition. It's common in dashboard design to have repetitive visualizations for different variables; e.g. bar charts for different KPIs so they're easily compared. We found that when there is high repetition of any like element—repeated line graphs or repeated numbers—the attention waned from left to right and top to bottom. More attention was given to the top- or left-most item, and then decreased as the person scanned the repetitive set. This result is a good reminder to designers that the sequence of presentation matters a lot, and to take advantage of this discovery if need be.

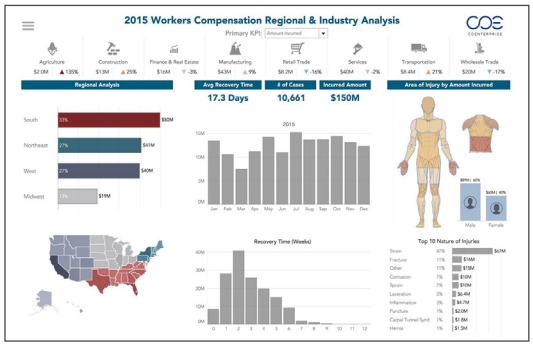


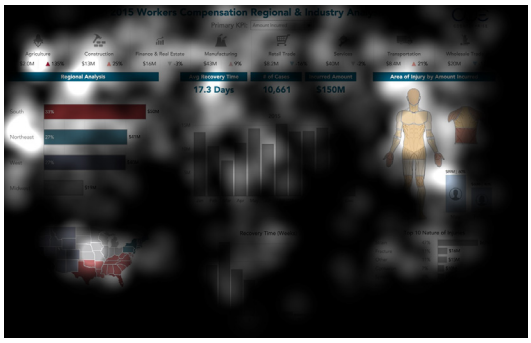
In both of these dashboards, there is a similar pattern repeated in each visualization.

Detailed findings

1. Humans like humans:

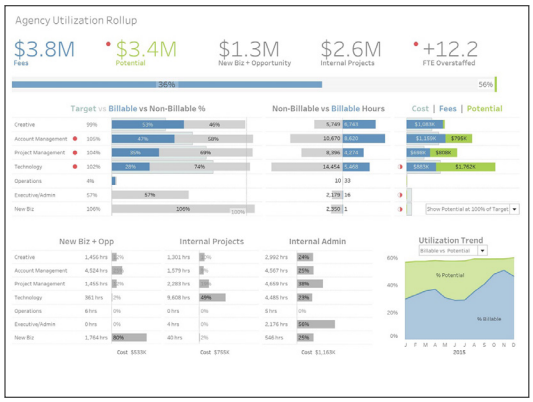
If a human or human-like figure is present, it'll get attention. We had dashboards with human-like figures (below) and others with pictures of people. Viewers of these dashboards displayed consistent results: Visual attention was concentrated on these forms. This isn't too surprising because our brains really like to find and look at humans. That being said, a dashboard designer must be extremely judicious in the use of human figures. We can be certain the humans will get attention, so make sure it's the attention you want and that it doesn't distract from your overall message. Inappropriate use and exploitation of this element will likely do harm to the reputation of your dashboard.

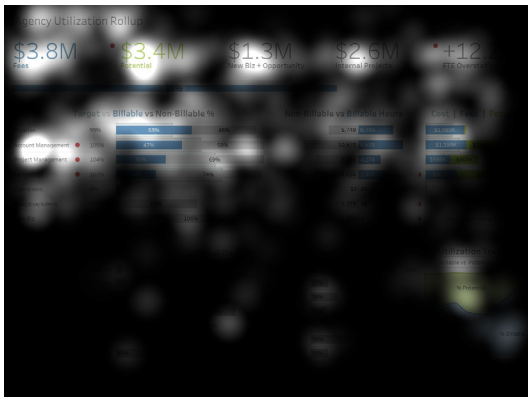




2. Numbers matter:

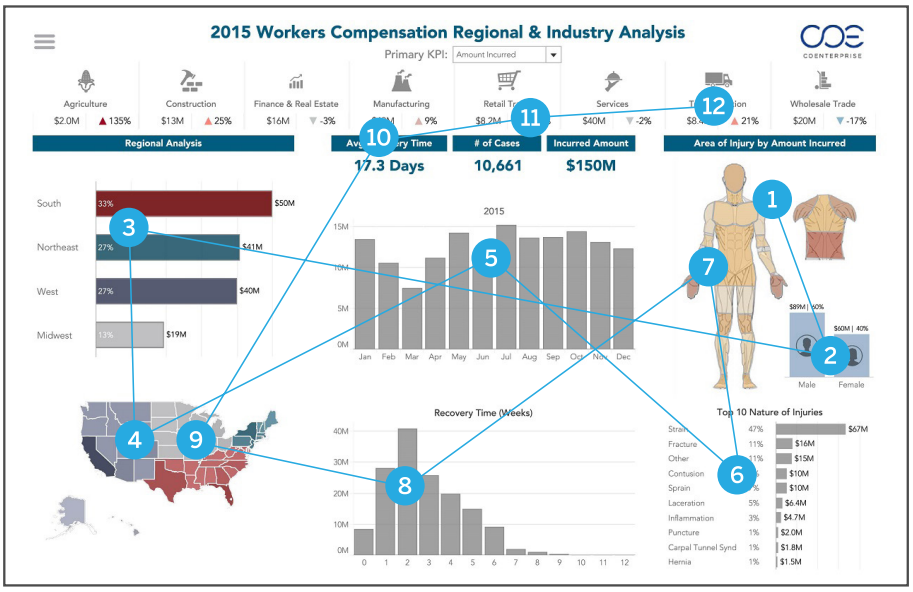
Big numbers got big results. One of the most striking patterns we saw was the visual attention paid to very large numbers. Analysis of dashboards with very large numbers showed concentration of visual attention on the big number, and that this attention happened very early in the viewing sequence. So, if you have an important number, make it big!





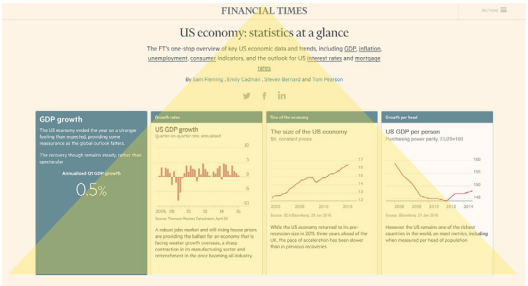
3. Guide by contrast:

Areas of high visual contrast acted as guideposts through a dashboard. During the early viewing sequence, the eyes tended to jump from one high contrast element to the next. Almost like a kid's dot-to-dot drawing, you can use high contrast elements to move visual attention around your dashboard. That being said, high contrast must be used judiciously. If used sparingly, high contrast elements will construct a logical path. Used abundantly, high contrast elements could create a messy and visually overwhelming dashboard.



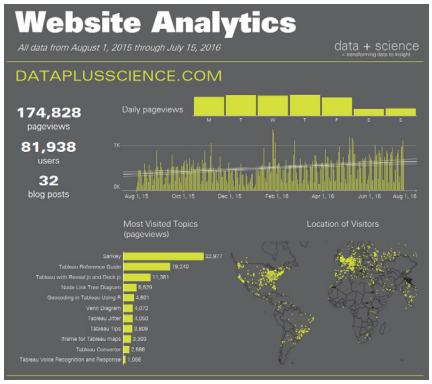
4. Form is part of function:

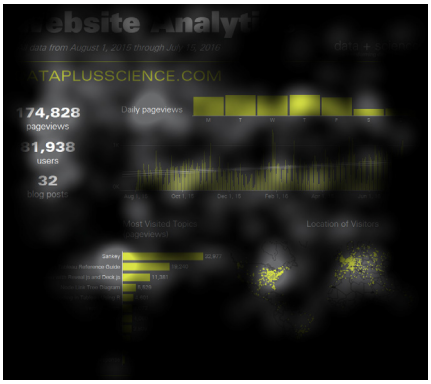
All dashboards have a form (triangular, grid, columnar), and the eyes follow this form. This result was both surprising and not surprising at all. As humans, we're information-seekers. When we look at something for the first time, we want information from it. So, we look at the information, not at areas with no information. This gives the author an amazing amount of design freedom. You don't need to conform to rules like "put anything important in the upper-left corner." Instead, be aware of the physical form of your dashboard and utilize your space accordingly.



5. Balance yields balance:

Equally balanced or not, the eyes will conform to the balance of the design. If you talk to those who've studied visual design, they know the power of balancing visual information. However, the novice designer doesn't usually have these instincts. The two dashboards below illustrate this point. The first dashboard is visually balanced. Each different element sits by itself with enough white space for it to be noticed and receive visual attention. Conversely, the second dashboard is top heavy. There are design elements at the top that are quite visually distinct, and, in turn, they get lots of visual attention. However, the bottom half of the dashboard is very dense and difficult to parse visually. Now, this density is probably ok, and the dashboard consumer will likely be able to get lots of good information out of it. However, in the first few seconds of looking at a dashboard like this, the designer should know what will and will not get the visual attention first.





As for all the other design elements we thought would get attention (logos, titles, etc.), the data was not strong in their favor. We think the reason has to do with a visual priority order. Something large, high contrast, and/or human-like is simply more compelling than other design elements. A logo or icon could very easily garner attention, but it appears that to do so, it must be coupled with a high priority variable. For example, a logo would probably get a lot of visual attention if it was high contrast, large, or featured a human element.

Implications

The data from our study illustrates where people look on dashboards when the task is not clear and context is not set. While it may seem unrealistic that a viewer be using a dashboard without a clear objective, there are a couple key scenarios customers encounter when these results are instrumental:

"I've got 10 seconds..."

Analysts make dashboards used to communicate to people they don't know. The most common version of this is a dashboard created for a C-level executive. There's a sense of urgency to communicate efficiently and effectively, to impress and convince. Can you get that exec (whom you've never met) to look at what you want them to look at in the 10 seconds they'll spend with your dashboard? We suspect some of these design techniques could help you do just that.

Remember me?

There are dashboards that receive intermittent, periodic attention. For these, although the viewer is familiar with the dashboard, they have not habituated to it. As a result, the viewer needs to reorient, look around, and find the data they need. In this case, their initial visual attention pattern will likely drift toward elements we identified in this study. By being deliberate about placement and use of the described elements, the designer can help viewers quickly make sense of the dashboard to get the information they need.

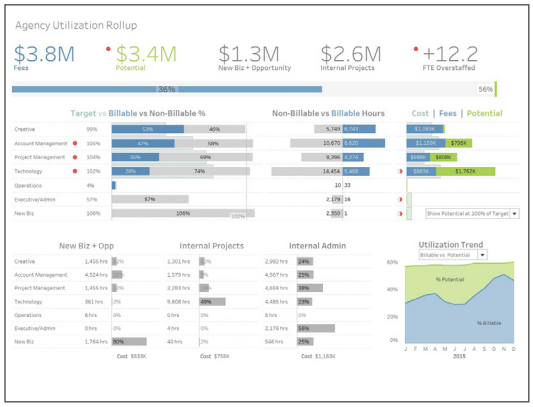
In our study, we didn't give participants discrete tasks, but that doesn't mean they were not goal-directed. Humans are meaning-seeking animals: We can't stop ourselves from finding a purpose. Every person looking at one of our dashboards had a task, we just don't know what it was. Perhaps it was, "Look at all the crazy stuff people create with Tableau?!" Or, "I wonder what kinds of data power plants collect?" Given this setup, we only know that in the case of an unknown task, when the dashboard is novel to the participant, there is a pattern of visual attention that conforms to some cognitive psychology and basic design principles.

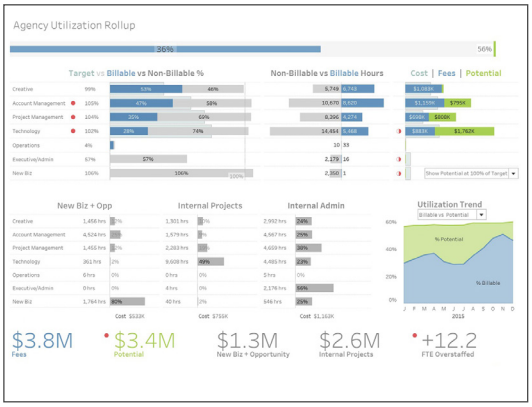
Next steps

The next step in our research will be to take a longer look at big numbers. We found there were a number of variables that may (or may not) affect the visual attention we saw in this area:

1. Position:

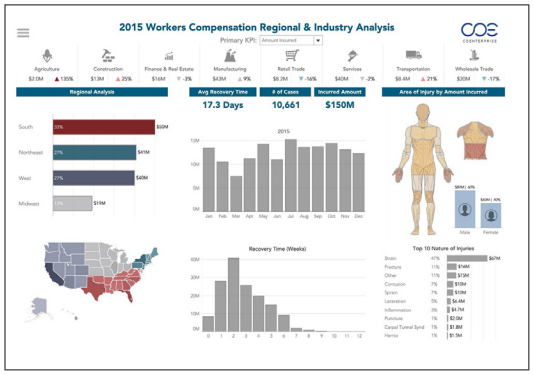
Does the position of the big number affect the visual attention it receives? If we moved the big numbers (to the bottom, to the right side, etc.), will we see any changes in visual attention?

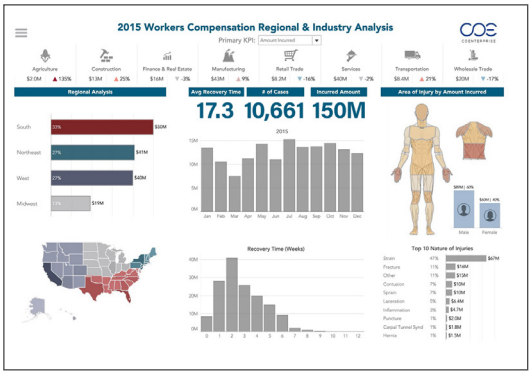




2. Size:

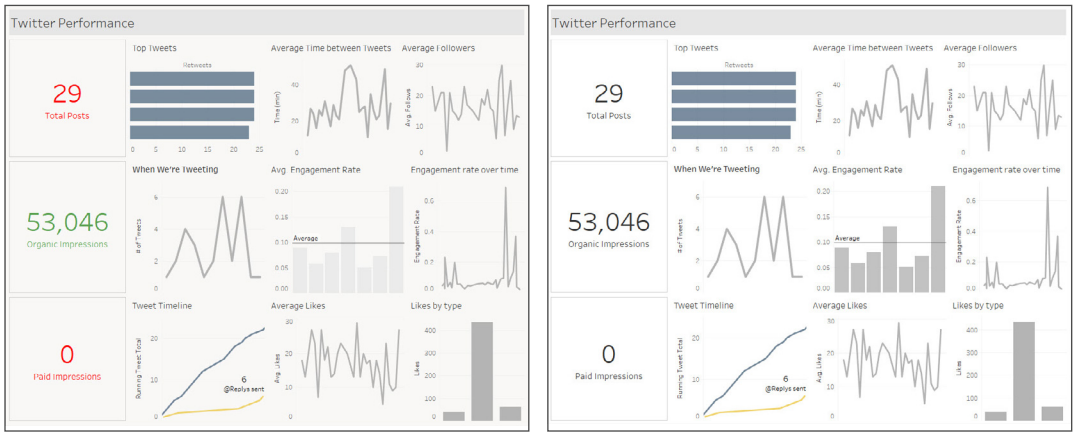
How much does size matter? How much do we need to increase the font on a big number of draw the eyes?





3. Contrast:

How much does the visual contrast matter with a big number? If we take away strong contrast, will that affect visual attention?



It's also interesting to consider what might happen in a study where the task conforms to one of the salient variables we identified. For instance, take the effect a big number has on visual attention. If a big number was on screen with another salient element (e.g. map or human), we observed distributed attention—viewers looked at the big number and the map.

But what will happen if the task directs the person to attend to the big number? We would expect to see even stronger visual attention to them. However, will we see all visual attention disappear from the map? We expect this to be the case, but we don't know yet.

Further research could help us better understand the effect "priming" has on these visual patterns. Priming is a cognitive psychology concept that describes how information in a person's brain affects how she interacts with the world. For instance, if I "prime" you by showing you the color orange, you will be faster in identifying the color orange in a picture than if I had never mentioned it. Assuming priming has an effect on visual attention patterns, we could use that to help dashboard designers. For instance, how could analysts best word their emails to execs so as to "prime" them to look at the data that's most important?

About Tableau

Tableau helps people transform data into actionable insights that make an impact. Easily connect to data stored anywhere, in any format. Quickly perform ad hoc analyses that reveal hidden opportunities. Drag and drop to create interactive dashboards with advanced visual analytics. Then share across your organization and empower teammates to explore their perspective on data. From global enterprises to early-stage startups and small businesses, people everywhere use Tableau's analytics platform to see and understand their data.

Resources

The dos and don'ts of dashboards

Building Effective Dashboards

Good enough to great