Background

I've been using dbMotion for a few weeks, both at Magee and at Mercy (using myapps.upmc.edu). Overall, I'm very impressed with it, in terms of performance, design, and functionality. I can only this were a RHIO (Regional Health Information Organization) project that would cross corporate boundaries.

I have a few minor suggestions for improvement. First, I'll lay out the specific literature on user interaction design that leads to these suggestions.

Information Design

Information Design is still defining itself; Wikipedia says it's: the art and science of preparing information so that it can be used by human beings with efficiency and effectiveness. Wikipedia goes on to say: the term has come to be used specifically for graphic design that has the purpose of displaying information effectively, rather than just attractively, or for the purpose of self expression by the designer as artist.

Action-Oriented Information Design is, even more specifically, information design that is designed to drive actions, such as the care of a stroke patient or MI patient in the ED. It aims to decrease error, to remind practitioners to do those things that they know to do but might forget, and to improve compliance with established guidelines, while not forcing practitioners into rigid protocols. Action-oriented information design also tries to educate practitioners about optimal ways to perform as they move through their daily tasks.

If this sounds like the goal of standing orders for common medical conditions, there is a strong correlation. Those who are writing standing orders are, know it or not, practicing action-oriented information design. More on that later.

This seems mostly related to computers, but many information design principles evolved long before the World Wide Web. A few examples follow. These have been used in this analysis and constitute a basic reading-list for information design practitioners (or critics).

- the layout of type on a printed page or a computer screen, discussed in Brighurst’s seminal Elements of Typographic Style.1

• the layout used in graphic design; a computer-oriented presentation may be found in the Sun textbook, Designing Visual Interfaces.

• the science and art of color, found most accessibly in Itten's recent publications.

• the science and art of presenting scientific and other data in comprehensible form, which finds its most profound expression in the published works of Yale's Edward Tufte.

• forms design; those with deep pockets and much money at risk (national tax agencies, large insurance companies) have funded research into forms design that has saved them billions of dollars in improved usability, and these bits of knowledge are found in Barnett’s focused and knowledgeable Forms for People.

• more specifically, dbMotion can be classed as an information dashboard; though dbMotion differs from a typical business dashboard, still much can be learned from works such as the outstanding Information Dashboard Design.

Usability and Performance

In his college textbook, Usability Engineering, guru Jakob Nielsen (useit.com) lays out a branching diagram for software suitability analysis (see below). The right side lists the components of usability. In the clinical setting – when users are sleep-deprived, interrupted with urgent concerns, particularly in the emergency department – usability becomes a much bigger concern, (see below) not


only from the viewpoint of user acceptance, but as a means to preventing medical error.

Another thing we learn from Nielsen is about the importance of performance. Once one clicks on the screen, an ordinary user will wait for one (1) second before turning to something else. In a busy clinical setting, one can reasonably suspect that users won’t wait nearly so long.

**Analysis Techniques**

Much of design is art and intuition. Nonetheless, there are a few engineering principles and heuristics that can analyze and improve a page.

Using a phrase and concept originated by Edward Tufte, one can analyze the ink on a piece of paper – or the pixels on a computer screen – in terms of *data ink* and *data pixels*. How many drops of ink – or pixels – actually convey needed data? How many don’t convey data? What is the ratio?

In Nielsen and Tahir’s *Homepage Usability*[^1], they analyze 50 representative home pages, including some of the most well-known, in terms including data pixel ratios. While they break down the screen real estate into multiple categories, for our use here – which is primarily a usability assessment – the main division is Tufte’s classic data pixels vs. non-data pixels, related specifically to the clinician’s task at hand.

A classic example is the display of lab values. I’ve found that I can use the Photoshop rubylith overlay as a quick-and-dirty way to mask out non-data pixels with a red-tinted overlay. Clinicians – and I focus now on emergency physicians as the most narrowly task-focused people around – want to have the essential data in front of them right away. For example, when taking a quick look at a CBC, they aren’t interested in the MCV, MCHC, or a variety of other information beyond the basic WBC, Hg, Hct, and platelet counts. If they want more information, for example the differential, they are happy to click on something to find this out. And, as a general medical design principle, I strongly espouse designing for the ED. It’s sort of a worst-case scenario. If the system works

there, it will likely work anywhere. Quoting from a recent presentation I gave for HIMSS:

"Emergency physicians are majorly stressed and working at max capacity already. Darwinian selection means that ED staff (from the Critical Incident Stress Management literature):

- have obsessive/compulsive personality traits
- like to be in control
- are risk oriented
- are action-oriented
- “need to be needed”
- are dedicated

Thus, those in the ED are intolerant of systems that waste their time. (Look at the picture on the previous page again; note the number of users of the handwritten greaseboard vs. the computer-based one.) This is why IT traditionally hates the ED, and why IT projects tend to fail in the ED more frequently than in other units. Nonetheless, striving to make things work in the ED is a path to success throughout the hospital.

Compare this with the dashboard design by Larry Nathanson of Harvard’s Beth Israel-Deaconess Medical Center on the next page. In this example, the lab values are grouped together, so that users don’t have to scan through haystacks of data to find the few elements they really need. The remainder of the screen also shows information that is more relevant to the acute-care clinician, compared to the more detailed laboratory report from Wellsoft, which nonetheless has fewer data pixels related to the user’s needs.

Another heuristic to analyze a screen is to consider position. Realtors speak of “location, location, location” and this is true of the computer screen as well. Western viewers tend to read the screen in a predictable fashion, giving pride of place to things displayed in the upper left or the center of the screen. The next diagram, from the previously-mentioned Information Dashboard Design, illustrates this. Inspect to see if critical information gets pride of place on the screen.

Finally – and we are getting a bit theoretical here – we can delve into cognitive psychology to...
see what we can learn about our screen design. If you are interested, there's no better place to start than Colin Ware’s scholarly yet practical text, *Information Visualization.*

A briefer and more accessible source of the relevant information is found in Few’s previously-mentioned *Information Dashboard Design*, where he presents a precis of the most relevant points of Ware’s text. The following excerpt gives the flavor of Few’s presentation:

Preattentive processing, the early stage of visual perception that rapidly occurs below the level of consciousness, is tuned to detect a specific set of visual attributes. Attentive processing is sequential, and therefore much slower. The difference is easy to demonstrate. Take a moment to examine the four rows of numbers in Figure 4-1, and try to determine as quickly as you can the number of times the number 5 appears in the list.

How many did you find? The correct answer is six. Whether you got the answer right or not, the process took you a while because it involved attentive processing. The list of numbers did not exhibit any preattentive attributes that you could use to distinguish the fives from the other numbers. Now try it again, this time using the list of numbers in Figure 4-2.

Much easier this time, wasn’t it? In this figure, the fives could easily be distinguished from the other numbers, due to their differing color.
<table>
<thead>
<tr>
<th>Category</th>
<th>Attribute</th>
<th>Illustration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Form</td>
<td>Orientation</td>
<td></td>
</tr>
<tr>
<td>Line length</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Line width</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Size</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shape</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Added marks</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enclosure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Motion</td>
<td>Flicker</td>
<td>A visual attribute of an object, such as color, continuously changes back and forth between two values, or the entire object itself repeatedly appears and then disappears.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual attribute</th>
<th>Useful expressions</th>
<th>Illustrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color intensity</td>
<td>A darker or more fully saturated version of any hue is naturally perceived as greater than a lighter or less-saturated version.</td>
<td>![Illustrations]</td>
</tr>
<tr>
<td>Size</td>
<td>Bigger things clearly stand out as more important than smaller things.</td>
<td>![Illustrations]</td>
</tr>
<tr>
<td>Line width</td>
<td>Thicker lines stand out as more important than thinner lines.</td>
<td>![Illustrations]</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Category</th>
<th>Attribute</th>
<th>Quantitative</th>
</tr>
</thead>
<tbody>
<tr>
<td>Color</td>
<td>Hue</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Intensity</td>
<td>Yes, but limited</td>
</tr>
<tr>
<td>Position</td>
<td>2-D position</td>
<td>Yes</td>
</tr>
<tr>
<td>Form</td>
<td>Orientation</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Line length</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Line width</td>
<td>Yes, but limited</td>
</tr>
<tr>
<td></td>
<td>Size</td>
<td>Yes, but limited</td>
</tr>
<tr>
<td></td>
<td>Shape</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Added marks</td>
<td>No</td>
</tr>
<tr>
<td></td>
<td>Enclosure</td>
<td>No</td>
</tr>
<tr>
<td>Motion</td>
<td>Flicker</td>
<td>Yes, based on speed, but limited</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Visual attribute</th>
<th>Useful expressions</th>
<th>Illustrations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hue</td>
<td>Any hue that is distinct from the norm will stand out.</td>
<td>![Illustrations]</td>
</tr>
<tr>
<td>Orientation</td>
<td>Anything oriented differently than the norm will stand out.</td>
<td>![Illustrations]</td>
</tr>
<tr>
<td>Enclosure</td>
<td>Anything enclosed by borders or surrounded by a fill color will stand out if different from the norm.</td>
<td>![Illustrations]</td>
</tr>
<tr>
<td>Added marks</td>
<td>Anything with something distinctly added to it or adjacent to it will stand out.</td>
<td>![Illustrations]</td>
</tr>
</tbody>
</table>
intensity (one of the preattentive attributes we’ll discuss below): the fives are black while all the other numbers are gray, which causes them to stand out in clear contrast. Why couldn’t we easily distinguish the fives in the first set of numbers (Figure 4-1) based purely on their unique shape? Because the complex shapes of the numbers are not attributes that we perceive preattentively. Simple shapes such as circles and squares are preattentively perceived, but the shapes of numbers are too elaborate.

In Information Dashboard Design, Few notes several attributes that can be processed preattentively, as shown on the previous page. A clever designer could, for example, highlight out-of-bounds and panic levels using one or more of these preattentive signals.

Forms Design

The previously-mentioned Forms for People is chock-full of useful information. Some applies to paper forms, and some to computer-based input forms, but there are sections relevant to the display of tabular data, too.

For instance, when presenting tabular data, Barnett recommends the use of dotted lines; Tufte also argues for de-emphasizing lines (which, after all, are not data pixels) by making them gray (as in dbMotion) or dotted or both.

Another of Barnett’s suggestions – de-emphasize everything except for what is directly relevant to the task at hand. For example, there may be requirements for certain logos or boilerplate text on a page, but, by decreasing contrast and color saturation, allowing users to focus on critical data on the screen. The examples of the UPMC Mercy MI floor orders and ED orders in the “new format” based on information design principles – such as having checkboxes and text right-justified (decreases error) also show the de-emphasis of non-critical elements to avoid “sign pollution.”

dbMotion Suggestions

First, let me comment on accessing data. While
dbMotion is primarily a display medium, one must provide enough information to access a particular patient’s records. To find a patient from Cerner Millenium FirstNet, one must simply type in either “Lastname, Firstname” or “Firstname Lastname.” Then, one is presented with a list of matches, with information such as SSN and birthdate, that one can use to identify the correct patient. Simple. Elegant. (One of the better features of FirstNet.)

But, if one is trying to access dbMotion directly, say from Mercy, one has to type in the patient’s last name. And first name. And birthdate, or SSN, or some other ID information.

As we’ve learned from Google, it’s more efficient to simply let users (especially those who are two-finger typists) type the information into a single field and then let them choose the best search result. If dbMotion could emulate the Cerner lookup method, it would make users much happier.

Next, consider page design in light of the foregoing. Look first at the lab display. Given what we know about “pride of place” and preattentive attributes, what grabs our attention? Based on contrast, color saturation, and distinctive shapes – and, just as much, what grabs the eye (which is one and the same thing), I have circled in yellow the five things that catch my eye, in this order:

1. First, my eye goes to the UPMC which has a bit of pride of place, in the right upper corner, and has high color saturation, and high contrast with the white space around it.
2. Next, my eye is drawn to the tubes full of red blood, with contrasting white surrounding them, and a big blue block with a contrasting red line in it.
3. Next the eyes move to a cluster of pushable buttons in the most important place at the top left; this is also the only green on the page except for the browser’s back arrow which we can (mostly) ignore as it’s part of the frame.
4. The big, bold, blue block with RESULTS prominently displayed in it is the next eye-target.
5. Finally, my eyes move to the list of blue, un-
derlined links.

Note that nowhere in this list are the actual lab results, not even the ones that are highlighted in red. Now others’ eyes may move differently. Nonetheless, from Ware’s work, and the art/engineering principles espoused by Few, Tufte, Barnett and others, one can suppose that most people’s eyes would move the same way.

Suggestion: make the DATA stand out, and use unsaturated colors with low contrast with their surrounding for all other, ancillary data.

Another suggestion, from both Barnett and Tufte: if one uses lines in a table, one should use gray lines (as are used in dbMotion now). Better would be gray dotted lines. Or, as shown above on Page 3 of the UPMC Mercy ED MI orders, no lines at all, just a tint behind every other row. (This is for gray-scale printing, but on-screen, a pale pastel tint is more common.)

While most of these changes are hard to show with just a screen shot rather than the actual code, one can play with Photoshop a bit. I trimmed off the browser frame, masked the column of actual lab results, and then de-emphasized everything else by decreasing saturation, contrast, and brightness by 50%. I then went through Photoshop’s filter gallery to find something that stood out but was still more or less legible. The result, while quite crude and ugly, and not all that legible, does bring your attention to the right spot.

Also, to avoid duplication of data elements on the screen, I “merged cells” where the date and the source were the same for multiple items.

Using data-hiding, or encapsulation (think object-oriented programming) it would be even
better to provide an overview of the CBC results, as provided by Larry Nathanson’s dashboard at BIDMC – even if the capsule summary is in text rather than the standard tree-graphic format he uses. If one presents that four essential elements of the CBC together: WBC, Hgb/Hct, Plats, and then offers these in a blue underlined link to get more information, it would allow more useful information on the screen.

As far as the summary screen, the example that I chose is for a well-known drug-seeker who often persuades physicians to prescribe various controlled substances to him. As you can see, where I’ve circled, almost the whole first screen of drugs is all the same thing. It also doesn’t tell one, or let one click to find out, when this was prescribed or how much was prescribed, which would be very useful.

Summary

Overall, dbMotion is very likeable. These design suggestions are merely tweaks – ones that would enhance the product, but still just tweaks.

- Improve manner of patient lookup as with Cerner – allow just entry of “firstname lastname” or “lastname, firstname” and then present the user with a pick list with other identifying information from which to choose.
- Increase data pixels.
- Emphasize data pixels (but not like my ugly demonstration)
- Decrease non-data pixels (for the task at hand).
- De-emphasize non-data pixels with decreased contrast and saturation.
- Encapsulate data (e.g., date, source, medication orders that are the same, subsidiary data from CBC) so as to fit more relevant data on each screen.
- With more use I hope to have other suggestions about the user interaction design, when I can watch residents and other attendings using dbMotion “in the wild” as it were.

Thank you for the opportunity to review and comment on this exciting new system.