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“Typography is to language what maps are to geography” (Baines & Haslam, 2005, p10)

How has the transition from paper to screen changed the use of typography in cartography, and can it be improved?

INTRODUCTION TO TYPOGRAPHY

What is typography?

Typography surrounds us in our daily lives. It is something we encounter everywhere we go, and it is something we interact with thousands of times per day. Typography is one of the most important tools that we have for communication, and yet it is something that most of us take for granted. Language, like everything else, is constantly changing (Aitchison, 1981, p16), and so understandably, our relationship with, and our understanding of typography has changed over the years too (Baines & Haslam, 2005, p6). Originally it was the craft of casting type out of metal and arranging it to be printed by hand, a job which was undertaken by few. Whereas today, advances in computer technology have seen typography become a digital craft, and one which is no longer restricted to specialists, as type can be created, arranged and printed by anybody with even the most basic computer literacy. There is no one correct definition of typography, and different sources provide numerous different descriptions. However, for the purposes of this investigation, typography is understood as “the mechanical notation and arrangement of language”, a definition which was first suggested in Baines’ & Haslam’s ‘Type & Typography’ (2005, p7). Whether it’s created by hand or by a computer, and whether it’s printed on paper, projected on a screen, or viewed on any other medium, essentially, the one element of typography that remains constant, is that it is a method of communication; it is a way of visually representing spoken language. Our ability to communicate through spoken language is what sets us as humans apart from other species, and typography is our way of documenting spoken language, presenting it and preserving it (Baines & Haslam, 2005, p.10; Robinson, 2003, p.36).

The structure of a typeface

Language is essentially a code. It is made up of strings of words put together to convey a message, and equally, words are made up of phonemes which are strung together to convey meaning. These noises, phonemes, are represented by a series of symbols, and it is these symbols which are the bare bones of a typeface. However, words and their meanings are only understood by people who speak the same language, people who are familiar with the code (Baines & Haslam, 2005, p10; Kane, 2002, p16). For this investigation, the primary focus will be on the Western, or Latin alphabet, and the English language.

The Latin alphabet contains 26 basic characters, which are constructed using strokes. These strokes can be vertical, horizontal, angular or rounded and almost all characters consist of a combination of these (White, 2005, p137), with strokes often meeting at vertexes or creating open or closed counters (Kane, 2002, pp2-4), to create letterforms which are unique and which can be easily distinguished from one another. Despite this, the letterforms of any given typeface do need to have a visual consistency to them, and they do follow the same basic structural rules. They each sit on the same baseline, they share the same x-height, ascenders and descenders are usually a consistent height, line width and the contrast between thick and thin is consistently applied across all the letterforms, the characters have the same serifs or terminals, and they share the same decorative features. It is the design of these differences in shape, proportion and weight which give a typeface it’s own style and it’s own unique visual identity and personality.

Key principles of typography

When creating a typeface, the designer has to balance form and function; the type needs to be practical and suitable for it’s intended use, but equally, it needs to be visually pleasing. Kane states that typographers have two goals: “easy readability, and an appropriate expression of contemporary aesthetics” (2002, p12). In the context of cartography however, the emphasis is usually somewhat different, as first and foremost the aim is for clarity and legibility or information.

Typefaces are classified according to their visual characteristics, the main classifications being serif, sans-serif, slab-serif, blackletter and script faces (Boardley, 2008, online). When setting type, it is important to consider what the type is being used for, as not even the best typefaces are suitable for every occasion (Boardley, 2008, online). Combining different styles of typefaces, and different sizes, can be visually confusing, or, if done appropriately, it can create a visual hierarchy, thus making the information easier to follow and understand

(Bartz, 1970b, p108). Another way that a visual hierarchy can be achieved is through the use of different weights; typefaces often have a range of weights from ultra-thin through to ultra-black, and often condensed and extended versions too, as well as italics (Kane, 2002, p8), all of which can be used to create a distinction between different levels of information. The appearance of typography is also affected by the leading and kerning of the type, which control the amount of white space between letters, and this has a large impact on readability.

What makes a typeface legible?

To determine what makes typography legible, we first need to understand how we read text, and how our minds interpret the symbols that make up our written language. In general, we read by recognising the patterns formed by the words; we do not read each and every letter individually, but typically the first and last letters, and the pattern of ups and downs formed by the ascenders, descenders, and neutral characters in between. Words set entirely in uppercase letters take longer to read than their lowercase equivalents, as they form a rectangular box shape around the word, rather than a recognisable pattern of ascenders, descenders and neutrals. This theory of word shape recognition was first proposed by James Cattell (1886), and his study has since been replicated and expanded upon by numerous others, notably Woodworth (1938), Reicher (1969), Fisher (1975), Haber & Schindler (1981), and Monk & Hulme (1983). It is because our minds cannot interpret uppercase words as quickly as lowercase ones, that uppercase, and also italic letters, are often used to give emphasis to words, as we are forced to read them slower, concentrate on them for longer, and thus pay them more attention (Burt, 1959; Paterson & Tinker, 1940; Boardley, 2008, online). Interestingly, it has also been proven that each of us reads differently, depending on the purpose for which we are reading (Unknown, 1927, p124). This is particularly relevant for map reading, as we are not reading lines of continuous, familiar text, but usually the singular, often unfamiliar text of names and places.

Another question that ought to be addressed, is the difference between legibility and readability. Although the two words are often used synonymously, there is a distinction between the two, as discussed by Baines and Haslam:

> "Legibility refers to the typeform, how easy an individual character or alphabet is to recognize when presented in a particular font. Readability encompasses both typeform and arrangement - how easily a text can be read." (2005, p125)

As well as numerous factors that are within the designer's control, the readability of the text is also affected by numerous environmental factors, such as the lighting, and the type of media that the text is being read from, be it paper, a computer screen, or anything else (Baines & Haslam, 2005, p125). The layout of the text also has a big impact when it comes to readability, and is especially important when used in cartography, as large amounts of detail have to be presented in a very small area.

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As for legibility, this is affected by the shapes and the proportions of the letters themselves. At small sizes, text can become particularly difficult to recognise, so for maximum legibility the defining features of each character need to be exaggerated to make them easily distinguishable from one another. The amount of white space within and surrounding each letter is an important factor on legibility too (White, 2005, p137), and the counters of letters, particularly three tiered lowercase letters such as e, a, and s, have a tendency to close up at small sizes. The most legible typefaces are those which have a generous x-height to allow for large, open counters, and also a line weight which is neither excessively light, nor excessively bold (Haley, 2001, online). There is also the issue of serifs. Serifs create a noticeable horizontal flow within the text, which many believe helps to guide the eye along the line it is reading (Poole, 2005, online). It has been argued in the past that serifs both improve legibility (De Lange et al., 1993, pp241-248), and that they worsen legibility (Haley, 2001, online). Countless studies have been conducted into the legibility of serif versus sans-serif typography, the most recent being undertaken by Arditi & Cho (2005), but all these studies have yielded results of "no difference" (Poole, 2005, online). Lund (1999) suggests that whilst there may be some slight difference in the legibility of serif and sans-serif typefaces, these differences have so little impact that they are rendered insignificant.

How printed type works

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The appearance of printed type differs depending on the printing method used. Traditionally, the main methods of printing were letterpress and hot metal typesetting. However, the introduction of offset lithography at the beginning of the 20th century offered an alternative to printers, and although it was very expensive, it was ideal for large print runs. The introduction of phototypesetting machines around the middle of the century made offset lithography more efficient, reliable, and cost effective to set up, and brought about a decline in the use of metal type. Offset lithography is still the most common printing method in use today for commercial printing, and is produced by transferring the text photographically, or digitally, onto a cylindrical metal plate which is chemically treated so that only the image areas will accept ink (Miller, 2009, online). The plate then has oil-based ink and water applied to it, and as oil and water do not mix, the ink clings to the image areas, and the water clings to the areas that are not to be printed (Bear, 2009, online). Finally, the ink is transferred to an offset cylinder before being pressed against the paper (Miller, 2009, online; Bear, 2009, online). Increasingly, people are using small-scale personal printers for home and office use, and nowadays, inkjet and laser printers are commonplace. However, these bring with them numerous complications, as type is displayed differently on screen to how it is on paper. Most digital type is optimised for screen use, and when output to paper the shapes and colours often appear different to how they look on the screen (Brown, 1993, p134; Gardner, 2006, online). These complications will be further explored later in this investigation, focussing on cartography and the issue of printing digital maps onto paper.

How digital type works

Digital type works in a completely different way to printed type. When viewing printed type, the eye is looking at a series of marks which have been imprinted onto paper, whereas when viewing digital type, the eye is looking at a series of pixels which are being displayed on a screen. Understandably, the quality and the sharpness of digital type is dependent on the quality of the screen that it is being viewed on, with the most important factor being the resolution of the screen (Tam, 2006, p6). The majority of contemporary computer screens use a Liquid Crystal Display (LCD) rather than the older Cathode Ray Tube (CRT) system.

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In order to understand how digital type is rendered on a screen, it is first necessary to understand the basics of how LCD screens work. An LCD display is made up of a grid of pixels, and each pixel is capable of emitting light, so that when combined, the pixels can form images on the screen. Each individual pixel is made up of a row of three sub-pixels, and each of these sub-pixels has a colour filter applied to it, to create the colours red, green and blue (Tyson, 2000, online). The amount of voltage applied to each sub-pixel controls the intensity of it's colour, and each sub-pixel has a range of 256 different shades (Tyson, 2000, online), which can combine to create 16.8 million different colours. It is worth noting that whereas screen displays use combinations of red, green and blue to create all the other colours of the spectrum, printed material combines colours in a different way, mixing cyan, magenta and yellow to create other colours; this is known as subtractive colour mixing, whereas the RGB method is additive colour mixing (Van Holten, 2005, online).

A digital typeface is stored on a computer as a set of ‘Bezier curves’ or ‘quadratic curves’, and this data tells the computer about the outline shape of each letter (Baines & Haslam, 2005). These curves are stored as a set of

Source needed?

equations, and so unlike images which are saved as a set of pixels, the letters can be scaled to any size without any loss of quality. However, even though digital typefaces are not stored as pixels, they have to be displayed using pixels due to the nature of the screen display; the Bezier curves tell the computer what shape the letter is, and the computer uses this information to determine which pixels to turn off and which to turn on in order to render the letter (Tam, 2006, pp2-7). When type is displayed as pixels this way it is known as a bitmap. Due to the relatively low resolution of screen displays, the curved parts of the letterform often appear to have jagged edges, because there are not enough pixels in the bitmap to create a smooth curve, and so the crispness and the clarity of the type is compromised. The way typographers get around this problem is by using a technique known as anti-aliasing. Anti-aliasing works by changing the pixels immediately surrounding each character to varying shades of grey (Tam, 2006, p7), and this gives the appearance that the outlines of the type gradually fade from black to white. Instead of the pixels simply being on or off, like they are with aliased type, anti-aliasing provides the option for pixels to be somewhere in-between the two states, with varying intensities of brightness, and this creates the illusion of smooth curves for the letterforms.

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The downside of anti-aliasing is that the varying shades of grey make the type appear less black than it did before, and although not a problem for display type, at small sizes this can make the text look very feint, and in some cases almost completely illegible. For particularly small text, say 8 point or below, it is often best to turn anti-aliasing off, and instead typographers use a feature known as hinting. Hinting is the process of individually adjusting the pixels of each character to provide the best possible bitmap image for the type at small sizes (Tam, 2006, p8). It is necessary for hinting to be done manually, because the automatic bitmap image determined by the computer may not always be the most legible.

INTRODUCTION TO CARTOGRAPHY

What is cartography?

Cartography, just like typography, is constantly evolving, and can mean different things to different people. Maps are made for a whole range of different purposes, from navigating an unknown environment, to visualising population statistics, or the temperature of ocean currents. However, just like typography, the primary function of cartography is to visually communicate information. I cannot find a more appropriate description than that given by the British Cartographic Society:

> “The function common to all maps is to show selected geographical features of the world in the clearest possible way.” (Darkes & Spence, 2008, p13)

Key principles of cartography

When designing any map, the designer is faced with the challenge of representing the three dimensional world on a two dimensional plane (Keates, 1996, p84; Pitkänen, 1980, p42; Meng, 2005, p5). Typically, this is achieved by representing the three dimensional world through a series of lines and symbols. The British Cartographic Society identify three main constituents that make up any map (Darkes & Spence, 2008, pp26-27):

- *points*, meaning symbols, icons, and semiotics in general;
- *lines*, such as roads and borders;
- and *areas*, which form the background of the map, and are usually coloured or patterned.

Typography should be in addition to these three, not replacing one of them.

However, as typography is central to this investigation, it is proposed that *lines*, *symbols* and *typography* might be a more appropriate explanation of what comprises a map. Not all maps include typography of course, and there are many thematic maps which don’t (Dent, 1999, pp113-131), but for all the maps relevant to this investigation, it is from these three basic elements that each is formed. When designing a map, the cartographer manipulates these three building blocks of lines, symbols and typography, varying their “size, shape, colour, lightness, orientation, and pattern or texture” (Darkes & Spence, 2008, p26), to give the map meaning, as well as it’s own style and appearance. However, these are purely cosmetic factors contributing to the appearance of the finished map; the appearance of the map will also, inevitably, be dictated by it’s purpose (Lee, 1995, p36). According to Lee, the most important consideration for any cartographer, is “what is the map to be used for?” (1995, p36). Lee’s work is expanded upon by Darkes & Spence, who say that every map must be designed for a specific purpose, with a clear and definite end use and target audience in mind (2008, p36), as well as considering the money and equipment available to make the map (2008, p18).

Cartography is concerned with map making of all varieties, and maps are made for a huge range of different purposes (Darkes & Spence, 2008, p13). This investigation will only be concerned with topographic general purpose maps, often referred to as road atlases or reference maps, as these are the most common maps in use today, and have made the most significant impact on the world of digital cartography, hence they are the most relevant. Robinson & Petchenik define reference maps as those which are primarily concerned with navigation and location, and which provide information about the geographical features of a certain area (1976, pp116-117).

What makes a map legible?

For any map to be an effective and easily understandable piece of communication, the cartographer must decide which geographical elements are worth including and which are worth omitting. “A map can't show every feature of the landscape and should never try to” (Darkes & Spence, 2008, p22). Soffer et al.’s research into the legibility of cartography for use in atlases showed that “a high density of information is counter productive” (2005, p5) and “reduces the legibility of maps to minimal levels” (2005, p5). Interestingly, the search and identification tests conducted by Soffer et al. also suggest that when concerning map legibility, the shape of map elements is more important than their size or colour (2005, p5). However, they note that this result seems counter-intuitive, and admit that it could be an anomaly due to the small size of the sample taken, (2005, p5).

The British Cartographic Society note that for a map to communicate effectively, first and foremost the data used to create the map must be of a high quality. Geographical source data must be “complete, consistent, and accurate” if a reliable and honest map is to be produced (Darkes & Spence, 2008, p31). A strong visual hierarchy is also very important, as it helps the reader to quickly interpret the map and pick out which elements are relevant to them and which are not. Typically, the larger and darker the feature is on the map, the more important it is (Darkes & Spence, 2008, p34). Elements such as colour and visual contrast, if used effectively, can also help users to easily distinguish between different geographical features (Darkes & Spence, 2008, p34), with natural and true colours, understandably being proven the most recognisable (Soffer et al., 2005, p6). Techniques such as simplification, exaggeration, and displacement, are also used by cartographers to deliberately distort certain features of the landscape to make them clearer and easier to understand (Darkes & Spence, 2008, pp22-23).

How people interact with maps

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TYPOGRAPHY IN CARTOGRAPHY

The role of typography in cartography

Typography has a very important role to play in cartography, as type is the most common feature found on maps (Lee, 1995, p37). As discussed, there are four main elements that make up any topographic map: points, lines, areas, and type (Fairbairn, 1993, p105). Unlike the first three elements, which can work independently from one another, text on the map face rarely makes sense in isolation; it is almost always connected to one of the other elements, to "indicate the names of objects which are themselves located by point, line or areal symbols" (Fairbairn, 1993, p105). Fairbairn illustrates his point with the basic example that the name of a village will always have an associated point symbol to clarify its location, the name of a river will sit upon, or meander along, a line symbol, and the name of a wood will sit within a woodland areal symbol (1993, p104).

Gardiner suggests that the only function of typography in cartography is to "assist the rapid transference to the mind of the user of the exact spelling of the name or word involved - no more, no less" (1964, p44). However, Gardiner's view seems narrow minded and outdated, as although the primary function of text on the map face is, indeed, to label other graphical elements, Karssen (1980, p126) and Fairbairn (1993, p111) argue that the typography used in cartography also has numerous secondary functions which assist the map user and aid their interpretation of the map. The style, size, spacing and layout of the typography are used to convey information about the nature of the geographical features they are associated with. For example, the size of the text indicates the size or importance of the place; the colour of the text indicates the type of the feature it is, and the letter spacing of the text indicates the extent of the feature geographically (Raisz, 1962, p55; Fairbairn, 1993, p104). The typography present on the map face also provides the user with information about the orientation of the document, and helps to confirm their interpretation of the map (Fairbairn, 1993, p111).

Map text is not purely toponymic either (Fairbairn, 1993, p105). The majority of maps include significant marginalia, which use text to identify the name of the area being mapped, to explain the graphical notation being used, usually in the form of a legend, and to indicate the scale of the map (Fairbairn, 1993, p104), as well as the date of production, source data, and any other information deemed necessary by the cartographer (Karssen, 1980, p126).

The problems with typography in cartography

The most obvious problem with typography in the context of cartography, is the overwhelming volume of it. Maps can become extremely complicated documents due to the amount of type used, and trying to convey too much information typographically can be detrimental to the effectiveness of the map as a piece of communication (Soffer et al., 2005, p5). As discussed by Bartz (YEAR, PAGE), and Taylor & Hopkin (YEAR, PAGE):

This last half might not be necessary?

> “Maps are exceptionally complex visual displays where type is distributed irregularly, often using a large number of type styles, and where the demands on the reader are very different from other types of display” (Phillips et al., 1977, p671).

In addition to the numerous different styles and sizes of typography found on a map, text also comes in a variety of different colours and is positioned against an equally variegated background (Gardiner, 1964, p42). Certain colour combinations are not very legible (DARKES & SPENCE???), and to ensure that text doesn’t become lost against a background of multiple colours and textures, cartographers often position text within ‘halos’ (Freelan, 2008, online), which wrap the type in a band of solid colour to separate it from the other features of the map.

The positioning of place names is often a complex procedure for the cartographer, as inevitably, names take up a certain amount of horizontal space on the map face, often resulting in the name of one location overlapping into another (Karssen, 1980, p126). One method to ease this problem is to use a condensed typeface to label map features, but the downside of this is that unlike their Roman counterparts, condensed types can become particularly illegible at small sizes (Saligoe-Simmel, 2009, online). To avoid over complicating the map, the cartographer has to be very selective when deciding which textual information to include on the map face and which to omit (SOMEONE, YEAR, PAGE). Often, there is not enough space to include all the information deemed necessary, and so the cartographer may use simple text or icons to “refer to other material, usually textual, which is placed away from the map face”. (Fairbairn, 1993, p108). Alternatively, some cartographers use abbreviations to free up extra space on the map face, however, Fairbairn (1993, p109) suggests that the use of abbreviations should be avoided as they can be confusing and misleading to the map user.

Previous investigations

The most thorough investigations into the relationship between typography and cartography are from Bartz, who conducted a comprehensive assessment of typographic legibility literature. In the investigation, Bartz examines a range of previous research into type legibility, but concludes that it is not relevant to the field of cartography. The article even questions the definition of legibility, and stresses that “legibility clearly means different things in different contexts” (Bartz, 1970a, p13), although fails to present a suitable alternative definition for use in the context of cartography, something which could be the subject of further investigation. Previous investigations into type legibility have all focussed on books, and the reading of long passages of continuous text (Gardiner, 1964, p42; Patterson & Tinker, year?), and fail to take into account the legibility of type in other situations. Of all the literature regarding typographic legibility, Ovink’s investigation into the legibility of “unconnected material” (1938), and Rothlein’s study of “isolated letters and meaningless word groups” (1912) are the only ones to consider situations which differ from that of normal text reading. Unfortunately they don’t discuss maps directly, but do conclude that when reading single words of unfamiliar material, individual letter design becomes of greater importance (Bartz, 1970a, p12; Gardiner, 1964, p43).

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Bartz goes on to conduct her own research into type legibility in the context of cartography, and uses the ‘Search Task’ to discover that it’s not necessarily the typeface, but rather the hierarchy of size and style of the typography which makes a significant difference to users trying to find a name on a map (1970b, pp107-108). When the size of the type is used to indicate the size or significance of the location, this “improves search time far more than any other type variation tested” (Bartz, 1970b, p108).

In contrast to the views of Bartz, Karssen believed strongly that artistic elements are essential in the map making process; the typography must “correspond to the essence of the map” and “is purely a subjective decision by the cartographer” (1980, p126). He emphasises the importance of balancing harmony, composition, and clarity when choosing and positioning type (1980, p126). Others such as Gardiner (1964) and Copland (1974) argue that there is “no room for artistic freedom in map design” (Gardiner, 1964, p42), and Copland’s research even led him to devise an elaborate set of equations, referred to as nomograms (1974, pp91-93), for calculating the ideal type size for any cartographic situation. Copland’s aim was to “remove most of the guess work, and place cartographic design on a more systematic basis” (1974, p93), and similarly, Stewart (1975) devised his own “detailed ten-fold categorisation” (Fairbairn, 1993, p105) for the use of typography on the map face. However, none of these attempts to standardise typography in cartography were wholly successful, as the efforts of both Copland and Stewart seem too complex to be taken up by cartographers. Ormeling argues that too much of this research into visual perception and legibility will “take

It’s Ormeling’s point of view, but I got it from an article written by Karssen.

Is it ok to put “Ormeling says ‘xyz’” and then cite Karssen as the source?

over 'the subjective creation of the artist' leading to a mere application of rules by each non-artistic draftsman" (Karssen, 1980, p124), which interestingly, is exactly what has now happened with the introduction of mainstream digital cartography; this will be discussed in more depth later in the investigation.

Other things I haven't included here, but might be worth mentioning, are:
- Uppercase vs. Lowercase (Phillips et al., 1977)
- Bold type is useless (Phillips et al., 1977)

Choosing typography for maps

Typography is usually the final design element applied to the map by the cartographer, and poor typographic decisions can ruin the effectiveness of an otherwise well designed map (Copland, 1974, p91). There's no definitive right or wrong way to choose and set typography for map use, although map designers are certainly "not short of advice on the best type style to use, or the best way to place it" (Phillips et al., 1977, p671). Cartographic investigations by the likes of Crocker (1964) and Copland (1974), and textbooks, such as those written by Robinson et al. (1984), Campbell (1991), and Keates (1996), all offer different opinions on how to choose type and position it on the map face.

Could perhaps be cut out if necessary?

Gardiner (1964) suggests that "extreme legibility of every individual letter" is of the most importance, and recommends choosing a typeface with a large x-height (1964, p42), and large counters (1964, p43). Phillips et al. (1977) observe that whilst larger point sizes, 12 point for example, will inevitably be more legible, it would "clutter the map unacceptably" if all the type were this size (1977, p680). As a result, most maps contain type in a wide variety of sizes, typically ranging from 4.5 point at its smallest, to 14 point at its largest (Gardiner, 1964, p43).

Bartz (1970b), and Foster & Kirkland (1971) have both shown the merit of using differences in the style and size of type to create a strong hierarchy of typographic information, although "neither study helps the designer decide which type styles to choose" (Phillips et al., 1977, p672). Phillips et al. (1977) conducted their own research into this issue, and compared the use of Times and Univers in the context of cartography. Interestingly, the results suggested that words set in Times were easier to find than those set in Univers (1977, p680), once again raising the issue of serif vs. sans serif typography, although Phillips et al. do go on to say that "the difference could be due to sampling" (1977, p680). The problem with a lot of sans serif typefaces is that certain characters are not distinct from one another, for example it is often difficult to tell the difference between a number '1', a lower case 'L', and an upper case 'i' (Phillips et al., 1977, p680). Serifs may help to provide more clarity and distinction between letters, particularly old style serifs which "accentuate those parts that are different", unlike modern, grotesque typefaces, which "accentuate those that are similar" (Gardiner, 1964, p42), thus increasing the likelihood of confusion between letterforms. Gardiner (1964) also suggests that serif typography may be ideal for naming map features which require wide letter spacing, as the serifs optically “provide a lead from one letter to another” (1964, p43). This recurring issue of serif vs. sans serif typography for use in the context of maps is clearly an area which requires further investigation.

Arnold (2004) created a font family specifically for cartographic use. Named Cisalpin, the font has “open interior forms, flattened curves, and tall x-heights”, as well as “pronounced italics” and letterforms which have “been optimised so that they cannot be easily mistaken for another” (Linotype, 2009, online). Arnold (2004) clearly aims to provide a solution to some of the problems identified in previous investigations concerning typography for cartography, but it is unclear whether or not Cisalpin has actually become widely used by cartographers, or indeed if it achieves its aim of making map typography more legible. This is another aspect of cartographic typography which ought to be the subject of further investigation.

DIGITAL CARTOGRAPHY

Paper vs. Screen

The very first digital maps were simply scanned versions of paper maps, which could be viewed on screen as static image files (Gooding & Forrest, 1990, p16). However, the quality of these maps was poor, and many of the finer details were rendered illegible, as the maps had never been intended for screen use (Gooding & Forrest, 1990, p16). As discussed earlier in the investigation, maps must be designed with a specific end use in mind, and “the single most important question any map maker should ask, is ‘what is the map to be used for?’” (Lee, 1995, p36). Computer screens are a completely different medium to paper, so in order for digital cartography to be effective, the map needs to be designed with different parameters in mind (Gooding & Forrest, 1990, p19).

Can I get away without a source for this?

Nowadays, mainstream digital maps are developed by professionals specifically for screen use, and even paper maps are now designed on screen before being output to paper. However, this digital revolution has also opened up the world of cartography, and typography, to non-professionals, and maps are frequently designed by people without an understanding of even the most basic of cartographic principles (Lee, 1995, p34). As a result, there are many maps available on the internet which are very poorly designed, and Lee (1995) specifically highlighted illegible text as one of the most common problems identified (p34).

The most significant factor affecting the effectiveness of digital maps is the hardware they use, most specifically the “size, resolution, and colour” of the screen, and the “speed and memory” of the processor (Lee, 1995, p38). Brown (1993) identifies the ideal computer for digital mapping as having “high resolution at a high refresh rate”, as well as “rapid access to the CPU”, to accommodate “easy image operations such as scrolling, panning, zooming and rotation” (p131). Since Brown’s (1993) investigation, there have been significant advances in technology, and much of what he predicted is now commonplace. However, resolution of the screen is still an issue. Almost all computer monitors use LCD screens; these come in a variety of sizes, but almost all have a resolution of between 90 and 110 pixels per inch (PPI) (Knight, 2003, online; Sheesley, 2009, online). This is remarkably small in comparison to the resolution of printed matter, which for professional printing is typically around 2,500 dots per inch (DPI) (Tam, 2006, p6), and for a typical inkjet printer is usually between 300-600 DPI (Sheesley, 2009, online). The low resolution of screen displays means that compared to paper, less information can be displayed in the same amount of space, and this becomes particularly problematic for cartographic use, where a lot of detailed information needs to be displayed in a relatively small area (Brown, 1993, p132; Gooding & Forrest, 1990, p15). As a result, digital maps are “not as clear as their printed counterparts”, and Gooding & Forrest (1990) suggested that this “could have a significant effect on the user’s ability to extract information from them” (p16).

The main digital mapping services

Nivala et al. (2008) conducted a thorough investigation into the usability of the four main web mapping applications available at the time. These were Google Maps, Microsoft Maps & Directions, MapQuest, and MultiMap. Nivala et al.’s (2008) investigation tested the usability of these maps by conducting a series of research experiments, involving eight ordinary users, eight cartographic experts, and eight usability experts. Between all the different tasks carried out, a total of 343 different usability problems were identified, and these problems were then ranked according to severity. Overall, Google Maps yielded the most successful results, with the least number of usability problems identified, as well as the least number of “catastrophic” and “major” problems too. MultiMap was the worst of the four, demonstrating the highest number of usability issues, including 13 which were deemed “catastrophic”, and Microsoft Maps & Directions, and MapQuest, came second and third respectively (Nivala et al., 2008, pp131-132). The web maps were criticised for having a confusing and restless visual composition, and a couple of the services (Microsoft Maps & Directions, and MultiMap) were found to have extremely confusing user interfaces (Nivala et al., 2008, p134). The investigation also identified problems with the typography used on the maps, which was either considered not legible, too small for screen use, or poorly positioned in relation to other graphic elements. Following the extensive usability evaluation carried out, Nivala et al. (2008) set out their own substantial set of guidelines for web mapping, to help cartographers avoid the main usability problems identified in the study.

Since Nivala et al.'s (2008) investigation, it appears that a number of their recommendations have been incorporated into web mapping applications. Also, it should be noted that the four main web mapping services tested in the investigation, are no longer the same main four today; Microsoft Maps & Directions has become Bing Maps (2009), and MultiMap no longer power their own web mapping facilities, but instead use the Bing Maps platform, combined with their own directions service (2009). Also, there is a new major contender: Yahoo! Maps, which launched in 2007 whilst Nivala et al. were conducting their investigation.

For this investigation, the four main web mapping applications in use today are considered to be: Google Maps, Bing Maps, MapQuest, and Yahoo! Maps.

Increased interactivity

Despite the comparatively low resolution of digital maps, cartographers have found a solution to the problem of displaying large amounts of information on screen, thanks to the element of interactivity available in digital cartography (Meng, 2005, p6). Unlike their paper equivalents, digital maps don't need to display every single feature of the map at the same time. Through the use of interactive, user controlled navigation features, such as zooming, panning, and hyperlinks, different levels of information can be displayed at different times, and the map face does not need to be as densely packed with information as it would on paper (van Elzakker et al., 2008, p139).

"Zooming works by separating the information, from the very general to the very detailed" (Cheung et al., 2007, p1), thus ensuring the map only displays the information that is relevant to the user at any particular zoom level. For example, if the user is zoomed out a long way, the map will only display the names of countries, and/or major cities, whereas if the user is zoomed in very closely, the map will display street names and perhaps the names of individual buildings (Cheung et al., 2007, p4). Similarly, panning allows the user to control which part of the map they are viewing, and gives them the ability to view the surrounding area (Cheung et al., 2007, p7), whereas with paper maps the information is often spread across different pages, or different maps entirely.

The disadvantage of panning and zooming, is that when zooming to a new level, or panning to a different area of the map, often, “a refresh of screen is required to show a new map image” (Cheung et al., 2007, p3). This sudden refresh of the screen can often lead the user to “lose the ‘mental’ link between the two map displays” (van Elzakker et al., 2008, p140), and may leave the user feeling momentarily lost or confused (Cheung et al., 2007, p5). Cheung et al. (2007), identify the need for “a smooth consecutive correlated map reading process” (p5), and recently, digital cartographers have had some success in achieving this goal (van Elzakker et al., 2008, p141), using a process known as “topological Generalised Area Partitioning” (tGAP) (Van Oosterom, 2005, pp331-346). The tGAP feature works using complex javascript language to create “a continuous range from rough to detailed representations” (van Elzakker et al., 2008, p141), so that when panning or zooming, the map does not need to be refreshed, and the “content will be progressively fed and displayed asynchronously” (Cheung et al., 2007, p7; see van Elzakker, 2008, p141).

In addition to panning and zooming, a further level of interactivity is achieved through the use of hyperlinks. Hyperlinks can provide the user with additional information about a feature on the map, including written information, as well as photographs and videos of the area, and links to external websites for extra information if necessary, making the map a far more powerful communication tool (Meng, 2005, p6). Brown (1993), predicted that in the future of digital cartography, users would “be able to influence the content and design” of the map for themselves (p133). Brown’s (1993) predictions were spot on, and now, through the use of hyperlink controlled actions, users have the ability to control how they view the map, with the option to toggle certain layers of information on or off, and the ability to change the background of the map between graphic elements and satellite imagery (Google Maps, 2010, online; Bing Maps, 2010, online; MapQuest, 2010, online; Yahoo! Maps, 2010, online).

Mobile Devices

Due to advances in technology, hand held computing devices, such as smart-phones, are becoming commonplace, and digital maps are no longer restricted to desktop computers, and instead are increasingly being used on wireless mobile devices whilst on the move, away from the home or office (Meng, 2005, p6). However, as with any new medium, mobile devices provide new constraints for the cartographer, and for mobile maps to be effective, they must be designed specifically with mobile use in mind (Cheung et al., 2007, p1). The difficulty with displaying maps on mobile devices is that they have very restricted capability in comparison to computers; “low processing power, limited storage, limited input capability, and the small display area” (Cheung et al., 2007, p1; see van Elzakker et al., 2008, p139), are the main problems that the cartographer has to overcome. The small screen size in particular is a difficulty when using mobile maps, and as a result, panning and zooming become of even greater importance to get “an overall spatial understanding of an area” (van Elzakker et al, 2008, p140).

Unlike other digital maps, maps on mobile devices are usually used whilst the user is actually in the environment that is being mapped (Meng, 2005, p7), more like traditional, paper, map use. However, unlike geo-centric maps, if a mobile map is to be effective, the cartographer must be extremely selective about which information to include (Meng, 2005, p7; Cheung & Chen, 2007, p1), in order “to accommodate in the mobile map only the information that is instantly needed and effortlessly comprehensible” (Meng, 2005, p7).

TYPOGRAPHY IN DIGITAL CARTOGRAPHY

How is typography used in digital cartography?

The use of typography in cartography has been reasonably well documented over the last 50 years, as is demonstrated by the significant amount of literature available on the subject. However, as web maps are a relatively new invention, the earliest significant attempts dating back to 2005 (Google Maps, 2010, online), and not gaining mainstream usage until a couple of years later, there is very limited literature available concerning the subject of typography in digital cartography. Other investigations, such as those by Skarlatidou & Hacklay (2006), and Nivala et al. (2008), have touched upon the subject of typography in web maps, whilst considering the usability of web maps as a whole, but the dedicated study of typography in the context of digital cartography seems to be a largely unexplored area.

The typography found in digital cartography appears to differ significantly from that used in traditional paper maps. Whereas printed maps usually use a combination of serif and sans serif typography on the map face (Saligoe-Simmel, 2009, online; Avraam, 2009, online), which helps to create an effective visual hierarchy (Bartz, 1970b, pp107-108; Sheesley, 2009, online), all the major web mapping applications available today, with the exception of Bing Maps, appear to use sans-serif typography exclusively (Avraam, 2009, online). Sheesley (2009, online) suggests that this dominance of sans-serif typography is perhaps due to the fact that when displayed on screen, particularly at small sizes, “small finishing elements like serifs and ears can degrade, interior spaces like counters, apertures, eyes, and bowls can change shape or collapse, and stems and strokes can loose their intended weight, contrast and curvature". To combat the issue of letterforms deteriorating and closing up at small sizes, one might expect the type found on digital maps to have wide letterforms and large x-heights, to allow for large open counters (Sheesley, 2009, online). As expected, large x-heights do indeed appear favorable amongst digital cartographers, however, wide letterforms take up too much horizontal space on the map face, and although they can be less legible, narrow typefaces are preferred instead (Sheesley, 2009, online).

In comparison to printed maps, the typography used in digital cartography is noticeably larger, with the majority of type on the map face being set at 10 points or more (Sheesley, 2009, online). Text set any smaller than 9-10 points in size, depending on the typeface, usually becomes illegible on a computer screen, whereas, due to their significantly higher resolution, printed maps can output text at sizes as small as 4 points, and still maintain legibility (Brown, 1993, p133). There also appears to be much less variation in the size and style of type found on digital maps compared with their paper equivalents. The different typographic elements found on a printed map typically range from 4 to 14 points in size (Gardiner, 1964, p43), whereas typography on digital maps appears only to fluctuate around four or five point sizes from its smallest to its largest.

As well as the style and size of the typography, the other main factor to consider is the placement of the type on the map face. The most common use of text on digital maps is to label road and street names (Avraam, 2009, online), and typically the lettering is "pushed to fit within the width of the road features" (Avraam, 2009, online). The position of the lettering is determined automatically by very sophisticated algorithms which try to pick the most appropriate position for the typography (Sheesley, 2009, online), and although not always successful (Avraam, 2009, online) (some web maps are better than others), the type is usually positioned well enough to ensure legibility.

Is it ok to put this in brackets?

How could the typography of digital maps be improved?

Three out of the four main web mapping applications in use today, make use of only one typeface (sans-serif) throughout the entire map face. Bing Maps (previously Microsoft Live Earth) does demonstrate some very limited and sporadic use of serif typography, although it does not appear to be applied very effectively (Nivala et al., 2008, p133). With such limited use of different styles, and indeed sizes, of typography, web maps are not creating a substantial visual hierarchy of information (Sheesley, 2009, online).

A mix of two different typefaces, particularly a serif and a sans-serif, has been proven to create a very effective visual hierarchy in printed maps, which helps the user to "discern information faster and easier" (Avraam, 2009, online). The introduction of a visual hierarchy could improve the typography used in digital cartography too, and given the evidence of the value that a strong visual hierarchy can bring to a map (Bartz, 1970b; Foster & Kirkland, 1971), it is surprising that this method of applying typography has not been tested in digital maps before.

If serif type is to be used in digital cartography, the typefaces used "should have robust serifs that won't degrade", particularly "heavier block-like, or square serifs" as these are usually the most legible at small sizes (Sheesley, 2009, online). Sheesley (2009) goes on to recommend one type family in particular which may be well suited to digital cartography: Officina. Officina is a family of fonts, comprising of both a sans (Officina Sans), and a serif (Officina Serif), which are both built around the same basic structure (Spiekermann, 2007, online). The typeface is, in theory, ideal for map use, due to its tall x-height, large counters, "blocky" serifs, low contrast line width and relatively narrow letterforms (Sheesley, 2009, online; Linotype, 2009, online). Sheesley (2009, online), proposes that Officina, with its complimentary serif and sans-serif counterparts, would be ideal for creating a visual hierarchy of information in digital maps whilst ensuring legibility and visual consistency.

There are of course other ways in which the typography of digital cartography could potentially be improved. Nivala et al.'s (2008) investigation into the usability of web maps suggests that increasing the size of the typography, improving the positioning of the type, and allowing customisable typography for individual users, are all ways which might help make digital maps more effective. All of these are considerations which ought to be the subject of further investigation. However, it is Sheesley's (2009) theory of creating a visual hierarchy of information using the Officina type family, that looks to be the most interesting and significant improvement suggested, and so it is this theory that this investigation will aim to test.

INVESTIGATION

Aim

The aim of this investigation is to test the theory put forward by Sheesley (2009, online), to see if altering the way typography is used on digital web mapping applications can improve the users ability to interpret the map accurately and effectively.

Hypothesis

It has been proven that a visual hierarchy, created through variations in size and style of typography, can help to improve the effectiveness of printed maps (Bartz, 1970b; Foster & Kirkland, 1971). The hypothesis for this investigation is that the application of a strong visual hierarchy to digital, web based maps, will also improve their effectiveness, particularly through the use of a complimentary serif and sans-serif type family, in this case Officina, as proposed by Sheesley (2009, online).

Method

To test this hypothesis, first of all it needs to be decided how the effectiveness of the typography is going to be measured. This is not a simple task, as there are a huge variety of different factors to take into account which can have an impact on the typography, its legibility and its readability (SOMEONE, YEAR, PAGE). Previous investigations have measured how accurately names can be copied from a map (SOMEONE, YEAR, PAGE), how accurately a route can be followed (SOMEONE, YEAR, PAGE) or how long it takes to find a name, or a set of names, on a map (Bartz, 1970b). The latter, known as the "Search Task" (Bartz, 1970b), may seem redundant, as users of web maps no longer need to search manually for a name, they can simply type it into the search box instead. However, it is proposed that the Search Task may in fact be the most appropriate way to measure the effectiveness of the typography, because as Gardiner (YEAR) says, the main function of typography on maps is to allow the user to identify and correctly interpret the name of any given location as quickly as possible (PAGE). The Search Task assesses exactly that; it determines how quickly and easily names on the map face can be read, and how easily the names can be distinguished from one another (SOMEONE, YEAR, PAGE).

This investigation uses the Search Task to compare the effectiveness of the Officina type family, compared with the the existing typography used on Google Maps. Google Maps was chosen because all the main web mapping services employ very similar grotesque sans-serif typefaces with homogenous stroke widths, and all are set out in very similar low-contrast visual hierarchies, so it was considered unnecessary to compare all four. Google Maps has already been identified as the best web mapping service in terms of overall usability (SOMEONE, YEAR), so in this experiment, Google Maps is being used as the benchmark for comparison, representing the best of all the mainstream contemporary web maps.

For the Search Task experiment, a section of the map was chosen, showing a large portion of India. This particular area was selected because it exhibited a wide variety of different map features, including four different districts, large cities, small cities and towns, both major and minor roads, and natural features such as National Parks and lakes. The section of the map was taken from Google Maps at the seventh level of magnification (scale: 100km to 1 inch), and a replica of the map was then constructed in Adobe Illustrator CS4. From this replica, a further three maps were created, each with different typography.

Elements such as the colour and texture of the background, the positioning of the text in relation to the map as a whole, the length of the words, and the combination of letters within the words, have all been proven to have serious effects on the users' ability to identify names on a map (SOMEONE, YEAR, PAGE). To ensure a fair investigation, all of these elements were kept constant across all four maps, and the only difference between the maps used in the experiment is the typeface used (Maps 1-4), and slight variations in the size and spacing of the words (Map 4).

The first map features Helvetica, the current standard typeface for Google Maps and other web mapping services. Map number two uses Officina Sans exclusively, map number three features Officina Serif, and map number four uses a combination of Officina Sans and Officina Serif to create a visual hierarchy, distinguishing between different geographical features through the use of different styles and sizes of typography. In Maps 1-3, there is a variation of just 4 points between the smallest and the largest type on the map, and all type is set in the Roman style. Whereas in Map 4, in addition to the variation of serif and sans-serif versions of the Officina family, there is also a variation in size of 6 points rather than 4, and bold and italic styles are used to further distinguish between different features (see chart).

The purpose of Maps 1-3 is to test whether individually, either Officina Sans or Officina Serif are more effective than the existing typeface, Helvetica. The purpose of Map 4 is to test whether a stronger visual hierarchy, using a combination of serif and sans-serif typography, and bold and italic variations, is any more effective than the previous three maps which use one typeface exclusively, and with little variation in size.

Respondents were shown one of the four maps, along with a list of six names, which were displayed on screen at the same time, and were asked to locate these six names on the map. Searching for just one or two names leaves too much to chance, and depends too heavily on where the user begins their search (Bartz, 1970b, PAGE), instead, participants were asked to locate six names, the same number of names used in Bartz's own influential Search Task experiment (1970b). The six names were chosen specifically to ensure that participants searched for words of varying length and letter combinations, as well as ensuring a mix of different geographical features, located in six different areas of the map, and with type positioned across backgrounds of varying complexity (see chart). The same six names were used for each map to ensure fairness and consistency across the four tests.

For each of the tests, the names in the list were set in the same style and size of typography used for each corresponding name on the map face, and the participants were made aware of this before they began the test. The participants were instructed to find the six names in any order, and to point them out with their finger after they'd found each one. Their times were recorded in seconds to 1 decimal point, including the time taken to find each individual name, and the overall time taken to find all six.

Experimental Conditions

The Search Tasks were carried out on an Apple MacBook, with a backlit 1280 x 800 pixel LCD screen. Each of the four maps measured 900 x 540 pixels, as these are the standard dimensions of the Google Maps map face as displayed on a monitor of this size.

The maps were displayed to participants in PDF format as an image only, with the map taking up the majority of the screen, and a small column to the left of the map displaying the six names they were required to locate. The PDFs were presented using Adobe Acrobat 9 Pro, and during the test, the image, containing the map and the list of names, was shown in 'Full Screen Mode', so that these were the only elements present on the screen, thus ensuring that participants were not distracted by the Adobe Acrobat interface.

Equally, the maps are devoid of any interactivity such as panning and zooming, as these introduce other usability problems (SOMEONE, YEAR, PAGE) which would likely have an affect on the results of the investigation. As there was no interactivity, the maps were displayed without the Google Maps interface, such as the zoom level bar and directional arrows, and without the surrounding Search interface, as inclusion of these elements would likely have caused confusion to participants, who would assume the interface was active, and attempt to use it to locate the names in question.

In total 200 participants were tested, 50 for each of the four maps. All the tests were carried out under the same conditions, with university undergraduates aged between 18 and 24. None of the participants had any prior knowledge of the area on the map that they were asked to examine.

RESULTS

Initial observations

There was a fairly wide range of times recorded across each of the four maps that were tested. This was to be expected due to the nature of the task; some participants are naturally quicker at locating the names than others, which is why it was important that a large sample was taken. The results range between 52.6 and 377.9 seconds in total, although standard deviation shows that the majority of participants took between 62.5 and 231.9 seconds to find all six names on any of the four maps. As with Bartz's (1970b) own search task some 40 years prior, there is far more variation at the slower end of the spectrum; there is a range of just 9.9 seconds for those results quicker than the standard deviation, whereas for those slower than the standard deviation there is a range of 132.3 seconds. As a consequence of this, the median is consistently lower than the mean on each of the four tests, however, this right skewing is not unusual for an open ended task of this nature (Bartz, 1970b, p107).

How people searched

The majority of participants searched for the names on the map in the same order that they appeared in the list. Across all four maps, Orrissa and Amravail were the first two names found 96% of the time. Muri was usually found third, and was typically found a lot quicker than both Balaghat and Katgnola, which were clearly the two hardest names out of the six, despite being set in exactly the same type size (see chart). The reason Muri was easier to find, was perhaps due to its length, or perhaps its location on the map. A number of respondents said that they searched the map by dividing it up into small sections, or clusters, of names, and searching these before moving on to another section. This common method of searching was also identified by Bartz (1970b) during her own search task (PAGE). Muri is located within one of the larger clusters on the map, whereas both Balaghat and Katgnola are located in between large clusters, so perhaps they were more easily overlooked. The latter two names are also located on more variegated backgrounds compared with Muri, and on the maps with a low visual hierarchy, it is possible that Balaghat could easily have been mistaken for a park or forest area, and Katgnola may have been mistaken for the name of a lake. Many respondents found that searching for Balaghat and Katgnola was taking too long, and would move on to finding any other remaining names on the list, usually only Panna National Park, and returning to Balaghat and Katgnola again afterwards. Interestingly, the small number of respondents who searched the map in a different order to that shown in the list, took less time on average to find all six names (see chart). It would be interesting to investigate how changing the structure of the list of names might have an affect on the search times.

Helvetica vs. Officina Sans

Maps 1 and 2 show very similar average times; Helvetica is shown to be marginally quicker than Officina Sans, but the difference is not significant enough to prove that either typeface is any more or less effective than the other. Interestingly, the range of times is much larger for Helvetica than it is for Officina Sans, with times up to 20 seconds quicker and slower at either end of the spectrum, suggesting that perhaps Officina Sans would be more *consistently* effective than Helvetica. However, this is just speculation, and would need to be tested on a much wider range of people before any further conclusions could be drawn on the matter.

Officina Serif

Compared with the first two tests, Map 3 (Officina Serif) took respondents significantly longer to find all six names, suggesting that when only one typeface is used on the map, serif typography is far less suitable than sans-serif. The obvious reason for this is because of the relatively low resolution of computer screens, which can cause the serifs to become distorted or broken when there aren't enough pixels available to render them accurately. This is particularly a problem at small sizes. This test has proven that even serif typefaces which have been optimised for screen display, such as Officina Serif, are still not as effective as their sans-serif equivalents, with users taking 32.9 seconds longer on average compared with Map 2.

Visual hierarchy

Map number 4, featuring a combination of both Officina Sans and Officina Serif, proved to be the quickest and easiest out of the four maps tested. On average, it took respondents just 113.2 seconds to point out all six names on the map, a whole 16 seconds quicker than the average for Map 1, which was an exact replica of Google Maps. This is a considerable improvement in time between the two tests, and suggests that the typography currently being used by web mapping applications is not the most effective. To test the significance of the results, a Chi Square was calculated, comparing the number of respondents who took less than 120 seconds to locate all six names, and the number who took longer than 120 seconds, for each of the four maps. The Chi Square returned a result of 0.0001, far surpassing the 0.05 level of significance, and proving that there is only a 0.01% probability that these results could have been achieved purely by chance.

Analysis

The results from Maps 2 and 3 have already shown that Officina Sans and Serif do not improve search time on their own, and in the case of Officina Serif actually worsen search time considerably. Therefore, the improvement demonstrated on Map 4 must be caused not by the specific typefaces used, but by the introduction of the strong visual hierarchy. However, this visual hierarchy was created by changing *several* features of the typography, and it could be argued that the improvement in search time could be due to just one of these changes, or a combination of them.

Size would be expected to improve search time, as research and intuition both tell us that the larger text is, the easier it becomes to read (SOMEONE, YEAR, PAGE). It is unsurprising then, that on Map 4, the names set in larger type (Orissa and Amravail), were located far quicker than the same names set two points smaller on Maps 1-3 (see chart). However, if all the names on the map were set two points larger, although the legibility of individual letters and words would be improved, this would cause an unsatisfactory over-crowding of the map face, likely obscuring other important features, and causing a deterioration in the overall effectiveness of the map (SOMEONE, YEAR PAGE). The improvement in search times for Orissa and Amravail on Map 4 appears primarily to be the result of the *variation* in size, making it easier for users to distinguish between one type of name and another.

However, as well as increases in size, for the names of the four districts, the letter spacing was also greatly increased, and was 300% larger on Map 4 compared with the other three maps. Such wide letter spacing would normally make the names difficult to read in a normal text reading situation, however, on maps the use of wide letter spacing helps to distinguish between the names of specific locations, and the names of regions or large areas. On Map 1 the four districts can be easily mistaken for large cities; the only noticeable difference between the two features is that the names of the districts are slightly larger, and they don't have a point symbol next to them to denote a specific location.

In addition to variations in the size and letter spacing of the typography, bold (for the names of cities and districts) and italic (for natural features) variations were also used to distinguish between different features on Map 4, and on top of that there was also the variation between Officina Sans (for the labeling towns and cities), and Officina Serif (for districts and for natural features). It is impossible to tell from this preliminary investigation how much impact each of these different factors had on overall search time. Many more maps would need to be created and many more search tasks carried out for the effects of these individual typographic variations to be determined.

However, it is predicted that the *combination* of these different styles, and the *variation* in typography used across the whole map, contributes far more to improving search time than any of these typographic features would individually. This is due to the way in which people search the map; when searching for a name, the user employs a process of elimination, often eliminating names based on their first letter, or the length of the word, (Bartz, 1970b, PAGE) until their target name is found. With a low contrast visual hierarchy, such as those found in Maps 1-3, the names on the map face all look very similar, and the user has to potentially eliminate every other name on the map before they find the one they are looking for. Alternatively, when a high contrast visual hierarchy is employed, as on Map 4, the variations in typography make it easy to distinguish between different map elements, and provided the user knows which typeface their target name is set in, this allows them to immediately eliminate all the names which do not match, typographically, the target they are looking for (Bartz, 1970b, PAGE), thus greatly improving search time.

An anomaly

Surprisingly, although proven to be the most effective, Map 4 also provided the longest time recorded across all four tests; one respondent took 377.9 seconds to locate all six names. This result does not correlate with the other times recorded for Map 4, with the next slowest time being 226.8, a staggering 151.1 seconds quicker. This anomalous result has been omitted when analysing the data statistically, however, if it is taken into account, the average search time for Map 4 increases by 5.4 seconds to 113.2. Although the respondent indicated that they *had* completely understood the test, it is speculated that they did not take into account the fact that the six names in the list were set to match the typography of those names on the map, thus meaning they had no expectation of what type style the target names would appear in. When the user has no expectation of the appearance of the target name, it has been proven that the use of type variations to create a visual hierarchy can hinder search time rather than improve it (Bartz, 1970b, PAGE), and it is believed that this is the most likely cause of this particular anomaly. This raises a very interesting and important concern, and suggests that although a strong visual hierarchy can greatly improve search time, and make the typography of digital maps more effective, it can also prolong search time if the user doesn't know what style of typography to expect, and so equally, it has the potential to make the map less effective. Although it is predicted that around SOMETHING% of map users do have some prior knowledge of the location they are searching for, this is perhaps the reason why existing web maps do not include a strong visual hierarchy, and would definitely be worth further investigation.

Gender differences

This investigation is not primarily concerned with the differences in visual perception between males and females, however, a considerable difference was noticed between the pattern of results for men and women across the four tests. Based on average search times, females were 14.7 seconds quicker than males when using Map 1, although remarkably, they were 32.4 and 52.2 seconds slower than males when using Maps 2 and 3 respectively. Map 4 is the only one where men and women performed similarly, suggesting that Map 4 is more consistently effective, and perhaps more appropriate for web maps, which have a very wide audience. A chi square calculation comparing the male and female search times provides a 'p' value of 0.0351, suggesting that these results are significant. However, roughly only 25 males and females tested each map, so more investigation with a larger sample would be required before conclusive information could be garnered from this.

CONCLUSION

Although digital typography is limited by the resolution of the screen, innovations in digital mapping such as searching, panning, zooming, hyperlinking, and user controlled content, help to make web maps extremely powerful and effective, and have led to web maps being used in a very different way to their printed equivalents.

Currently, most web maps use just one typeface across the whole map, and demonstrate little variation in size and style of typography. Sheesley's (2009) theory, to improve the usability of web maps by introducing a stronger visual hierarchy, specifically using the Officina type family, was tested as part of this investigation, using a technique based on the search task method developed by Bartz (1970b). Of the four different typographic scenarios tested, the use of varied typography to distinguish between different map features and introduce a strong visual hierarchy, was proven to greatly improve search time.

This investigation looked at just one way in which the typography of digital web maps could be improved, through the introduction of a strong visual hierarchy. The search tasks conducted were taken out of context, and were devoid of any interactivity, so did not accurately represent the way that people use web maps in a real world situation. It is yet to be seen if interactive elements such as panning and zooming, and the digital map interface, have any significant impact of the effectiveness of the typography. The tests were limited to university undergraduates aged between 18-24, and do not attempt to show how changes in typography might affect the user experience for a wide range of map users of different ages and backgrounds. Also, the experiments carried out only tested the typography when using 'Map' view, and did not attempt to investigate the effectiveness of the type when used on very different backgrounds such as 'Satellite' view, 'Terrain' view, or 'Street' view, all available in Google Maps.

Perhaps the biggest limitation to this investigation is that it was only concerned with examples where the respondent had a good expectation of the appearance of the target name. Where the map user has no expectation, or indeed an incorrect expectation, of the appearance of the target name, it is suspected that this would likely impede the users ability to interpret the map effectively (Bartz, 1970b, PAGE). Although not tested here, this is clearly a subject which requires further investigation.

Despite these limitations, the investigation shows an interesting starting point for improving the effectiveness of typography on digital maps, and the initial results appear significant. It would be interesting to explore how the introduction of a visual hierarchy might work with different type families other than Officina, perhaps by using the existing and extensive Helvetica family for example. It would also be worth exploring how these changes to the typography might work in the real world; how they interact with other map features which have not been considered here, and also the technical limitations involved, such as font licensing, and processing and download speeds. The typography used in digital cartography is clearly a very complex issue with a huge number of factors affecting it. This investigation merely skims the surface of the topic, and there is clearly much need for further investigation.

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