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The Positioning of Type on Maps: The Effect of Surrounding Material on Word Recognition Time

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Two visual search experiments, one of which measured eye movements, show that material close to words on a map-like display has a proximity effect which prolongs the word recognition time. This effect is particularly pronounced if the material is a) very close to the first letter of the word, and b) of a similar size to the word, or component letters. Possible causes of the effect are discussed and the practical application for maps and other displays considered.

INTRODUCTION

Ensuring that names on maps are both easy to find and easy to read are two of the many objectives of a map designer. Factors contributing to name clarity that have already been studied experimentally are typeface (Bartz, 1970; Phillips, Noyes, and Audley, 1977), and the arrangement of type (Foster and Kirkland, 1971). Both have been shown to have some effect. However in another map legibility study, search time differed widely between names of the same typeface and arrangement (Phillips and Noyes, 1977). Obviously there were other variables affecting performance, but the experimental cartographic literature gives few clues as to what these might be.

One possibility is the positioning of the type. Of course the geographical location determines the actual position of the site, but the labeling can be positioned in several ways within the area. The Swiss cartographer Imhof has said that this is important for legibility and has given detailed advice on where to place names (1962, 1975). Unfortunately these recommendations have not been tested experimentally, so it is impossible to assess their validity. There is however one study which emphasizes the importance of context and contrast of alphanumerics (Taylor, 1974). In this experiment information theory was used to study map reading, so it was possible to assess the different aspects of map content in relation to the readers' abilities.

The majority of experiments on map legibility have used search tasks as an evaluative measure, as these have been argued to be the most representative task for the purpose (Bartz, 1969). It may be that results from visual search experiments on other material may indicate what is happening in map reading experiments. However caution is necessary in such generalizations, as results from material arranged in a predetermined order such as lists, or pages of typescript may

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not be applicable to the random display of a map (Bartz, 1969; Taylor and Hopkins, 1975).

Results from search tasks with an irregular, or random display are more likely to be relevant as the task is similar, even though the material may differ. Many papers have shown the effect of background on visual search and some of these are discussed in a paper statistically determining the probability of background constraint (Brown, 1976). The density of material in particular has often been shown to increase search time (Teichner and Krebs, 1974; Williams, 1971), but some more specific research showed the local density of target surround to prolong search time (Brown and Monk, 1975; Monk and Brown, 1975). Their findings, although for irregular displays, were for a display of dots so again may have limited application for words.

A quick pilot study was conducted on 70 students to discover what features of type positioning on a map increased the likelihood of a word being remembered. It was argued that for a short learning time the most conspicuous words were most likely to be remembered. Perhaps predictably, large type and horizontal setting of the words had a facilitating effect, which is in agreement with previous findings (Foster and Kirkland, 1971; Worrall and Coles, 1976). Isolated words and those close to smaller print were also remembered more frequently than those flanked by words of a similar, or larger size, a plausible finding in the light of Brown and Monk's results.

The present research was, therefore, designed to test the effect on visual search performance of objects adjacent to the words being searched. The work of Monk and Brown would lead to the prediction of anything close to a word being disruptive. However, other work has indicated that the first letter of a word is of special importance in perception, so it is likely that only material at the beginning of the word would have an effect (Eriksen and Eriksen, 1974; Phillips, Noyes and Audley, 1978). The first experiment was designed to test the effect of the position of distracting material on visual search for names. The second experiment tested, by a simpler method, a wider range of possible distractors more likely to be found on a map.

EXPERIMENT 1

Method

Design. The position and length of each fixation prior to the target fixation was measured from the corneal reflection with a Polymetric V-1164-3 eye movement recorder linked to the PDP-12 computer. For each word fixated the independent variables were the position of the distractor and the word's initial letter. All distractors were words similar in length and typestyle to those being searched, but they were all written vertically, so were distinguishable from the words being searched which were in the horizontal. Each horizontal word was associated with a vertical word in one of five relative positions: a) close to the first letter; b) one letter space distant from the first letter; c) close to the end letter; d) one letter space distant from the end letter; e) completely separate; (see Figure 1).

Material. The material to be searched was produced on slides, which were back projected onto a screen 60 cm from the searcher. There were two kinds of slides. Firstly those with a single target word typed across them called the *word slide* and secondly the *search slides,* which contained 20 horizontal and 20 vertical words. Each word was composed of six letters in the form of capital consonant (B,C,H,S), vowel, consonant with ascender (e.g., h), consonant without descender or ascender (e.g., r), vowel, consonant with a descender (e.g., g). The words were therefore pronounceable nonsense words. The horizontal words were placed evenly over the slide, within a square border, to form a map-like display with no order such as lines or columns (see Figure 1). Map-like displays rather

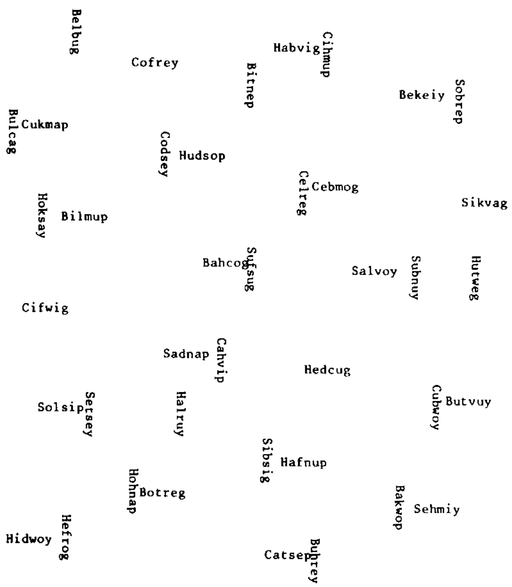

Figure 1. *Example of a search slide showing horizontal names wtih the various positions of vertical distractors.*

than real maps were used to enable better control of the variables. The visual angles subtended were 0.17 radian (10 deg) for the width of display and 0.02 radian (40 min) for the length of each word. The interletter center distance between the more distant distractor and the nearest letter of the word was about 0.006 radian (18 min) and for the closer one about 0.003 radian (9 min). For each display there were four of each type of vertical position, one for each initial letter of the horizontal words. There were five search slides and the vertical positions were moved for each slide, so each one appeared in each of the 20 positions once.

Procedure. On each trial the word slide was projected for about two s, then the search slide appeared. The appearance of this slide started the recording of the eye fixations by the computer. When the target was located the searcher pressed a button which terminated the recording. Vertical words were to be ignored during the search, as the target was always in the horizontal position and always present. After two practice trials each person made 10 searches, such that each subject saw each slide twice, but never consecutively. Previous experiments suggested that slides were not remembered. The searchers consisted of five male and five female students, who had normal vision without glasses.

TABLE 1

The mean fixation time of the horizontal words as a function of the relevant vertical distractor

Position of the Vertical Distractor	*Mean Fixation Time in ms*
Close to the beginning	356
One letter from the beginning	336
Close to the end	336
One letter from the end	332
No distractor	313

$p < 0.001$

Results

The first and last fixations of each search task were not included in the analysis, as they are invariably longer than the normal fixation time. In addition there was some data loss due generally to head movement. About 1000 fixations were made during the experiment and some 10% of these could not be reliably analyzed. The mean fixation time was 334.4 ms. An analysis of variance showed that the effect on fixation time of the relative positioning of the vertical words was highly significant $F(4,36) = 6.30, p < 0.001$. A Duncan's multiple range test showed that the 356 ms needed to fixate a word with the vertical distractor close to the beginning was significantly longer than for the three other distractor conditions, which in turn were significantly longer than the 313 ms for the names without distractors (see Table 1). The different first letters of the horizontal words did not affect fixation time $F(3,27) = 1.78, p > 0.05$. As in previous experiments words beginning with the same initial as the target word were fixated for a significantly longer time than other words $F(1,9) = 16.92$, $p < 0.005$. The means were 358.5 and 325.9 ms, respectively. There were no significant interactions. As well as analyzing mean fixation times, the data were examined to see whether the independent variables affected the number of fixations which fell on names in different conditions. Neither the vertical distractors, nor the initial letters altered the number of fixations expected by chance, $p > 0.1$, chi square, for both.

EXPERIMENT 2

Method

Design. In this experiment the material was presented in booklets and the distractors were chosen from examples often found on maps. Eye movements were not recorded and the dependent measure was search time. The repeated measures design was based on a Williams square (1949), so each person had each page in a different order. Arguments against this sort of design, put forward by Poulton (1973) on the grounds of range effects, were not considered to be of great importance in this instance as this kind of effect is likely to be naturally present in any map reading. There were 18 different distractors, plus two control conditions with no distractors. The material was presented in two booklets, to allow for a break in the middle to reduce fatigue. There was one condition on each page and the same set of pages, including one control condition, always made up one booklet, although the order was different for each person. The number of target words found in a given time was measured.

Material. The distractors were other items often found on maps, such as words, lines, symbols, and open and closed dots. In one condition the whole page was covered with triangles, which represented general visual noise. An example of each type of distractor can be seen in Figure 3. Each book had nine of the 18 distractor conditions and a control

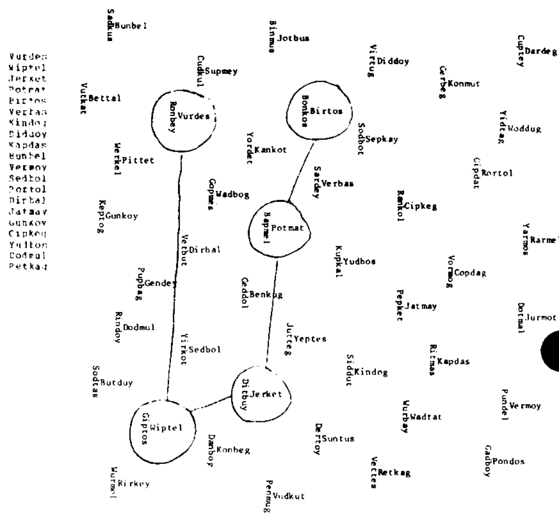

Figure 2. *Example of a page of the booklet used in experiment two showing an answer route.*

page, with alternating blank pages. There were 43 randomly distributed words on each page formulated in the same way as in the previous experiment (see Figure 2). Only one type of distractor was used on each page and this distractor was present for all 43 names. There were five different sets of words used, so each appeared twice in each booklet, but the order varied each time to prevent the positions being remembered. To the left of each page was a list of 20 target words for which the person had to search. The list was different for each page, for each person. This was done by randomizing the order of words from the page on a computer and printing the first 20, so there were 2000 different lists.

Procedure. Participants were shown an example of the booklets and with a diagram on a blackboard it was demonstrated how to look at the first word on the list, search for it on the display and circle it when found. The procedure was then repeated with the next word on the list and the two circled words were then joined together with a line. This was intended to make people keep to the order of the list and to prevent them searching for several words at once. With the conditions where other words were the distractors it was carefully explained which of the words was the correct target. Examples were put on the blackboard and participants were told always to search for a horizontal word. If the distractor was also a horizontal word, then the target would be the word on the right of the pair. The instructions were repeated three times, with intervening chances for questions. The search time for each page was 60 s. At the end a loud buzzer sounded when everyone had to turn over the page. It was easy to see if this was done. There was then a 30 s pause with everyone looking at a blank page. This was done to minimize fatigue and confusion. There were 100 participants, mainly first year students. Of these 44 were men and 56 women, with a mean age of 19.12 years. Of these 90% were between 18 and 20 years old. All data were included in the analysis.

Results

Each page of the booklets was scored by counting the number of names correctly found. There were only three errors and each was subtracted from the relevant page score. An analysis of variance showed the effect of distractors to be highly significant $F(19,1881) = 19.72$, $p < 0.001$. The mean number of words found per person per trial was 5.8 and there were no significant differences between the two booklets. The means ranged from 4.3 for the horizontal word distractor, to 6.6 for the controls (see Figure 3). Duncan's multiple range test, adopting the $p < 0.05$ level, showed that lines and the small dot near the beginning did not significantly slow the search, but other distractors had a significant effect.

DISCUSSION

The data from the eye-movement experiment showed that a distractor in the proximity of a word being fixated significantly prolonged the mean fixation time. This was true for distractors both at the beginning and end of a word. When the distractor was adjacent

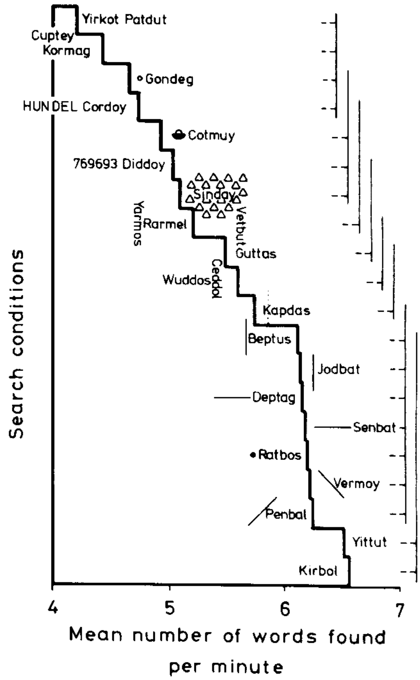

Figure 3. *Mean number of words found per minute for each condition shown. The vertical bars indicate Duncan's multiple range test. Those conditions joined by a bar are not significantly different.*

to the beginning of the word the mean fixation time was significantly longer than for any other position. This increase over the mean fixation time for the controls was 43 ms for the latter condition and about 20 ms for the others. It was unlikely that the vertical distractors were being consciously read, as instructions had been given to ignore them and no one reported trying to read them. It would also be very difficult to read words printed vertically without moving the head, which was restrained in the eye-movement apparatus. It seems probable therefore that any increase in fixation time is directly due to a *proximity effect* of the distractor words. How the effect might operate is discussed below.

The second experiment also showed that distractors close to a word had a disrupting effect on performance, but only for some conditions. Lines and dots did not significantly prolong search time, whereas words and shapes did. This effect was not merely due to the quantity of the background (visual noise) on the page, as the condition where the page was entirely covered with triangles did not produce significantly different effects from most other distractors.

It could be argued that for the two distractors which were most disruptive (the horizontal words of the same type) it was possible that there was confusion as to which of the pair of words had to be searched and so took longer. There is no way this could be refuted from these data, but it seems an unlikely explanation. It should be reemphasized that instructions stated very clearly that it was the right hand word of the pair that had to be searched and examples were constantly visible on the blackboard.

These findings show that the time for reading words in an irregularly placed display is prolonged by a proximity effect of words and shapes of a similar size to the letters. This explanation should be contrasted with Bouma's observation that interference in visual search is specific, that is, targets are particularly hampered by backgrounds of a similar size and shape (Bouma, 1976). To clarify this point it is necessary to examine some of the details of the visual search process. A word is fixated and simultaneously, from clues in peripheral vision, the next fixation point is decided upon. The eyes then move to that point. If it is clear from clues in peripheral vision that an object is not the target, it is ignored and the eyes are placed somewhere else. On the other hand if that object in periphery cannot be distinguished from the target it must be fixated. It is this discrimination that largely determines the number of words fixated.

Visual search time (time taken to find the target) depends on both the number of fixations and the mean length of fixation (Gould, 1967; Phillips et al., 1978). Bouma's interference effect in visual search is the inability to distinguish target from background in peripheral vision, which results in an increase in the *number* of fixations made. On the other hand the proximity effect reported here results in an increase in the *duration* of fixation.

Theoretical considerations

To find the possible cause of this proximity effect, it is helpful to look at some of the theoretical work on visual perception. The first possibility is a masking effect. When identifying a word the first letter is of particular importance (Eriksen and Eriksen, 1974, Phillips et al., 1978). If the position of this letter is indistinguishable in periphery, the eye fixation for that word is likely to be misplaced, which in turn will prolong recognition. This masking in periphery has been well described by Bouma (1976). A second possibility is that the eye is correctly placed, but that the surround material although distinct is close enough to prolong the processing time (Eriksen and Hoffman, 1972).

How do these ideas apply to the results? Where the distractors are very different in shape to the word they have little effect on either stage. They do not mask in periphery, nor do they prolong processing to any great extent while in central vision. On the other hand when they are of similar shape, but placed at the end of a word, they can only affect the latter processing stage. When the distractor is at the beginning of the word, but some distance away, it is probable that again only the central vision processing stage is prolonged. This would explain why the mean fixation time is the same as for similar distractors at the end of the word. However, when the distractor is close to the beginning the effect is more complex and there are at least three possible explanations. First the fixation may be incorrectly placed for the reasons stated above. A slight eye movement of a few milliradians of arc may then have to be made to the first letter. Such tiny moves have been reported in reading by McConkie (1979). A second possibility is that the eyes are not adjusted, even though they may be fixating the wrong position. Consequently, the first letter could be processed as if it were somewhere within a string of letters and would therefore require more processing time (see Wolford and Hollingworth, 1974). A third possibility is that the word is correctly fixated, but that processing is less efficient possibly due to masking effects of the distractor which flanks the first letter. Most masking studies have found the effect to occur in eccentric vision, but there is evidence also for a foveal occurrence of this phenomenon (Flom, Weymouth, and Kahneman, 1963; Loomis, 1978). This third possibility may be synonymous with the second. It is obvious that more experiments are needed to clarify all these uncertainties.

However, what does seem clear is that there are at least four stages to the word recognition process. (1) The word is located in periphery. (2) The beginning of the word is identified, either in peripheral or central vision. (3) The surrounding distractors are ignored. (4) The word is identified. Distractors can cause the prolonging of stages two or three.

Practical application

For optimum performance in searching for a word it is important that the beginning of the word is well clear of other material that is similar in shape, or size. The rest of the word should also be kept as clear as possible to aid speed of processing. It would seem particularly important that these recommendations are followed in a complex display like a map, where there is no fixed order of reading. Examples of the optimum positioning of type proposed by Imhof (1962, 1975) are usually, but not always, in keeping with this recommendation. Unfortunately, many cartographers do not follow his example. The following examples of poor positioning of type often found on maps will illustrate the point. An unfilled circle can be a strong distractor (see Figure 3), but it is widely used as a town symbol and all too often the corresponding name is placed directly to the right. It is precisely this arrangement which was found to delay recognition. A more legible alternative would be to use a filled circle as the town symbol and to move the corresponding name slightly up, or down. Names are also to be found to the right of a knotted complex of roads, or other symbols and names.

Street maps contain many examples of bad type positioning. Very often the first letter of a name is less than a millimeter from another word. In the light of the above results it seems probable that the presence of this initial letter is then not distinguishable in peripheral vision. If in addition the whole name is cluttered by surrounding words, the chances of this word being decided upon for the next fixation would be slim, as there would be many other words in periphery to choose from. Under such crowded conditions, people may simply miss the fact that a name is there at all. This would explain why some words take so long to find. The area would have to be searched several times, each time more thoroughly.

It is likely that these findings are also important for other types of displays, such as directional signs and advertisements, where it is desirable to fixate a number of fairly randomly arranged words. A quite different display pattern where a similar location problem seems to apply is the arrangement of a list of bibliographies (Spencer, Reynolds, and Coe, 1974). The best arrangement for ease of search was where there was a distinction a) between successive entries and b) of the first word of an entry. This was best achieved when the first word of an entry was extended to the left by two letters, so hung out into the margin making it completely uncluttered.

There seem to be two main findings from this experiment: (1) The position of type does have an important effect on detectability. The less cluttered the word, especially the initial letter, the more efficient the recognition. (2) When looking at the cause for variation in visual search times, it may be important to look at the duration, as well as the number, of fixations.

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