Left or Right? Spatial Arrangement for Information Presentation on Large Displays

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Abstract

Paradoxically, recent increases in the physical size and resolution of displays have introduced new challenges for interface design over a wide field of view. Since the visual system processes information very differently depending on whether it is presented in the central or in the peripheral regions of the visual field, the effectiveness of our ability to process information at large visual angles is largely unknown. Whether processing capability varies significantly in the periphery of computer displays is an unsettled question. An answer to this question could guide the development of best practices for the spatial arrangement of information in large displays. In our experiment, we show that information presented in the left visual field is processed faster and more accurately than in the right visual field. This difference suggests that more important information and data requiring immediate attention or rapid processing should preferably be presented in the left visual field. We discuss potential applications of our results using the dashboard interface with two examples: real-time stock market monitoring and the arrangement of gadgets on personalized pages.

1 Introduction

The size of computer displays has increased substantially in recent years. Benefiting from the rapid development of graphic processing power and declines in manufacturing cost, large computer displays are increasingly affordable and available. Ten years ago, almost everyone was using a 15-inch monitor; nowadays, a 30-inch display is not uncommon. In fact, many enthusiasts are not content with a single large monitor but expand their display area even more by using multiple monitors. Some manufactures build large seamless screens from smaller ones to satisfy the demand for screen area. The total size of such setups can be considerable, e.g. 50 inches diagonally when three 20-inch monitors are horizontally fused together in a gentle curve. These increases in physical size have led to larger horizontal visual angles. If we take 35 inches as a typical viewing distance from the user to the display, a 30-inch monitor would subtend a horizontal visual angle of 41^o (Figure 1), compared to only 19^o for an older 15-inch monitor. Given that our high-resolution central vision only covers about 5^o visual angle [1], a much larger viewing area now lies outside the center of our visual field. Important features and objects in the display can now be more than 20^o or even 30^o away from the observer's central field of view, whereas, with yesterday's monitors, peripheral objects were never more than about 10^o distant.

The popularity of large displays is presumably a reflection of greater user satisfaction; however, these improved displays also pose new challenges for interface design and research. Physically large displays can improve the user experience and performance on some tasks [2,3,4,5], possibly because users are more immersed in the task environment when interacting with a large display [3,5]. However, since most existing interfaces were designed for a relatively small screen, many usability issues have been identified when these applications are hosted on large displays [2,6,7]. For example, how best to manage multiple tasks on a large display with many active applications; how to minimize the time spent on resizing, relocating, and switching among task windows; how to reduce the overload on the user's memory during frequent task-switching; how to accommodate individual differences in the ability to distribute attention over a wide field of view [8,9]. Fortunately, efforts are already underway to develop effective design guidelines and new approaches to meet these challenges [2,3,6,7,9,10,11].

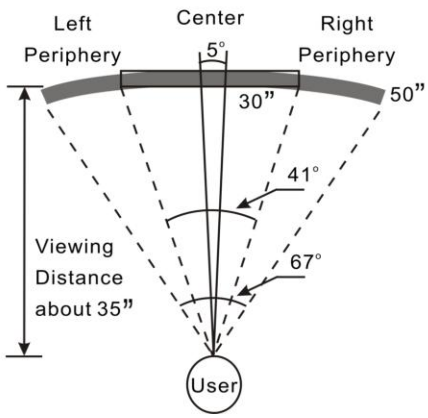

Figure 1. Visual angles subtended by 30" and 50" widescreen monitors at a viewing distance of 35".

To support the development of effective solutions to usability problems, knowledge regarding how information is processed in the visual periphery is helpful. Compared to central vision, processing in the periphery is less acute and accurate [10], but can be faster with some type of information [12] and more sensitive to particular properties of objects like motion [13]. These differences in perception are a consequence of the distinct brain mechanisms supporting the central and peripheral visual areas. Processing of information from the left and right visual fields is also managed, at least partially, by different brain structures. The brain is highly lateralized [15], with the right brain specialized for spatial tasks, while the left brain is more involved in verbal tasks. Because most visual information from one side of the visual field is processed in the other side of the brain [14], this asymmetry suggests that visual information from the two different sides of the visual field may be processed differently. If so, it would make sense to display important information in either the left or the right side of a computer display depending on which side was better suited for optimal performance of the task. However, if there are no significant differences in the speed and accuracy of processing between the two sides of the display, the arrangement of information could simply follow aesthetic considerations or personal preference.

In this study, we examined whether the ability to deploy attention is uniform across the peripheral visual field. Our study compared users' processing accuracy and speed in the left and right visual fields.

2 Method and Results

Our experiment investigated how attentional ability changes with varying eccentricity ($10^o/20^o/30^o$) from the central focus, exposure (time allowed for processing, 20ms/30ms/50ms) and side of the visual field (left/right).

The experiment adopted a well-established psychological paradigm for assessing attentional ability over a wide field of view. The Attentional Visual Field (AVF) task evaluates a person's spatial distribution of attention and the ability to pick out a target among distractors. The stimulus display consisted of twenty-four squares with each uniquely localized at an eccentricity of 10^o or 20^o or 30^o in eight equally spaced directions. One location was randomly selected for the target – a filled square surrounded by a circle. The other 23 locations were left for the distractors, which were unfilled squares. The stimuli were presented very briefly for 20ms, or 30ms or 50ms. On each trial, the participants were required to report the direction of the target. A sample trial is shown in Figure 2.

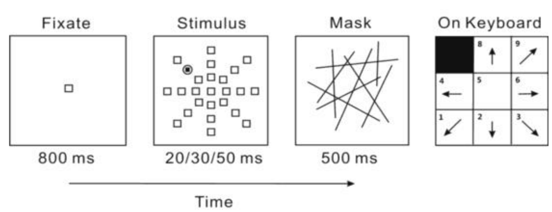

Figure 2. Attentional Visual Field (AVF) Task

Ten undergraduates participated in the experiment (all right-handed, normal or corrected to normal vision). Everyone completed the AVF task which consisted of 720 trials. The testing sessions were carried out in our lab and participants performed the task using a head/chin rest to insure accuracy of the desired visual angles of the stimuli.

We found that task accuracy decreases with an increase in eccentricity (70%, 65%, 50% for 30^o, 20^o and 10^o, respectively), $F(2,18) = 26.84$, $p < .01$, and shorter exposure (70%, 62%, 52% for 50ms, 30ms and 20ms, respectively), $F(2,18) = 41.37$, $p < .01$. Information from the left (directions 1,4,7 as illustrated in Figure 2) and right visual fields (directions 3,6,9) are processed differently, $F(1,9) = 36.58$, $p < .01$: with the left visual field being more accurate (Figure 3 left panel), and faster (Figure 3 right panel). On average, processing was 28% faster and 9% more accurate in the left visual field. The difference on accuracy is apparent at all eccentricities (but particularly at 20^o and 30^o) and also at all exposures.

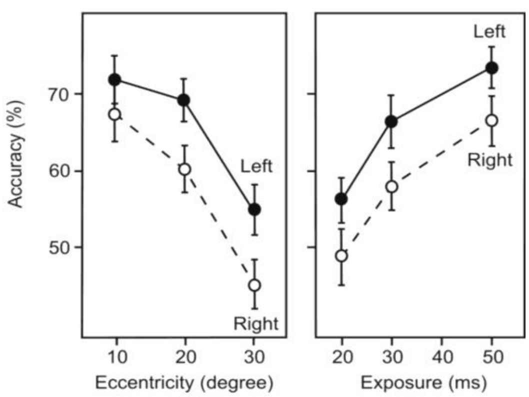

Figure 3. Accuracies in the left and right visual fields by eccentricity (left) and exposure (right).

Better processing performance is achieved when information is presented nearer to the center of the visual field and also when presented for longer. More interestingly, the left visual field shows an advantage over the right visual field in terms of both accuracy and speed. In practical terms, we are better at picking out a target among distractors when it is closer to the center of our visual field, or when we look at it for longer, or when it is placed to the left rather than to the right of our center of focus. Admittedly, since our participants were all right-handed, we may not claim that such results would apply equally well to left-handed population. Further exploration with left-handed participants is necessary. However, our results still have important implications for the design of large information displays, at least for the majority right-handed population.

3 Discussion

Our study has demonstrated an uneven distribution of the ability to deploy attention across the visual field: 1) attentional ability declines with increased eccentricity, that is, when information is presented farther from the central focus; 2) for the same eccentricity, information presented in the left visual field is processed more rapidly and also more accurately than in the right visual field. Hence, to optimize performance, information should be arranged so that it matches our natural ability to deploy attention. Analyzing parameters like the importance, relevance to the primary task, and urgency of the information would help to determine the most suitable location on the screen. We discuss possible applications of our findings in the content of dashboard interfaces, using two specific examples: window management in a stock monitoring application and the spatial arrangement of gadgets in a personalized page.

A dashboard is a type of interface that locates a variety of information in an organized and easy-to-comprehend arrangement. It is normally used to organize and summarize large amounts of data, to track performance, and to support decision making. It is widely used in areas like enterprise management, sales analysis, operations monitoring, traffic control, and personal task management. The information on a dashboard normally consists of several distinct content areas organized and arranged within a single screen.

For example, an air traffic control dashboard might include a summary of the traffic movements on the ground and in the air, a record of radio communications, and a variety of other relevant information, for example, changing weather conditions. Organizing different content areas properly is not always easy even though useful tools like IBMILOG Diagram for .NET are available to support this kind of task. The incorporation of additional design heuristics (based on empirical research such as ours) can increase the effectiveness of tools that are used to help build user-friendly dashboards. Our results suggest that the arrangement of the gadgets that communicate these parameters to the air traffic controller, could significantly affect the speed and accuracy with which the controller performs a variety of tasks that require accurate and timely awareness of changing parameters.

3.1 Stock Monitoring

A real-time stock monitor is a practical application where information regarding stocks, such as current volume and price, is displayed. Users may also be able to set alerts that monitor price, volume, and gains or losses. Multiple windows are normally a feature of stock monitoring applications and important information is presented over a wide field of view. Effective monitoring usually requires the user to distribute attention over multiple windows where numerical data and trend graphs are changing dynamically (Figure 4).

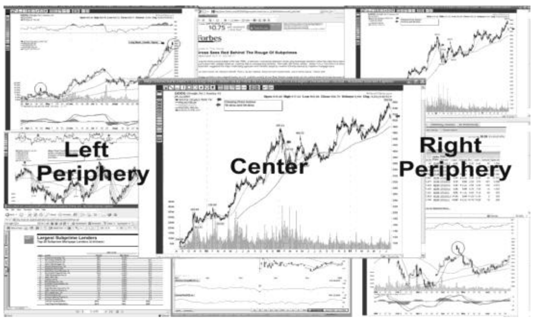

Figure 4. A typical multi-window stock monitoring application. The display area is divided into left periphery, center, and right periphery.

Stock monitoring displays are generally quite cluttered with many pieces of information presented simultaneously. Some information will be important to the user, but much of the data will be of no great concern since it does not relate to the user's current interests or investments. The user's task is to notice and distinguish the relevant data from the irrelevant; in other words, to selectively attend to the targets among the distractors.

Although a physically larger screen allows more windows to be shown with less spatial overlap, it also expands the visual area to which the user must attend. Given the amount of information presented, and its dynamic nature, successful detection of useful information can be difficult, particularly if the spatial locations of windows are not properly organized.

Our results suggest guidelines for the proper spatial arrangement of windows in a stock monitoring application. First, we assume that the current task window(s) should occupy the center of the screen. This will be the normal situation for most analysts who will naturally deploy their attention close to the central focus. When important events unrelated to the current task occur, alerts (based on pre-specified user preferences) will be triggered. The window(s) containing the alert information should be displayed to the left of the current task window, so that it is more likely to capture the analyst's attention. Other windows which contain less important information that does not require immediate attention should be placed on the right, where less important changes will be less likely to disturb the primary task. Of course, such a scheme implies that the importance of events may be automatically prioritized. As always, it obviously makes sense to present the most important events or information in the center, thus pre-empting the current task. However, less critical, but still important information should be presented at left rather than on the right.

3.2 Personalized Page

The placement of application gadgets in a personalized page is another area where the location of objects may be optimized across a wide field of view. Gadgets are placed on the page because they are relevant to the user's interest or planned task activities. For example, in Figure 5, the page includes email, message, map, and other gadgets. The gadgets provide direct simultaneous access to several different kinds of information, which can reduce the time needed to find particular facts and figures. Changes in information are often of most interest; for example, the notification of a newly arrived email or instant message. However, as the number of gadgets increases, noticing the important information becomes progressively more difficult for the user, particularly when the spatial arrangement is not compatible with human attentional abilities. Usability problems become more likely and can lead to declines in performance.

Figure 5. An example of desktop personalized page with multiple customized gadgets. The display area is divided into left periphery, center, and right periphery.

Ideally, the location of each gadget should depend on its relevance to the current task, the importance of the information it displays, and the urgency of a response. Applications like the clock, calendar, weather report, or media player should probably be placed on the right side of the screen, unless, of course, one of these conveys information that is critical for the user's current task. Gadgets that convey more important changes (for example, movements in the price of critical commodities or exchange rates) should be placed on the left, thus making the change more noticeable. Similarly, email, instant messenger or reminder notifications may be placed at left, depending on the user's preferences regarding the general urgency of such interruptions. And, again, it obviously makes sense to place gadgets that are important for the successful completion of the current task, near the center of attention. When no longer needed, these application widgets should yield the central space, moving left or right, depending on their likely future importance.

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