Using Delboeuf’s Illusion to Improve Point and Click Performance for Older Adults

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Abstract
Older computer users often exhibit poorer performance in point and click tasks on a computer than younger adults. This paper reports on the first phase of research that examines whether a visual illusion that makes an object appear to be larger (Delboeuf’s Illusion), can help to improve point and click performance for older computer users. In this first phase, we look at the effect sizes for different configurations of the Delboeuf illusion. The results will inform the design of a second phase, in which the configurations which demonstrate the largest effects will be investigated using a Fitts’-style study of pointing performance.

Author Keywords
Older adults; Delboeuf’s illusion; point and click performance; visual illusions

ACM Classification Keywords
H.5.2. Information interfaces and presentation (e.g., HCI): User Interfaces – graphical user interfaces (GUI), input devices and strategies, screen design, theory and methods.

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Introduction
As the worldwide population grows older, there is an increasing interest in providing better access to computer systems and the Internet for older people and the benefits they can afford [2]. But studies have consistently demonstrated that older people (particularly novices) have difficulties with point and click tasks on a computer, such as the selection of on-screen targets [14]. As Wood et al [19] note: "...one of the first challenges seniors encounter with computers involves navigating the use of the input device."

Although experience is a factor, many of the difficulties experienced by older people can be attributed to age-related declines in perceptual function, and a reduction in motor control and coordination. Difficulties are also exacerbated by impairments such as essential tremor, arthritis and Parkinson's disease.

Target selection tasks can be modeled using Fitts' law, which suggests that pointing performance can be improved if targets are either brought closer or targets are made larger [4]. Since the reaction time to visual stimuli reflects their perceived size, rather than their retinal image size [15], movement time performance should improve for a target that is perceived to be larger.

Visual illusions have been shown to improve performance in manual targeting tasks [16, 5] where the size of a target was made to appear larger by the addition of small circles surrounding the target (Ebbinghaus illusion) or the addition of a concentric circle (Delboeuf's illusion). For example, both [16] and [5] found an improvement in movement times in a manual pointing task (i.e. physically pointing to a target with the finger) when using the Ebbinghaus circles illusion.

This paper reports on the first phase of a two-part study which investigates the potential of Delboeuf's illusion to improve point and click performance for older computer users. The prediction of the study is that on-screen targets which are perceived to be larger (due to Delboeuf's illusion) will produce an associated improvement in point and click performance.

In this first phase we look at the illusory effect size(s) when using different configurations of stimuli, and how this interacts with age group. In the second phase we will use the configurations which exhibit the largest effects in a series of basic point and click tasks to see what impact the different configurations have on performance.

Background
Age-related changes in movement control can affect point and click performance using a device such as a mouse, resulting in longer movement times and a greater number of errors, such as slipping off a target [14, 7]. Slower movements could be explained by an increase in the noise to force ratio and less efficient perceptual feedback [18], or as a result of pausing more frequently during a ballistic movement [7].

Age-related declines in spatial ability could affect target selection, and reduced speed in translation tasks might help to explain why older adults experience more difficulties with a pointing device than younger adults [13] In general, older users have more difficulty homing in on a target, take longer to move the mouse
pointer over the target and are prone to slipping off a target before it has been selected [e.g. 10].

Techniques have been devised to help improve point and click performance, such as expanding targets [9], sticky targets and area cursors [20]. For instance, Worden et al [20] showed that area and bubble cursors can help to improve targeting by providing a larger activation area over a target. Sticky Targets modifies the pointer gain so that the pointer moves less in response to the mouse movements so the target is perceived as larger in motor space. Applying Fitts’ law, techniques in which the targets are made larger, or made to appear larger should help to improve pointing performance.

The Delboeuf illusion is a perceived change in the size of a circle or disk (in this case a central black disk) in the presence of a concentric circle. Delboeuf originally proposed 4 hypotheses concerning disks and concentric circles [11] two of which were used as the basis for this study (1) The outer ring makes the central disk appear smaller than it really is; (2) The illusion varies as a function of the diameter of the outer [or inner] rings. In Figure 1 the black disk on the right is perceived to be larger than that on the left.

People are most susceptible to Delboeuf’s illusion when the ratio of the diameter of the central disk to the diameter of the outer circle is close to 2:3 for an overestimation or 1:3 for an underestimation [see 6, 17, 1]. Other estimations have been suggested (e.g. Morinaga [cited in 12]) but as we are primarily interested in the overestimation of the size of a target, we have chosen the ratio of 2:3 suggested by [17].

Fitts’ law tells us that the pointing movement time is dependent upon the distance to the target and the width of the target [4]. As the perceived size of a stimulus increases, reaction time decreases [see 15]. Thus, reaction time will be less if a target can be designed so that it is perceived to be larger. Put another way, the reaction time to visual stimuli reflects the perceived size, rather than the retinal image. Thus Fitts’ law would tell us that movement time performance should improve for a target that is perceived to be larger.

When Delboeuf carried out an experiment on a group of people from 20 to 80 years old in 1865 to test his hypotheses, he did not find that age had an effect on the illusion. However, more recent studies have shown that age could be a factor in the perception of visual illusions based upon size-contrast or assimilation. For example, in a study by Lorden, the magnitude of the Delboeuf illusion was found to be stable in adulthood, but increases in old age [8] and Doherty et al. [3] found that the Ebbinghaus illusion had a greater illusory effect on adults than young children when discriminating circle sizes. These findings suggest that visual illusions could be selectively advantageous to older computer users in the display of interface objects.

**Experiment**

In this experiment two groups of participants (young adults and older adults) were shown a series of visual objects consisting of three black disks on a computer screen, each having either no concentric circle, a small concentric circle or a large concentric circle (see Figure 2 for an example). The disks/circles adjacent to the centre disk/circle were of identical configuration, but
could be different to the central disk/circles. A summary of each condition is shown in the sidebar.

Although we were principally interested in overestimations for this study (to produce the Fitts’ law effects), both overestimates and underestimates were studied. The size of the central disk could be changed from a minimum of 24 pixels (slider far left) to a maximum of 70 pixels (slider far right) using a standard Windows slider control. The minimum value was chosen to be half the original size, and the maximum value chosen to be the largest diameter that would just lie inside the small concentric circle.

Participants
15 older adult volunteers (5 male and 10 female, aged between 54 and 73, mean age = 61.8 years) and 15 younger adults volunteers (10 male and 5 female, aged between 20 and 28, mean age = 22.8 years) participated in the study. All participants had experience of using a computer and could manipulate the slider control on the screen using a mouse without difficulty. All participants had normal or corrected to normal eyesight, and stated that they could clearly see the objects presented on the screen.

Experimental Conditions
Nine conditions were presented, which differed in the configuration of the small or large concentric circles, and were chosen so that they covered all permutations but keeping the outside disks/circles the same. The left and right black disks were fixed at 48px in diameter, which is consistent with the standard icon sizes in Windows. The concentric circles had diameters of 144 pixels and 72 pixels, and were based upon values suggested by [17] to produce underestimations and overestimations respectively.

Figure 2: The three disks (in this case condition 5), the slider control that changes the size of the centre disk, and a button which is clicked when the participant has completed the task.

Method
Participants were initially interviewed to ascertain that they could use a mouse without difficulty and reveal any health-related conditions that could affect their participation in the study. Each participant was then asked to perform ten blocks of nine trials. A short practice session (not included in the results) of three trials (using conditions 1, 3 and 5) was provided at the start of the session to familiarize participants.

In each of the ten blocks, the nine conditions were displayed in a random order. Each participant was asked to use the slider control to adjust the size of the central disk so that it appeared to be the same size as the two adjacent black disks (see Figure 2). Once satisfied with the size, they clicked on a button labeled ‘Done’ situated beneath the slider control. This blanked
On the screen (black) and saved the data to a file, and a second click then revealed the next condition.

**Results**
In all three of the baseline conditions (Cond 1, Cond 2 and Cond 3) both younger and older adults on average perceived the central disk to be within 1 pixel of veridical. Thus, differences from veridical in the other conditions are not due to response biases.

Both older and younger participants perceived Cond 4 as larger than veridical (older group $t(14) = -6.6, p < 0.05$; younger group $t(14) = -5.0, p < 0.05$) when compared with base condition Cond 1. Similarly, both older and younger participants perceived Cond 7 as larger than veridical (older group $t(14) = 6.6, p < 0.05$; younger $t(14) = 2.7, p < 0.05$) when compared with base condition Cond 1, but the effect was much more pronounced in the older group (perceived as 4% larger for the younger group vs. 12% for the older group), and the difference between the two groups was significant by independent samples ($t(28) = 2.9, p = 0.007$). These results support the initial prediction that on-screen targets will be perceived as larger due to Delboeuf’s illusion, and also suggests that the effect is larger for older adults than younger.

**Implications and Future work**
The purpose of this first phase study was to (1) find out which of the conditions produced the largest effects for older people; (2) get an idea of the size of those effects. In Figure 3 it can be seen that conditions 4, 5, 7, 8 and 9 produced large perceptual biases. With Cond 4, both groups of participants overestimated the diameter of the central disk by more than 4 pixels (8.3%), and in Cond 7 the older group overestimated the diameter by almost 6 pixels (~12%). Applying Fitts’ law to the latter overestimation, with distance $D = 700$px and Width $W = 48$, the index of difficulty would decrease from 3.96 to 3.80.

In the second phase of the study (currently underway), we compare the performance of target selection based upon conditions 4 and 7 against a base target (as in condition 1) in a Fitts’ law targeting task. With the perceived overestimation of target size found in this current study, we expect to find performance improvements in target selection, in accordance with the observed overestimation of disk size.

**Conclusions**
The Delboeuf illusion shows an overestimation for two conditions, with over 8% in Cond 4 for both groups and 12% in Cond 7 for the older group. In all conditions the older group showed an equal or larger perceptual bias than the younger group. The latter suggests that the benefits of using the Delboeuf illusion in interface design could offer greater benefits for older people, taking advantage of age-related changes in perception.

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References