Enabling Health Literacy for Older Adults Through Anamorphic Perspective

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ABSTRACT

The US Institute of Medicine defines health literacy as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions." As more health resources move to computer access it is important that people are able to obtain the information and understand it from computers. This is especially important for older adults that might be less able to read and understand health resources from a stationary or bedridden situation. In this paper, we describe a new visualization technique for helping stationary older adults better read from computers. We use the concept of anamorphic perspective and large displays to extend stationary adults' reading area thus allowing the benefits of large displays from a stationary position. We present two experiments on the technique and show that it has potential to help stationary individuals read from far away distances.

Categories and Subject Descriptors

H.1.2 User/Machine Systems: *Human information processing*

General Terms

Performance, Human Factors.

Keywords

large displays, older adults, bedridden

1. INTRODUCTION

The US Institute of Medicine defines health literacy as "the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions" [5].

For better or for worse, more and more health related information is moving to computers and the Internet. For example, recent studies show that over 80% of Internet users have looked online for information about any of 15 health topics such as a specific disease or treatment [6].

However, using the Internet for older adults is not necessarily an easy task. For example, a study on web usability for older adults seeking online health resources found from 125 web sites that offer health resources that most of the site were not "senior-friendly" and only 12% of them offered a Spanish version [3].

An outcome of those websites not being "senior-friendly" – or what we call usable – is that information that might exist on the websites is difficult or impossible to obtain. If the website is unusable then the information is not obtainable, therefore there is no understanding.

As an example, according to Kutner, high blood pressure is the most common chronic disease treated by doctors in the black community. Also, the rate of death from the effects of high blood pressure for black people is nearly one and one-half times the rate for Caucasians. Kutner blames low health literacy rates among the black community as the main reason for differences in the rate of death between the races [11].

Based on Kutner's results with high blood pressure in the black community, low health literacy can equate to loss of life. There are very little things that a person might hold more precious than their own life. The most striking argument that Kutner makes is that many of the high blood pressure deaths are preventable.

Where do people get health related information? In today's world, people are likely to get it from the Internet after their doctors [6]. Based on that research and trends in computers, a key point about health literacy is the following:

Whether society wants it or not, information is going digital.

Our research is based on providing better health literacy for older adults, particularly stationary adults. Example targets are older adults that are bedridden, are in wheelchairs, or have low mobility.

Specifically, this paper addresses increasing readability in remote projections, which could have implications in interface design. We show how readability is increased and larger areas of wall space are utilized. We promote the idea that this can help bedridden and stationary individuals better use their environment.

1.1 Large Displays and Anamorphosis

We propose a solution to help improve health literacy among stationary people, particularly older adults, by combining modern projector technologies with a sixteenth century art technique called anamorphic perspective.

Large displays are becoming more common and have shown enormous potential (e.g. [16, 23]). For example, Ball, *et al.* [2] report up to a ten times performance increase with certain tasks

PETRA '13, May 29 - 31 2013, Island of Rhodes, Greece

http://dx.doi.org/10.1145/2504335.2504341

when using physical navigation. The increased physical navigation (e.g. walking, crouching) allowed participants to make better use of spatial memory and optical flow.

However, when the user is stationary many of the benefits of large displays are diminished. Shupp, *et al*. report on a study comparing large, circular displays to comparable flat displays. For flat wall-sized displays, where people were seated in a fixed location, they found a threshold of human vision where participants did not use part of the display. As a result of staying in a fixed location, large flat displays become underutilized [18].

A simple example of diminishing returns with large displays from a stationary position can be seen in hallways. A person standing at one end of a hallway may have trouble reading writing on walls from far away. The closer the person comes to the writing the easier it is to discern the words, the farther away, the harder it is. In other words, there are human perceptual limits with large displays [23].

Artists have known about human perceptual limits for centuries. In order to overcome these limits artists have created what is now known as anamorphosis or anamorphic perspective.

A simple example of anamorphic perspective is shown in Figure 1. The same text is shown in Figure 1.a and Figure 1.b. The reader can view the distorted text (Figure 1.b) normally by viewing the paper (or the computer screen) from the side at nearly an oblique angle.

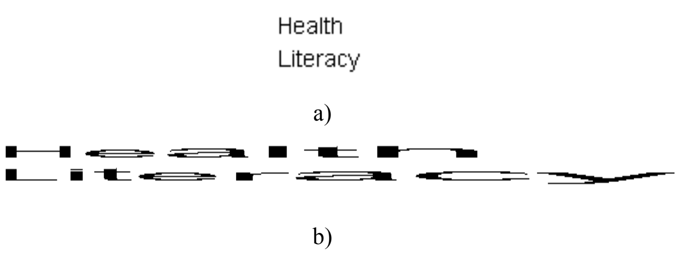

Figure 1 a) Normal, non-distorted text. b) Distorted, anamorphic perspective text.

In a treatise on early modern theories of perspective, Lyle Massey explains the connectedness between the view (the piece of art) and the viewer in the following (italics added) [13]:

> Perspective presents the viewer with neither a purely rational, geometric transliteration of optical experience nor with a true, objective point of view. At the same time, however, we cannot say for certain that perspective is false, or ideologically circumscribed. This is because *perspective identifies the viewer as a node* in a structural configuration that contrasts subject to object, seeing to being seen, and the world to the self.

In other words, perspective is created with the viewer's position in mind. Whereas a traditional Greek sculpture is presented as a facsimile or reproduction of the real thing, perspective is designed to accommodate the user's view.

The Jesuit Gaspar Schott coined the term anamorphosis in 1657. Before that time it was often referred to as distorted perspective or curious perspective. Anamorphosis was studied in the sixteenth and seventeenth centuries and then largely ignored until the latter part of the twentieth century [13].

At its simplest, anamorphic perspective is simply stretching an image so that it appears distorted from one angle and appears normal from another angle. Perhaps one of the most famous uses of anamorphic perspective belongs to Hans Holbein the Younger who in 1533 painted *The Ambassadors*.

The Ambassadors is a well-known painting in the London National Gallery that shows two men standing with different artifacts of their lives between them. What usually draws attention to the viewer is a diagonal line at the bottom of the picture that often appears to be driftwood. Viewing the "driftwood" from an acute angle from the top right of the painting the viewer can see that the "driftwood" is actually a skull.

1.2 Application of Anamorphosis

Leaving behind the field of art, one can take the idea of anamorphic perspective and use it to benefit stationary older adults. Coupled with large displays the technique has enormous potential to overcome human perceptual limits.

In this paper we show how large displays can be better utilized using anamorphic perspective to extend the usable area by stretching text and graphics. By using interactive anamorphic perspective we show how stationary users can extend their surroundings to be more useful to them.

Health literacy is based on obtaining, processing, and understanding basic health information in order to make appropriate decisions. In a bedridden or stationary situation it can be difficult to read all the information that an older person might need in order to make difficult decisions.

By displaying the information on walls using projectors, or similar technology, older adults can use the benefits of large displays. By stretching text that is too far away to see due to perceptual limitation anamorphic perspective can be applied to text and graphics are they are farther away.

We introduce interactive anamorphic perspective because if the user were to move an application from one side of the wall to another then the text and graphics inside the application would automatically stretch based on the distance of every pixel from the user's physical location.

At this time we are unaware of anyone using the idea of interactive anamorphic perspective for assisted living. In the rest of the paper we present our preliminary results from our interactive anamorphosis prototype.

2. Related Work

Do older adults read faster than younger adults on a computer? It turns out that if the font size of the computer is sufficient for the older person's eyesight, then, yes, older adults do read faster than younger adults from computers. In addition, what most people don't realize is that reading from computers is not slower than reading from paper these days. With today's crisp displays, reading from paper and from computers does not provide a statistical difference in performance. While reading speed may not be statistically different, there is often a preference among older workers to read from paper instead of computer screens. The degree of preference is related to the amount of experience with reading from computers versus paper [1].

Although older adults generally read faster than younger adults, they generally only read faster on computers with large displays where the font size can be considerably increased [1].

The media generally reports that the Western World (and many parts of the Eastern World) has an aging population. In reality, it is not so much that people are not dying as much that people are not having enough children to take care of the older generations [21].

Regardless of the origin, the problem remains that there are more older adults than ever before. Also, the US National Center for Health Statistics report that 45.1 percent of individuals aged 75 and older possess at least one limitation caused by a chronic condition [9]. Obviously, there is a need to improve health literacy.

Much research has been conducted in human–computer interaction looking at the requirements, design, and evaluation of user interfaces for older adults. Studying older adults and their interactions with computers is particularly relevant given the decline that most older adults face in cognitive, perceptual, and motor abilities (e.g. [4, 17, 19, 20, 24]). Declines occur in many abilities that are important when using computers, such as episodic memory, vision (e.g., lack of contrast sensitivity, glare sensitivity), hearing, and the ability to use input devices. Research on interaction design for older adults includes research on providing more appropriate experiences on the web, speech interfaces, multimodal feedback, input devices, and the use of handheld devices (e.g., [7, 8, 12, 22]).

3. Prototype

For our interactive anamorphic perspective prototype we essentially recreated Notepad – a simple text-only application found in the Microsoft Windows operating system. Our prototype has two modes: anamorphic perspective mode and normal mode.

An imagined scenario for this prototype is for a bedridden user to have a keyboard and a mouse on his bed. Instead of a monitor, which is very difficult to use from a bed, the display is projected on the wall.

It is important to note that the hardware used to project the display on the wall is not important. Whether traditional projectors, near-throw projectors, or even OLED's are used, the technique works the same. In other words, the technology used to display information on the wall is irrelevant.

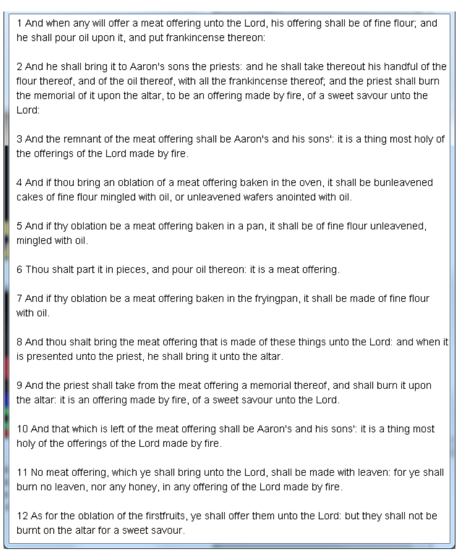

Figure 2 Screenshot of the text viewer prototype in normal mode. In this mode it is essentially a clone of Notepad from Microsoft Windows.

Figure 2 shows the prototype in normal mode. When the user drags the application farther away from his physical location along the wall the text becomes harder to discern. The text becomes more difficult to read the farther the text is from the user until the perceptual limit of the human eye is reached and the text is impossible to read.

From a third-person's perspective whose physical location is on the far side of the wall (far away from the user), as the application is moved away from the user in the bed and closer to the other person standing far away, the text becomes more clear as the text comes closer physically to the other person.

Figure 3 shows the prototype in interactive anamorphic perspective mode. When the user drags the application farther away from his physical location along the wall the text appears to be the same size as Figure 2 regardless of the distance.

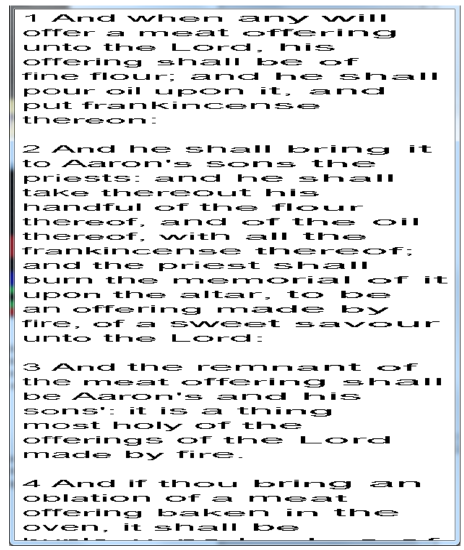

Figure 3 Screenshot of the text viewer prototype in interactive anamorphic perspective mode when the application is farther away from the user. From the user's stationary perspective the text appears to be the same size in Figure 2 and in Figure 3.

Note that the text in Figure 2 and Figure 3 is not what was shown to the participants – it is for demonstration purposes for this paper only.

The text is normal (not stretched) when the application is right in front of the user. When the application is moved farther from the user's physical location the text automatically stretches to make the text more readable from the user's stationary position.

From a third-person's perspective whose physical location is on the far side of the wall (far away from the user), the text is never easily read. When the text is directly in front of the user, far from the other person, the text is too far away to discern. When the application moves closer to the other person, farther from the bedridden user, the text is stretched and difficult to read.

4. Experiments

In order to test the technique of interactive anamorphic perspective we first created a text-based prototype that stretches text based on the user's position then we ran two experiments.

The first experiment was to understand how effective the technique could be on a range of ages; we focused as much on qualitative data as quantitative data. The second experiment was to more thoroughly test the technique with more participants.

4.1 First Experiment

In order to scientifically evaluate the effectiveness of our prototype an initial experiment was performed to determine the effectiveness of the technique. The experiment was a with-in subject experiment that included eight people ages 21 to 73; two were female.

We were especially interested in determining if the older adults could use the interactive anamorphic perspective technique. In addition, a range of ages was desired to see how the technique affected the overall population.

All participants used computers on a normal basis. All participants sat in the same fixed position in a normal office swivel chair (i.e. a chair that can pivot or spin).

For the experiment four projectors side by side were used that covered one wall. Each projector had a resolution of 1024 X 768. The participants were positioned in front of the first projector so that the other three projectors were to the participants' right. We focused the experiment mainly on the right side of the user to further emphasize how the technique could be used at farther distances. The participants were 16.6 feet (5 meters) from the right side of the last projector.

The experiment used a fully balanced Latin square design for ordering with text being shown on only one projector at a time. The experiment had each participant read text from the projectors then answer basic reading comprehension questions about what they read.

For the initial experiment participants were first given a practice reading from a projector. After the practice the participants then read text from each projector and answered questions about what they read. There were eight conditions: four projectors with the technique and four projectors without the technique (control case).

4.2 First Experiment Results

For this experiment we were particularly interested in the following two research questions:

- How does the interactive anamorphic perspective technique affect reading speed? This question focused entirely on how long it took the participant to finish reading the text.
- How did the interactive anamorphic perspective technique affect the time it took to answer questions about the text? This question focused on how well the participant was able to understand, internalize, and then answer the question.

For the reading task we performed a two-way ANOVA on the projector number (to give an idea of how distance affected the participant) and the technique. The result was a statistically significant ($p<0.05$) interaction and a main effect of projector number (distance of text from user) - see Figure 4.

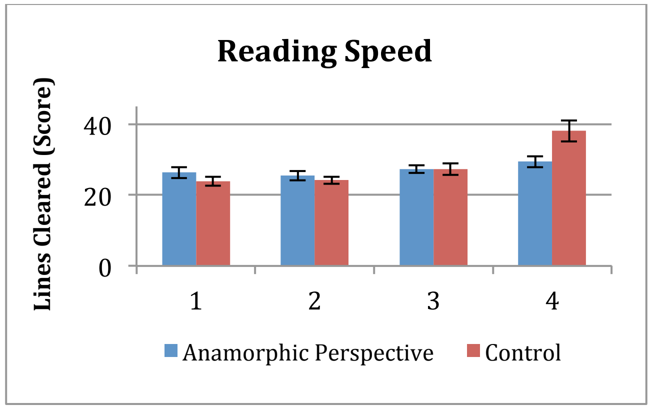

Figure 4. Quantitative results for the reading task. The error bars indicate the confidence levels of each condition.

For the answering questions task we performed a similar two-way ANOVA on how long it took the participants to answer the questions. The result was a statistically significant interaction, a main effect of projector number, and a main effect of technique - see Figure 5.

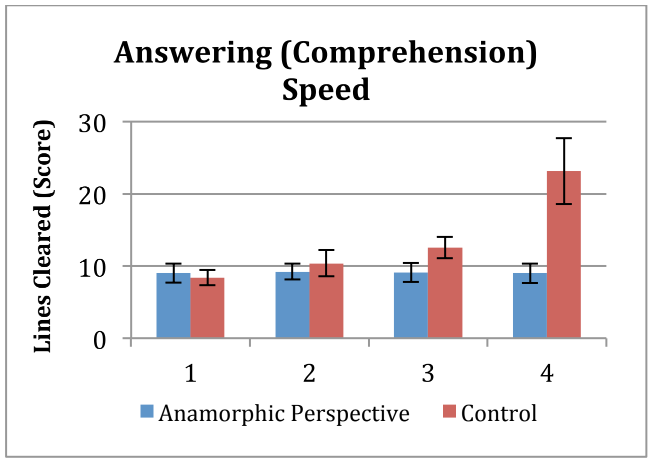

Figure 5. Quantitative results for how long it took to answer the questions. The error bars indicate the confidence levels of each condition.

Looking at Figure 4 the reader will note that the farther away the text was from the user the longer it took to read the text with the control situation. Looking at the trend for Figure 4 and Figure 5 there appears be an exponential increase in performance time in relation to the distance for reading comprehension. However, for the interactive anamorphic perspective technique performance speeds there appears to be a flat line.

Referring back to our first research question - How does the interactive anamorphic perspective technique affect reading speed? – it appears that the interactive anamorphic perspective technique has considerable effect in reading speed. In fact, there is no statistical significance in reading speed between any of the projector conditions for the interactive anamorphic perspective technique. On the other hand, for the control condition, the farther away the text, the slower it was for the participants.

Referring back to our second research question - How did the interactive anamorphic perspective technique affect the time it took to answer questions about the text? – we found that even though some people were able to "read" the text, the participants did not always understand what they read. The farther away the text was the less "reading" took place and the more "looking" at the text took place. In other words, for the far away projectors, especially projector 4, participants often had to decode the words letter-by-letter instead of word-by-word.

By adulthood people generally read by decoding what they see by large chucks - whole phrases and words. Reading letter-by-letter takes more time, takes a much higher conscious cognitive load, and results in less understanding [15]. The interactive anamorphic perspective technique appears to have greatly helped the participants.

It should be pointed out that the text on the second half of the fourth projector was much harder to read for the majority of the participants without the interactive anamorphic perspective technique. That distance was approximately the end of where most of the participants could see clearly given their visual acuity.

It appears that the farther away the text was from the participants the more effort they put into perceiving the words or letters versus understanding the content. As one participant explained about the fourth projector (the greatest distance away) when not using the technique, "I had to read word-for-word instead of reading the sentence."

Feedback from the participants indicates that the greater the distance of the text away from the control (normal) condition the greater the eyestrain. For example, one participant speaking of the text on the fourth projector with the control text said, "It hurts my eyes looking over there." They also indicated greater frustration, dissatisfaction, and the likelihood of headaches with long-term use.

On the other hand, for the interactive anamorphic perspective technique participants said, "The text appears to be the same on all the projectors," and "The other way is too squished, I can read this one fine."

4.3 Second experiment

The initial experiment gave promising results. However, with only eight people with a large range of ages we conducted a more thorough investigation. Specifically, we recruited thirty (30) additional participants all between the ages of 18 and 28.

In addition, we decided to focus on other research questions in order to refine our understanding. First, the initial experiment focused entirely on reading speed and the speed it took for the participants to answer the questions. Second, it only focused on purely textual non-graphical, non-rotating visual performance. As a result, for our second experiment we asked the following research questions:

- How does the anamorphic perspective technique affect reading speed?
- How does the anamorphic perspective technique affect reading comprehension?

In order to test the two research questions we tested the participants on more robust text. The initial experiment tested participants on text that was on average 96.5 words long and had an average Flesch Reading Ease Level of 45.4 (moderate to difficult reading level). The Flesch Reading Ease Level is an indication of the comprehensive difficulty level of a given text based on a scale from 0.0 to 100.0. The Flesch Reading Ease Level is based on a formula that takes into account total words, sentences, and syllables. The lower the number, the more difficult the text is considered.

In order to have a more robust experiment we used text that was on average 152 words long with a similar Flesch Kincaid score. This more robust experiment on reading more closely mirrors other research on reading from computers (e.g. [14]). We also tested our participants on two forms of comprehension: gist and cloze tasks. The gist task is a short answer quiz where the grader is looking to see if the reader got the gist - or main idea - of the article. The cloze task is a reading comprehension task that focuses more on memory than the gist task. Meyer et al. explained that the cloze task is "a measure of the word-level processing that occurred during reading from the different methods of display" [14] (p. 795). Specifically, every 10th word was removed from the articles, and participants were asked to replace those words. See Kintsch and Yarborough for more information about the cloze task [10].

Instead of four projectors we only tested the participants on three projectors for the second experiment. With longer text and two comprehension tasks we did not want to fatigue our participants. As a result, we were able to keep the second experiment to approximately one hour of duration. The participants were 21.9 feet (6.7 meters) from right side of the last projector.

The protocol for the second experiment also followed a with-in subject Latin square design. Each participant was given a practice reading sample, sample gist task, and sample cloze task before beginning the experiment.

4.4 Second experiment Results

For the second experiment we performed a two-way ANOVA on the projector number and the technique for the reading speed, the gist comprehension task, and the cloze comprehension task. The results for the analyzes of the second experiment was the same as the first experiment with a statistically significant ($p<0.05$) interaction and a main effect of projector number (distance of text from user).

We were able to reproduce the results from the first experiment regarding reading speed. Figure 6 shows the results for reading speed. Once again the interactive anamorphic perspective technique resulted in a general straight line suggesting that performance was not negatively affected as the distance away from the person increased.

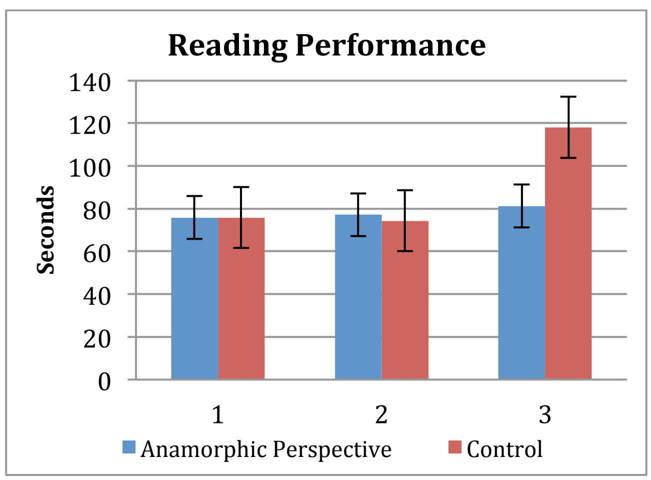

Figure 6 The results from the second experiment showing how the raw reading speed was affected by the technique and distance.

The reader should note that for the results from the first projector were approximately equal with and without the interactive anamorphic perspective technique. For the first projector even when the interactive anamorphic perspective technique was used, the text and graphics were so close to the participant that very little stretching was applied. In other words, for the first projector the text was virtually identical with and without the interactive anamorphic perspective technique, thus explaining why the scores were approximately the same.

Figure 7 shows the results from the second experiment showing how the gist comprehension of the text was affected by the technique and distance. There appears to be a general degradation of understanding of the text as the distance away from the user increased for the control. For the interactive anamorphic perspective technique there appears more a straight line or slight trend down. There is no statistical significance for the interactive anamorphic perspective technique for distance.

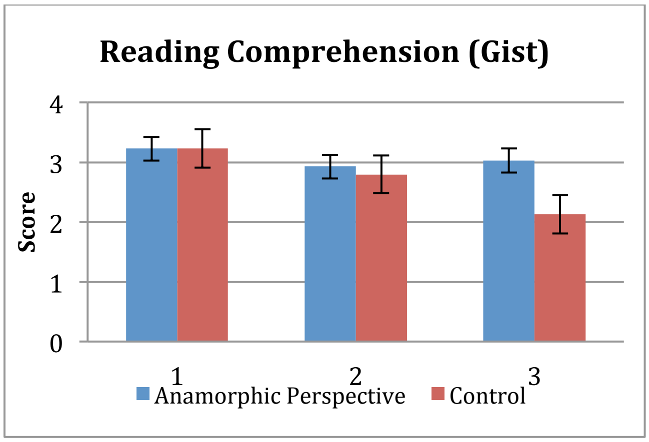

Figure 7 The results from the second experiment showing how the gist comprehension of the text was affected by technique and distance. Higher scores are considered better.

Figure 8 shows the same general trends as the gist comprehension task. That is, there was a general degradation of comprehension with the control and no statistically significant difference with the interactive anamorphic perspective technique.

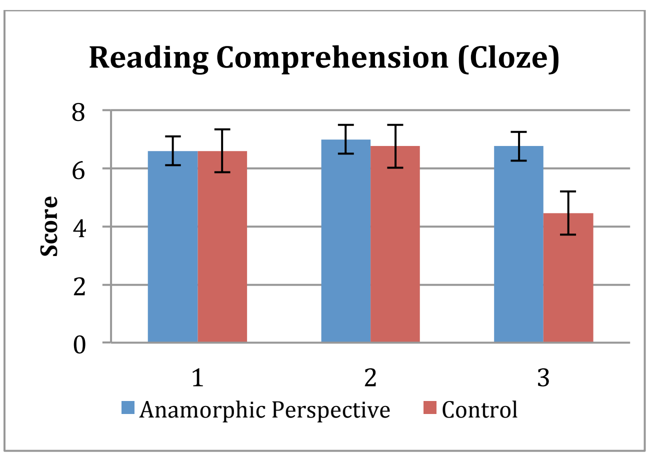

Figure 8 The results from the second experiment showing how the cloze comprehension of the text was affected by technique and distance. Higher scores are considered better.

In summary, we found that with reading speed and reading comprehension that the interactive anamorphic perspective technique outperformed the control the farther away from the user.

Two things should be noted. First, regardless of the task, the interactive anamorphic perspective technique helped the participants to effectively maintain the same performance level regardless of the distance away from the user.

Second, the participants' performance with the control (not using the interactive anamorphic perspective technique) appears to have an exponential drop off. The drop off occurs at the visual acuity distance of the individual.

We found no reason to scientifically show that the interactive anamorphic perspective technique performs better than the visual acuity of the participants (e.g. where they can no longer decode the text or graphics) because any performance is better than zero. In other words, after the visual acuity of the participants was reached, the interactive anamorphic perspective technique still worked, but there is no reason to scientifically compare it to the control because people cannot see the text.

5. Conclusion

Health literacy is the degree to which individuals have the capacity to obtain, process, and understand basic health information and services needed to make appropriate health decisions. As the average age of the world increases it is more important than ever to help older adults with health literacy.

In this paper we presented a new visualization technique that extends the useful area of a large display from a stationary position. The technique uses the idea of anamorphic perspective to distort text in order to help a stationary user read text from far distances.

We created a prototype that uses the technique and presented two experiments on the interactive anamorphic perspective technique. The experiments showed that the interactive anamorphic perspective technique outperformed the control and has the potential to help stationary individuals read from far away distances. This in turn has the potential to help bedridden individuals better use computers with their health literacy needs.

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