Strategic Promotion of Ageing Research Capacity

Improving Computer Interaction for Older Users: investigating dynamic on-screen targets

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Funded by

EPSRC Engineering and Physical Sciences Research Council

bbsrc biotechnology and biological sciences research council

June 2008

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Computers can help older people in many activities such as communicating with family and friends, accessing information about healthcare and community services, and booking air and train tickets. For some people, though, difficulties with mouse and cursor control can present a significant limitation to using a computer easily and effectively. This study investigated the response of older and younger users to various techniques to improve target selection on a screen using a computer mouse to "point and click". By using targets which expanded to a larger size, giving the user a larger area to click on, users were able to "point and click" faster and make fewer mistakes.

Key Findings

- Compared with static targets, typical of a "regular" computer interface, *expanding* targets (targets which expand to a larger size as the cursor moves towards them, giving the user a larger area with which to interact), provided a 13% improvement in the time taken to select, and a 52.4% reduction in errors made for both older and younger users.

- Compared with static targets, *proxy* targets (targets which are brought closer to the cursor, reducing the distance that the user needs to move the cursor in order to reach the target) had no effect on movement times for younger people, but resulted in a 12% increase in movement times for the older users. For both age groups, proxy targets had no effect on error rates.

- Dynamically expanding targets which expanded only after the cursor was already inside the original (smaller) target area enabled quicker movement times and a reduction in errors for both age groups. The improvement was approximately half of that observed for expanding targets where the expansion occurred before the cursor reached the target.

- These findings support the use of expanding targets as a method of improving target selection performance for older computer users. Further investigation of how to implement expansion for multiple targets is required, but these studies indicate that the use of dynamically expanding targets is a promising option.

- For older users selecting targets on a single screen, the use of proxy targets to reduce distance may not be an effective way to improve performance. However, a more detailed analysis of users' cursor movements in response to these proxies could suggest how the technique might be improved.

Introduction

The Issues

Older people use computers in many ways, for example, communicating with family and friends, accessing information about healthcare and community services, and booking air and train tickets. Using a pointing device, such as a computer mouse, to select targets on a screen is typically an integral part of computer use, but these pointing devices can be difficult to control. Compared with younger users, older people experience greater difficulties positioning the cursor, take longer making selections and homing-in on a target, and make more mistakes when selecting targets. These difficulties can present a significant limitation to using a computer easily and effectively. With target selection being such an important and frequent task, any improvements will have an impact on overall computer use.

Previous studies of techniques to aid target selection have shown the benefits for younger users, but the performance of older people has not been fully investigated. Compared with younger users, older people take longer to complete selections, so could potentially benefit. However, as they take longer to process information and require more time to respond to changes, they may find it more difficult to adapt to some new techniques.

The Aims of the Project

The aim of this project was to investigate how older people respond to techniques which are designed to improve performance in selecting targets on a computer screen. In particular, this project focussed on two techniques involving the use of *dynamic targets*:

- *expanding targets* - the targets expand to a larger size, giving the user a larger area with which to interact and to click on;
- *proxy targets* - the targets are brought closer to the cursor, reducing the distance that the user needs to move the cursor in order to reach the target.

The Technical Background

Performance in selecting a target using a mouse can be modelled by a mathematical equation known as Fitts' law:

$$MT = a + b\log_2\left(\frac{D}{W}+1\right)$$

where *MT* is the movement time, *D* is the distance to the target, *W* is the width of the target, and *a* and *b* are empirically determined constants. The logarithmic term is the index of difficulty (*ID*).

The difficulty of the movement is dependent on the target width and the distance to the target. The more difficult the movement, the longer the time it takes to make that movement.

This suggests two approaches for improving performance. Firstly, reduce the distance that the cursor must travel to the target (reduce *D)*; secondly, make the target larger (increase *W*). Directly changing *D* and *W* involves changing the position and size of objects on the screen. This may not always be possible, for example due to limitations in screen size, or desirable, where the spatial layout of the targets is essential. However, there is the possibility of indirectly changing *D* and *W* in ways that do not alter the visual layout of the interface.

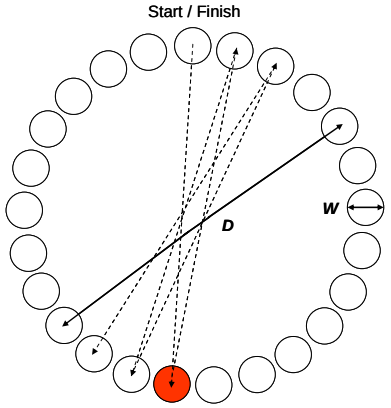
The Study

Three studies were conducted. The first two investigated expanding targets and proxy targets, with the aim of understanding how older people respond to these techniques, compared with younger people. The third study considered different types of target expansion, in order to investigate ways in which it could be practically used in real-life situations.

Study 1: Expanding Targets

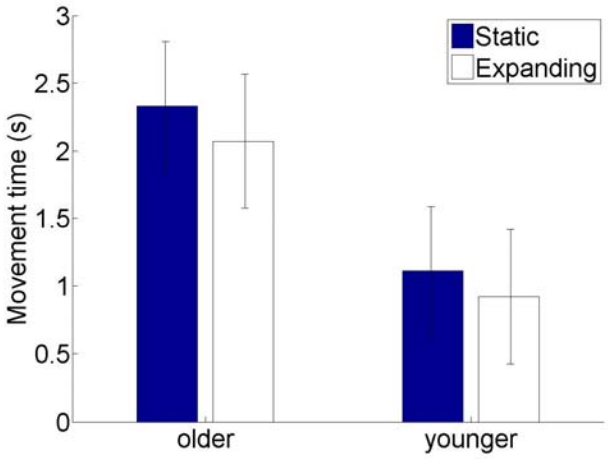
The aim was to investigate how older people respond to expanding targets, compared with younger people. The participants were 10 older people (average age 72 years; 6 female and 4 male) and 10 younger people (average age 24 years; 4 female and 6 male).

Using a laptop and an optical computer mouse, participants performed a series of "point and click" selections using a procedure recommended by the ISO 9241-9 standard for pointing device evaluation. Briefly, the participant had to select a red circle target, which moved around a circular shape on the screen (see below). Each participant performed this task for both *static targets* (where the target's width remained constant throughout a selection) and *expanding targets* (where the target expanded to twice its original width when the cursor crossed over 50% of the initial distance to the target). Performance between the two age groups and between the two types of targets was compared. Studies 2 and 3 used the same equipment and task.



The target selection task used in the studies. Users selected the target shown in red, with selections progressing around the circle in the sequence as illustrated by the arrows. *D* and *W* indicate the target distance and width respectively.

The older group of people took over twice as long as the younger group to complete the task, with overall average movement times of 2.2 seconds (older) and 1.0 seconds (younger). For both groups, selections were completed faster with the expanding targets than with the static targets. Overall average movement times were 1.5 seconds for expanding targets, and 1.7 seconds for static targets, an improvement of 13%. There were no differences between the older and younger age groups in how much benefit was gained from the expansion.



Average movement times for older and younger users and static and expanding targets. *(The error bars shown in this and other figures are the 95% confidence limits not the standard errors of the means).*

An error occurred when the user clicked outside the target. Error rates are the percentage of times an error occurred when making a selection. The older people made nearly three times as many errors as the younger people, with overall average error rates of 22.2% (older) compared to 7.5% (younger). For both groups, fewer errors were made when the targets expanded, with overall averages reduced from a rate of 20.2% for static targets to 9.6% for expanding targets. As with movement times, for expanding targets there was no difference between the groups in how much benefit was gained from the expansion.

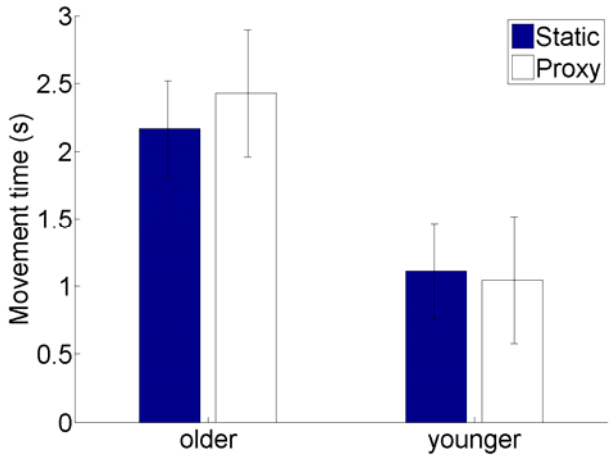
To summarise, compared with static targets, expanding targets improved performance both in terms of speed and accuracy.

Study 2: Proxy Targets

This study investigated how older people respond to proxy targets, compared with younger people. The participants included 11 older people (average age 70 years; 5 female and 6 male) and 11 younger people (average age 23 years; 1 female and 10 male).

This study compared *static targets* with *proxy targets*. With proxy targets, as the user begins to move the cursor towards the target, a copy of the target appears approximately 80% nearer to the cursor. Users can select this target in the same way that they would select the original target, but without having to move the cursor over the longer distance.

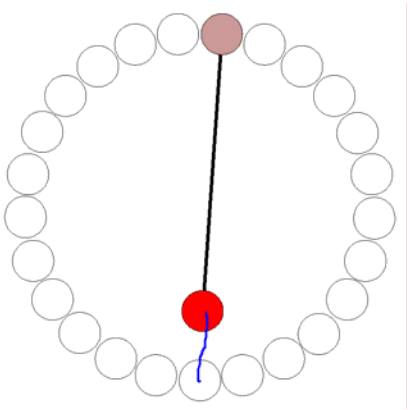
The older people took over twice as long as the younger people to complete the tasks, with overall average movement times of 2.3 seconds (older) and 1.1 seconds (younger). In contrast with Study 1, older and younger users differed in their responses to proxy targets. For the younger users, proxy targets had no effect on movement times. For the older users, however, average movement times for proxy targets were found to be 0.26 seconds or 12% *slower* than that for static targets.



Mean movement times for older and younger users and static and proxy targets.

The older people made nearly six times as many errors as the younger people, with overall average error rates of 11.3% (older) and 1.9% (younger). Although the finding that older people are more prone to errors than the younger people is consistent with that of Study 1, the actual error rates reported in Study 1 were much higher. The type of target had no effect on the error rates; that is proxy targets did not reduce errors.

The reasons why the proxy targets did not appear to help older users were investigated by examining the cursor trajectories. Perhaps users were not moving directly to the proxy target due to confusion about which target to aim for. However, on the whole, both older and younger users were able to interact with the proxy targets without difficulties. All participants were able to take advantage of the closer position of the proxy targets in the sense that there was a general tendency to move the cursor directly to the proxy, consequently reducing the distance travelled.



Sample cursor trajectories from one older adult In general, there was no confusion about which target, the original or the proxy, was to be selected and in most cases, users moved the cursor directly to the proxy target.

Although users were moving the cursor over a shorter distance this did not translate to an improvement in movement times. This may be because the older people tended to move the cursor more slowly when selecting proxy targets, to move in a series of small “hops” and to pause more frequently. This possible “hesitance” may be related to a lack of certainty about the final location of the proxy target or a need to shift the focus of attention from the original target to the proxy.

To summarise, for older people selecting targets on a single screen, the use of proxy targets to reduce distance may not be an effective way to improve performance.

Study 3: Different Methods of Expansion

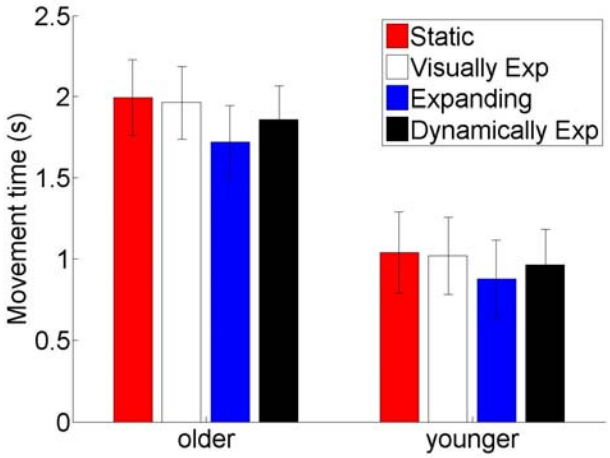
In Study 1, only a single isolated target was expanded. In a more realistic interface with multiple targets, there are difficulties with targets colliding with or hiding adjacent targets during expansion. Possibilities for using multiple expanding targets include *untiled targets* (these are separated by some “empty” space, such as icons spread out on a desktop) and *tiled targets* (where targets are next to each other without any space between them). This study involved 16 older people (average age 72 years; 10 female and 6 male) and 14 younger people (average age 22 years; 2 female and 12 male).

Each participant performed the selection task over four conditions so that different methods of expansion could be compared:

1. *Static targets* - the target's width remains constant throughout a selection. This was the control condition.
2. *Visually expanding targets* - the target expands to twice its original width when the cursor enters the original target area, and shrinks back to its original size once the cursor leaves the original target area. The resulting effect is that although the target is bigger visually, the area available for selecting the target does not change. This can be used with *tiled* targets.
3. *Expanding targets* - the target expands to twice its original width when the cursor is in the area that would be occupied by the expanded target, giving the user a larger area with which to interact. This is similar to the method of expansion used in Study 1, except that expansion occurs later in the movement. This method is intended for use with *untiled* targets.
4. *Dynamically expanding targets* - elements of (2) and (3) are combined. The target expands to twice its original width when the cursor enters the original target area and remains at its expanded size while the cursor remains within the expanded target. This gives the user a larger area with which to interact. This method can be used with *tiled* targets.

The effects of the different types of expansion were found to be the same for both groups:

- Visually expanding targets did not improve movement times compared with static targets.
- Expanding targets gave a 0.22 second or 14% improvement over static targets for movement time. This is consistent with the results of Study 1, but also shows that even when the expansion occurs this late in the movement, it can still be beneficial for older people.
- Dynamically expanding targets gave a 0.10 second or 7% improvement over static targets for movement time. Users still gained a benefit from the expansion, even though the expansion only occurred *after* the cursor was already inside the original, smaller target area. It may be that this type of expansion helps by eliminating the need to correct for the cursor overshooting the target. Although the degree of benefit is less than that observed for expanding targets, dynamically expanding targets can be used with *tiled* targets and so offer wider applications.



Average movement times for older and younger users for the four conditions.

As with the movement times, the effects of the different types of expansion on error rates were found to be the same for both groups:

- Visually expanding targets provided no improvement in error rates compared with static targets.
- Expanding targets provided an overall 51% improvement over static targets, reducing error rates from an overall average of 15% to 7.4%. Even when the expansion occurs this late in the movement, the expansion can still reduce the errors made by older people.
- Dynamically expanding targets provided a 21.2% improvement over static targets, reducing error rates from an overall average of 15% to 11.8%. As with the effects observed for movement times, although the improvement in error rates is not as large as that observed for "regular" expanding targets, the finding that this method can improve error rates is a step toward developing expansion techniques that are practical for *tiled* targets.

These results provide further support for the use of expanding targets in interfaces for older people, by showing the beneficial effects of expansion techniques that have the potential to overcome some of the challenges associated with multiple expanding targets.

Findings, Discussion and Implications

Key Findings

Compared with static targets, expanding targets provided a 13% improvement in movement times and a 52.4% reduction in error rates for both older and younger users. However, the use of proxy targets had no effect on movement times for younger people, but resulted in a 12% *increase* in movement times for the older people.

Even when the expansion occurred relatively late in the movement, expanding targets were beneficial for both age groups, providing similar improvements in times and reductions in errors as when the expansion occurred earlier in the movement.

Dynamically expanding targets which expanded only after the cursor was already inside the original (smaller) target area also provided improvements in times and reductions in errors for both age groups. With improvements of 7% for movement times and 21.2% reduction for errors, the effects were smaller than those observed for "regular" expansion.

Compared with static targets, visual expansion had no effects on times nor on errors.

Discussion and Implications

This project makes a contribution to the work of the human-computer interaction (HCI) research community through its investigations of *expanding targets* and *proxy targets* for older people. The studies provide evidence about how older people respond to these techniques when selecting targets with a pointing device. This information can be used to help further research on the development and use of these techniques in computer interfaces for older people. The technology which could potentially benefit includes not only interfaces with personal computers, but also less-traditional interfaces such as wall-sized displays, touch-screens on mobile devices, or interfaces to assistive robots.

By investigating methods to improve a fundamental aspect of computer interaction, this project makes progress towards improving the accessibility of computers for the older population. This has implications for providing better opportunities for older people to benefit from computers and the Internet, including improved access to information, greater independence, and opportunities for social interaction.

The project has generated a wealth of data about the responses of older and younger users to static and dynamic targets. Analysis of this is continuing and will provide a more comprehensive picture on the overall effectiveness of these techniques, as well as inform further investigations of how target expansion can be incorporated into more realistic interfaces where there are challenges with multiple targets arranged side-by-side in “tiled” arrangements.

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The Study

The study received financial support from SPARC of £42,703 and ran for 12 months ending in November 2007. Additional support was provided by the University of Reading.

More information about the study can be found on the SPARC website www.sparc.ac.uk and obtained directly from the investigators.

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Acknowledgements

The research team thanks all participants, and the staff and volunteers of Age Concern, Berkshire and Age Concern, Reading and Professor Rachel McCrindle, who acted as mentor on behalf of SPARC, as well as Professor Paul Sharkey, Professor William Harwin, and Dr Matt Cross for their help and advice throughout the project. The team is indebted to the Interactive Systems Research Group and the School of Systems Engineering for support which has enabled continuation of this research and its dissemination beyond the period of the original award.

Disclaimer

SPARC

SPARC is a unique initiative supported by EPSRC and BBSRC to encourage the greater involvement of researchers in the many issues faced by an ageing population and encountered by older people in their daily lives. SPARC is directed, managed and informed by the broader community of researchers, practitioners, policy makers and older people for the ultimate benefit of older people, their carers and those who provide services to older people.

SPARC pursues three main activities:
Workshops to bring together all stakeholders interested in improving the quality of life and independence of older people.
Advocacy of the challenges faced by older people and an ageing population and of the contribution of research to improving quality of life. SPARC is inclusive and warmly welcomes the involvement of everyone with a relevant interest.
Small Awards to newcomers to ageing research, across all areas of design, engineering and biology and at the interfaces relevant to an ageing population and older people. In 2005 and 2006 SPARC received 185 applications for support in response to two invitations for competitive proposals of which 34 were supported.

Executive Summaries

SPARC is supporting its award holders through funding, mentoring, a prestigious dissemination platform, professional editorial assistance, international activities and provision of contacts. Each of the projects has been small, yet the enthusiasm for discovery, and impatience to contribute to better quality of life for older people, has more than compensated for the very limited funding which was provided.

This executive summary is one of a series highlighting the main findings from a SPARC project. It is designed to stand-alone, although taken with summaries of other projects it contributes to a formidable combination of new knowledge and commitment by newcomers to ageing research, with a view to improve the lives of older people. This is a tangible contribution towards ensuring that older people receive full benefit from the best that research, science and technology can offer.