Adapted technology, in particular smart cards and terminals, can help people with special needs, such as those with physical disabilities, in the information age to carry out common activities independently. This paper illustrates the possibilities of the technology with results from the SATURN (Smart Cards And Terminals Usability Requirements and Needs) project. Economically viable smart card technology can now provide a range of adaptations to accommodate the requirements of this population. The practicability of this technology is illustrated with case studies. When implementing the technology, the selection of appropriate adaptations by occupational therapists and other professionals will be paramount. Forces towards implementation can lead to wider availability of the technology in the near future in order to enhance the quality of life for people with special needs.

Adapted Technology for People with Special Needs: the Case of Smart Cards and Terminals

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Introduction

Enhancing a person’s quality of life is an important goal for professionals working in rehabilitation (deLateur 1997). In particular, improving the quality of daily living activities of people and facilitating their independence in carrying out these activities can improve their subjective wellbeing.

Special needs, such as those due to physical disability, can have a major effect on the quality of performing tasks in daily life. Related to this, Petrie and van Schaik (1995) produced a functional classification of disabilities relevant to the (re)design of smart card and terminal technology. The classification has been adapted for the purpose of this paper and is presented in Table 1. According to this classification, a range of physical and cognitive capabilities or dimensions is involved in tasks that people engage in on a daily basis. These include sensory capabilities (vision, hearing), motor capabilities (upper limb, lower limb) and cognitive capabilities (memory, attention). The purpose of this paper is to raise awareness among occupational therapists of, first, the possibilities that adapted smart cards and terminals offer to enhance the quality of life for people with disabilities and, secondly, the role that occupational therapists can play in improving capabilities. The potential of smart cards and terminals for people with special needs is illustrated with findings from the SATURN (Smart Cards And Terminals Usability Requirements and Needs) project.

Smart cards and terminals

Modern information and communication technology provides various opportunities to enhance the quality of life of individuals. There are two main types of technology that can benefit users with special needs. Firstly, assistive (custom-made) technology is developed for particular users, such as communication systems for non-speakers (Hickey 1996) and electronic travel aids for visually impaired people (Petrie et al 1996). Organisations such as REMAP in the United Kingdom design and produce, predominantly mechanical, tailored aids for disabled people. Secondly, adapted (off-the-shelf) technology is mainstream technology used by the general public, but adapted for use by those with special needs, such as the World Wide Web (Wesley et al 1996) and cashpoint machines (Feeney 1999). This paper focuses on the latter type of technology and, in particular, on how smart cards and terminals can empower people with special needs in the information age with their day-to-day life and can thereby help to enhance their quality of life.

A smart card is a credit-card-sized piece of plastic into which an integrated circuit chip has been inserted. Most of these cards contain a memory chip and are used in a similar way to conventional magnetic stripe cards, which are for example used as bank cards. On the memory chip information can be stored, for example access rights for security systems and a monetary balance where the card is used for payment.

Strictly speaking, the name ‘smart card’ should only be used for those cards that incorporate both a memory chip and a microprocessor (Zoreda and Oton 1994). The microprocessor can extend the range of applications of the card considerably. Smart cards can indeed be used as multifunctional cards. For example, in Dublin the same card
can be used for making telephone calls, for public transport and for paying for car parking. Other examples include multifunctional cards that are being used in different universities in various countries, such as the University of Twente in the Netherlands. Because of the microprocessor embedded in them, smart cards can be more secure to use. This is achieved by verifying the identification of its user without the need for a personal identification number (PIN) stored in some central computer. The verification can all be done using the memory and information-processing power that reside in the chip on the smart card. Smart cards are used not in isolation but in conjunction with terminals, such as public telephones.

With the proliferation of smart cards and terminals, their use will become more important in daily life. At the same time, card-operated terminals are often unusable for people with disabilities since they seem to have been designed for able-bodied users.

### Smart cards to enhance the quality of life

The following description of technical possibilities is based largely on Klein and Lingström (1995); these authors provide a systematic review of technical possibilities for access to card-based equipment and adapted interface for input to and output from terminals.

**Static adaptation**

There are two basic ways in which smart cards, if designed appropriately, can enhance the performance of daily activities. Firstly, referring back to the functional classification (Table 1), the way that the card itself is used can be adapted to accommodate reduced motor capabilities by eliminating the requirements to insert the card; instead, users can employ a contactless card at close distance to identify themselves to the terminal. This can be implemented by different technologies for short-range communication, such as infrared communication, radio transmission, inductive or capacitative coupling and microwave. This mode of card operation is a static adaptation and decided on at design time; it can be used to address the effects of various conditions related to motor impairments.

**Dynamic adaptation**

Secondly, dynamic adaptations can occur at time of use, when the card can trigger the terminal to adapt its interface with the user. The smart card can hold information about the adaptations that are required for its user. When the user presents his or her card to the terminal, the terminal then adapts itself depending on the individual requirements for that user as they have been coded on the smart card. This mode of operation makes it possible for the same terminal to be used by people with different needs, thereby promoting inclusiveness rather than having separate terminals for people with disabilities. The following are examples of dynamic adaptations for various impairments:

1. Adaptations related to visual capabilities. For visually impaired people, text magnification and colour-contrast adjustments can make information and instructions presented by a terminal readable. Voice output can make information and instructions presented by the terminal usable by blind people (van Schaik et al 1995).

2. Adaptations related to auditory capabilities. Increased volume, differentiated frequency spectrum – perhaps tailored to the individual’s hearing loss – and a simpler message can benefit those with some remaining hearing capability. With multimedia terminals, those who are completely deaf and those with some remaining hearing capability can benefit from visual information display in addition to auditory display.

3. Adaptations related to motor capabilities. Voice input can benefit people with reduced dexterity; however, because of technical problems and financial cost this option is currently unlikely to be implemented. For people with reduced capability to make fine movements, the increased use of touch screens can be made easier by text magnification: the options to be selected will be further apart which requires less fine movement.

### Table 1. Functional classification of disabilities relevant for smart card and terminal design (excerpt), based on and developed from Petrie and van Schaik (1995); reprinted with permission of the National Secretariat of Rehabilitation, Lisbon

<table>
<thead>
<tr>
<th>Capability or dimension</th>
<th>Psychological function</th>
<th>Common diseases, impairments and disabilities</th>
<th>Common effects of ageing</th>
<th>Consequences for smart card and terminal design</th>
</tr>
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<tbody>
<tr>
<td>Static acuity for different parts of the visual field</td>
<td>Ability to see the world as a continuous field, with peripheral vision of nearly 180°</td>
<td>Glaucoma, Retinitis pigmentosa, Diabetic retinopathy</td>
<td>Macular degeneration</td>
<td>Vary print and icon size</td>
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<tr>
<td>Long-term memory</td>
<td>Retrieve previously encountered information</td>
<td>Use of, for example, antidepressants can severely affect long-term memory</td>
<td>Alzheimer’s disease</td>
<td>Avoid identification procedures which require remembering a code</td>
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<tr>
<td>Joint swelling/stiffness</td>
<td>Motor control</td>
<td>Rheumatoid arthritis</td>
<td>Osteoarthritis</td>
<td>Avoid actions that require fine control (handling items and pressing keys)</td>
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4. Adaptations related to cognitive capabilities. The user interface can be simplified, for example by giving fewer options, for those with difficulties in reading, an overall lower level of intellectual processing, reduced information processing speed and reduced ability to learn new concepts and instructions. In addition, time-out intervals can be increased to allow for reduced processing speed.

Given the range of possible adaptations described above, it is essential that appropriate adaptations are selected depending on the abilities of the person. Clearly, the expertise of occupational therapists and other relevant professionals should be used to make informed decisions on individualised adaptations.

Disadvantages of smart cards
Despite the considerable benefits that they can bring, there are potential disadvantages to the use of smart cards. For example, the electronic storage of any personal information always gives rise to the issue of privacy. However, smart cards are at least as secure as and can even be more secure than other commonly used technologies involved in information storage. Furthermore, it is not expected that all existing terminals will be retrofitted for adaptation; however, new terminals nowadays have in-built graphics and audio capabilities and can be suitably used to implement adapted smart card systems. Another disadvantage could be that the selection of adaptations could be a difficult process because of the myriad of possible adaptations. However, the SATURN project has developed a practicable coding scheme which can accommodate a wide range of adaptations; it is expected that in practice a small set of adaptations will usually suffice for each person (Gill 1994).

Case studies

Two case studies from the SATURN project demonstrate benefits and the feasibility of the concept of adaptation through the use of smart cards to enhance the quality of life.

Case study 1: Adapted Automatic Teller Machine (ATM)

Based on user requirements for visually impaired and older people (van Schaik et al 1995), an existing ATM was modified. Card operation was adapted by giving users a choice: they could either employ a contact card, requiring card insertion, or a contactless card. The following adaptations depended on the information encoded on the smart card. For terminal output, there were three different sizes of letters on the screen and different colour-contrasts. Another option was voice output: the machine could be used with speakers or with headphones and the ATM would then present instructions and information by voice. The range of services was either the full range of functions or restricted to cash withdrawal only. The time allowed for steps of a transaction was either fixed with a time-out or the user was prompted as to whether he or she needed more time.

Compared with a previous evaluation of the same ATM without adaptations, an evaluation study in a controlled setting found that the overall acceptance of the system by blind users increased significantly and that partially sighted users found the adapted machine to be significantly more useful (van Schaik and Petrie 1996). In a following field trial, blind, partially sighted and older users found the adapted machine easy to use and useful, had a positive attitude towards using it and intended to use it if it would become available (van Schaik et al 1996). Blind and partially sighted users also mentioned that the adapted machine would give them independence with financial transactions; rather than having a clerk sign a cheque for them at the counter, the adapted machine would put visually impaired users themselves in control. Both studies identified additional user requirements that, when met, would further empower users with special needs.

Case study 2: Adapted information terminal

Based on an analysis of the needs of cognitively impaired people, an information terminal for a social security system was adapted. Three sizes of text and buttons were available; at the same time, there was less information on the screen with larger type-sizes. In addition, voice output was available to supplement the text. Cognitively impaired users liked medium-sized and small-sized text and buttons because they provided a good overview; they also liked large-sized text and buttons because they made it easy to focus on the alternative at hand (Bergström 1996). The users were positive about the use of smart card technology and adaptive interfaces.

Forces towards implementation

Given the feasibility and potential benefit of adapted smart cards and terminals, the question arises as to what extent and when adapted smart cards and terminals will become widely available. Two forces may act to speed up and expand the process of implementation.

Legislation

Public card-operated services should be available to everyone who wants to use them. From an ethical perspective, all effort should be made to ensure that this is technically possible. From a legal perspective, the issue is to determine what is a reasonable cost to ensure that people with different functional capabilities can use the available services. Some adaptations will, in practice, cost very little and may also offer an improved service to all users. The service providers have a major responsibility in this, but the manufacturers should also take responsibility by developing cost-effective adapted systems. Current relevant legislation in the United Kingdom is found in the Disability Discrimination Act (1995). This act is implemented in stages. Stage three came into force in autumn 1999 and charges those who provide goods and services to tailor these
to the needs of disabled people. Therefore, it can provide an impetus for pushing the implementation of adapted systems.

**Increased customer base**
This can be achieved in two ways. Firstly, new customers can be attracted to services. There is a lack of research in this area. However, the studies by van Schaijk and Petrie (1996) and van Schaik et al (1996) indicate that there may be a substantial group of consumers who would become users of card-operated self-service technology if the user interfaces were adapted to their requirements. The group consists of older adults and/or those with some degree of reduced functional capability. The increased sales to consumers with special needs could offset the cost of implementing adapted user interfaces. This will become increasingly likely with the proliferation of cost-effective multimedia terminals which can easily produce different visual outputs and sound outputs.

Secondly, service providers can get a competitive advantage by providing services in a more accessible way than other providers. If a service provider adapts its equipment then it can expect to gain additional users, who previously used less usable cards and terminals from competing service providers.

**Summary**
Smart cards and terminals can help to empower people with special needs in their day-to-day life by adapting the way in which they interact with terminals. Various adaptations can give disabled and older people more independence, for example when carrying out financial transactions. Occupational therapists and other relevant professionals should be involved in the selection of appropriate adaptations. The feasibility of this approach has been demonstrated through case studies. Legislation and a drive for an increased consumer base can act as forces towards implementation. Adapted smart cards and terminals will then improve the quality of life of people with special needs.

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**References**


**Note**
A full list of SATURN publications is available through the author.

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