Environmental Control Systems– a starter pack for persons with high cervical spinal cord injury

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Abstract

Objective Environmental control systems (ECS) enable control of electronic devices and appliances in the home. Despite their proven efficacy however, there is limited access to ECS for those with high cervical spinal cord injuries (HCSCI) living in Ireland. This study aimed to explore the possibility of providing basic ECS in a simple starter pack that could be installed and customized by an occupational therapist.

Main content This paper describes a basic ECS package that was developed by an occupational therapist for one person with a high cervical SCI during a 3-week pilot study. This ECS pack was subsequently trialed and evaluated over an 8-week period with six people living in their own homes in Ireland. Pack contents and individual customizations are described. A basic ECS package, developed by an occupational therapist for one person with a high cervical SCI during a 3-week pilot study, is described.

Findings It was possible for an occupational therapist to design a basic pack of ECS and to customize six participants’ installations, although some minor maintenance and adjustment of the ECS was required during the trials. Four participants used the pack for the entire trial period of eight weeks and expressed an interest in having their own ECS. One participant used the pack for just three weeks as she received her own ECS during the trial. The remaining participant was not able to use the ECS independently.

Conclusions In Ireland there is limited access to ECS for persons with high cervical spinal cord injury. In situations where a multidisciplinary team approach to the installation of ECS is not practical, an appropriate and useful ECS starter pack can successfully be installed by an occupational therapist. Such an installation is however accompanied by technical challenges. Close collaboration with the ECS user facilitates customization of the ECS pack aimed at limiting abandonment. These findings contribute to a larger study that investigates the contribution that ECS makes to facilitating quality of life for persons with high cervical spinal cord injuries.

Keywords Environmental control systems ECS, domotics, electronic aids to daily living EADL, spinal cord injury, occupational therapy

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Introduction

Environmental control systems (ECS), also known as Electronic aids to daily living, (EADL), are a type of electronic assistive technology (EAT) that facilitates the control of household electrical appliances for persons with physical disabilities. They are activated, directly or indirectly, using switches. ECS allows several functions of multiple appliances to be controlled by one switch accessible unit.

ECS are reported to improve independence, autonomy and psychosocial well being [1-6]. In addition, satisfaction with ECS has been reported by users [7, 8]. There is limited access to ECS in Ireland and thus persons with high cervical spinal cord injury (HCSCI) may never have the opportunity to use ECS and to experience its benefits. This study sought to explore the possibility of providing basic ECS in a simple starter pack that could be installed and customized by an occupational therapist.

Other trials of ECS have varied in length from a single day to 16 weeks long [9-13]. There is no known study of ECS trials in Ireland.

1. Overview and background

This paper reports on an ongoing study comprising 3 stages. The first stage involved a series of focus groups for persons with high cervical spinal cord injuries (HCSCI) to explore the experience of living with and without ECS[6]. This was followed by the development of an ECS pack which was trialed with one person in a 3 week pilot study to assess the contents of the pack and the feasibility of a larger trial. In the final stage 6 persons were evaluated using the ECS pack in their own homes for an 8 week period.

1.1. Focus group findings

The findings of four focus groups (n = 15) reaffirmed the potential value of ECS to people with HCSCI. It also revealed participant desire for ECS to be simple, reliable, aesthetically pleasing and voice activated [14]. Participants raised practical issues such as the need for support and training as well as the importance of physical positioning and differing physical abilities. They also demonstrated some knowledge of what is possible and what is practical in order to avoid over supply and abandonment. They expressed some frustration with the reliance on commercial suppliers preferring active involvement in the assessment and set up of their own ECS. Due to the severity of paralysis several participants were heavily reliant on mouth sticks and powered wheelchairs. Thus they considered it desirable to be able to integrate ECS with mouthsticks and powered wheelchairs.

2. The ECS Pack

2.1. Design of the pack

The GrEAT –generic electronic assistive technology pack was designed on the basis of findings from the focus group, a review of the literature and of ECS practices in Ireland and Canada and the clinical experience of the authors.

Cost, availability, and non specialist installation were considered important in the selection of content. Desirable features included simplicity, aesthetics, reliability and capacity to be operated by a mouthstick. Voice activation was not feasible for both technical and financial reasons. Other requirements for the pack included appropriate
switch options, flexible mounting, and a backup system. The pack needed to include both communication and entertainment functions.

2.2. The Pilot study

The pack was developed by an occupational therapist (the first author) for one participant, Owen (chosen pseudonym), a 37 year old male with a C4 injury who used the proposed pack for 3 weeks. The pack was adjusted during the course of the pilot period on the basis of feedback from Owen. Customizations included increasing the scanning speed of the environmental control unit, supplying different mounts and mounting plates, adjusting sound switch settings, adding appliances and integrating a mobile phone.

Owen tried a variety of switches and favoured a neck switch, rather than mounted switches for in-bed use. This switch also became the preferred switch for in-wheelchair use. Owen valued having both a landline and a mobile phone. A stand-alone backup system consisting of a sound switch and a voice activated wireless personal alarm was provided for use in the case of technical failure. A telephone listening function was activated which allowed a family member or carer to ring the phone and thus functioned as a sound monitor to assess the situation from a distance.

Difficulties encountered included landline phone interference due to internet connection, limited communication range of personal alarm, mobile phone integration, and difficulties in copying infra red (IR) codes for both the phone and for SKY (satellite TV) functions. Several visits by the occupational were required to make minor adjustments to the ECS which could have been avoided by a more rigorous testing of all functions during the initial installation.

During the 3-week pilot period, Owen was videoed and photographed in order to provide a record of potential uses which could then be included in an information folder and DVD. The pilot study allowed the feasibility of the trial ECS pack to be evaluated for a larger trial within the Republic of Ireland.

2.3. Contents of the pack

The initial GrEAT pack used for the pilot consisted of an environmental control unit, a variety of switches and mounting options, a stand-alone IR double electrical socket, an IR telephone, a Bluetooth mobile phone, and a sound activated alarm. During the 3-week trial period the contents of the GrEAT pack were finalised between Owen and the occupational therapist in line with Owen’s experiences and preferences. The final pack included an information and instruction folder, 2 environmental control units, 4 switches, 2 mounts, 2 phones and spare batteries (see table 1). The installation procedure was also improved during the pilot period by increased checks on function, the provision of different mounting options, thus allowing time for Owen to learn and increase scanning speed.

<table>
<thead>
<tr>
<th>Environmental control unit</th>
<th>Switches</th>
<th>Mounts</th>
<th>Communication</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proteor KEO</td>
<td>neck</td>
<td>medium flexzi clamp</td>
<td>SiCare Quickphone</td>
<td>double IR electrical socket</td>
</tr>
<tr>
<td>SENIOR pilot</td>
<td>micro lever</td>
<td>Magic arm</td>
<td>mobile phone</td>
<td>wireless personal alarm</td>
</tr>
<tr>
<td></td>
<td>mini cup</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>micro light</td>
<td></td>
<td>bluetooth headset</td>
<td>information booklet</td>
</tr>
<tr>
<td></td>
<td>sound switch</td>
<td></td>
<td></td>
<td>demonstration DVD</td>
</tr>
</tbody>
</table>

Table 1. Contents of the GrEAT pack of ECS
3. The GrEAT Trial

3.1. Customization

Following the pilot study, a video of Owen (the pilot participant) using the pack was shown to participants taking part in the main trial. A GrEAT pack was then set up and customized in each participants’ home by the first author. Each participant selected suitable switches and mounts for use from a wheelchair and a bed. They also chose the household devices they wished to operate and the functions desired for each device. The environmental control unit in the pack was a Proteor KEO with a dynamic black and white touch screen and one switch input. The screen could be configured to have either 9 or 16 buttons per page. The KEO environmental control unit was programmed following planning of suitable ‘pages’ of functions by the occupational therapist and each participant (figure 2). The numbers of pages varied between participants from just one page to 11 pages. Each page contained up to nine buttons which either sent IR signals or linked to other pages.

The SENIOR pilot environmental control was intended to be programmed as a backup in case of KEO failure. However, no participant made use of the SENIOR pilot for two reasons. The first was the limited functionality of only 15 IR signals compared with hundreds in the KEO. The second was the occupational therapists inability to complete the programming due to both time and technical constraints. Each installation took one to two days.
3.2. Maintenance during the trials

During the trials several technical and practical challenges arose ranging from a faulty charger and a dead KEO battery, to telephone failure and the need to add additional appliances. Trouble-shooting and adjustments were made in person where possible, and over the telephone or by postal repair if distance made a personal visit difficult.

![Image 1](image1.png)

**Figure 1.** ECS set up for James – minicup switch attached to chin control of wheelchair, KEO mounted with Flexzi clamp mount.

3.3. Use of the ECS – GrEAT

Six persons participated in the main trial, details of each can be found in Table 2 (pseudonyms have been used throughout). Mid way through the trial one participant, Bridget received her own ECS which replaced the GrEAT. This system was installed by an engineer from the company providing the ECS. She did however continue to use the study sound-switch and wireless personal alarm with her new system. Four of the remaining participants reported regular use of the GrEAT throughout the 8-week trial period and expressed an interest in having their own ECSs. The sixth participant, Joe, abandoned the GrEAT as he could not operate a switch consistently and did not understand the scanning function. His daughter was able to make some adjustments to the KEO with guidance from the occupational therapist over the telephone but the participant chose to continue to rely on his wife for assistance with all activities as he had been doing prior to taking part in the study.

### Table 2. Details of customizations of ECS for all participants

<table>
<thead>
<tr>
<th>Pseudonym</th>
<th>ECU mount</th>
<th>Switch choice</th>
<th>switch position/clamp</th>
<th>devices controlled</th>
</tr>
</thead>
<tbody>
<tr>
<td>Owen</td>
<td>flexzi mount</td>
<td>chin switch</td>
<td>taped to t-shirt</td>
<td>TV, Digital TV, DVD/Blu-ray, telephone, mobile phone, radio, fan, lamp, wireless alarm</td>
</tr>
<tr>
<td>Matthew</td>
<td>lap/ beanbag tray</td>
<td>chin switch</td>
<td>under collar of golf shirt</td>
<td>TV, <em>x2</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em></td>
</tr>
<tr>
<td>Emily</td>
<td>lap</td>
<td>micro light switch</td>
<td>Velcro to clothes, thumb activation</td>
<td><em>x</em>, <em>x</em>, <em>x</em>, <em>x</em></td>
</tr>
<tr>
<td>James</td>
<td>flexzi mount</td>
<td>mini cup &amp; chin (bed) on wheelchair chin control cup</td>
<td><em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em></td>
<td></td>
</tr>
<tr>
<td>Joe</td>
<td>flexzi mount</td>
<td>chin switch</td>
<td><em>x</em></td>
<td><em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em></td>
</tr>
<tr>
<td>Bridget</td>
<td>lap</td>
<td>small micro lever</td>
<td>stabilised with carpet tape</td>
<td><em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em></td>
</tr>
<tr>
<td>Peter</td>
<td>flexzi mount</td>
<td>chin switch</td>
<td><em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em>, <em>x</em></td>
<td></td>
</tr>
</tbody>
</table>
4. Limitations

This small study has several limitations. Only six persons living in the Republic of Ireland were included in the main trial. It is not known if findings from this study would generalize to other HCSCI persons and those living in other countries. The ECS pack was installed by an occupational therapist and not by an ECS expert or engineer and therefore it is not known if installation by a professional would have been more satisfactory for users. The use of ECS was also restricted as some participants did not want to use some items for the short time period of the trial preferring instead to have those same items on a long term basis.

5. Implications and Conclusions

ECS can be considered a specialized field which typically results in potential users relying on experts [15]. Focus group participants in this study commented on their dissatisfaction with this approach and stated a preference for a collaborative approach involving the client, carers, ECS experts, suppliers and therapists [16]. In Ireland, due to financial and service constraints, this is not often possible with the result that many people who could benefit from ECS do not have access to it.

The current paper demonstrates that it is possible for an occupational therapist to install an appropriate and useful ECS starter pack. However, this was not without technical challenges in both installation and functional maintenance. Each GrEAT was idiosyncratic despite the use of a generic pack which was possible through selection of both the contents and the customization thereof. As with all assistive technology abandonment or nonuse, due to the device itself, the person and/or their environment is a concern [16, 17]. Close collaboration with service users as outlined in this study is likely to minimize such effects.

This study is part of a larger study which explores participants’ experience of ECS. Preliminary findings from the wider study are consistent with the findings reported in this paper. Using ECS in the home was found to be a positive experience and themes such as the ability to be alone, and reduced dependence on others, together with frustrations with technology and the challenges of introducing ECS within established daily life for people with a high cervical spinal cord injury were identified. Five of six participants found the experience of using ECS beneficial and expressed a desire to have ECS in their own homes in the long term.

Findings from all stages of this study will provide a comprehensive understanding of how ECS contributes to enhanced quality of life for people with high cervical spinal cord injury living in the community and during rehabilitation.
Acknowledgements

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