Journal of

Enabling Technologies

User inclusion in health, support, social care and education

Number 3

137 Dementia-friendly design of television news broadcasts
   Liam Funnell, Isabel Garrick, Ben Shirley and Tracey Williamson

150 Conversation Analysis (CA) as a tool for exploring interaction in an online video-conferencing based support service
   John Chatwin and Phil McEvoy

158 Building rating system: an instrument for building accessibility measurement for better indoor navigation by blind people
   Watthanasak Jeamwatthanachai, Mike Waid and Gary Wills

173 SiLearn: an intelligent sign vocabulary learning tool
   Jestin Joy, Kannan Balakrishnan and Sreeraj M

188 Economic impacts of changing technologies on New Zealand homecare delivery
   Julia Lesley Hennessy and Averyl Rodrigues

www.emeraldinsight.com/loi/jet
Dementia-friendly design of television news broadcasts

Liam Funnell, Isabel Garriock, Ben Shirley and Tracey Williamson

Abstract

Purpose – The purpose of this paper is to understand factors that affect viewing of television news programmes by people living with dementia, and to identify dementia-friendly design principles for television news programmes and factors for personalising object-based media broadcast.

Design/methodology/approach – Extensive public involvement comprising two discussion groups with people with dementia and family carers informed the study design and provided supplementary secondary data. Primary data collection comprised a focus group interview with people with dementia (n = 4) and family carers (n = 4). Past viewing experiences and perceived barriers and facilitators to viewing television were explored. Participants commented on an array of video clips comprising varying segments of fictional news programmes, plus control versions of each segment.

Findings – Four themes were identified: content (general comments, context, type of media and pace); presenter (body language, clothing and accent); background (location and studio appearance); and technical aspects (graphics, sound, colours, camera, transitions, general issues).

Research limitations/implications – Limitations included a modest sample size which is offset by exemplary public involvement in informing the study design.

Practical implications – Measures ensured research involvement and participation was made accessible to people living with dementia.

Originality/value – This study is the first to be published which focusses on dementia-friendly television news programmes.

Keywords Dementia, Television, Design principles, Dementia-friendly design, News programmes

Paper type Research paper

Background

In 2014, there were 835,000 people in the UK with dementia, and this is projected to increase to over 1m people by 2021 (Dowrick and Southern, 2014). According to Hayne and Fleming (2014, p. 1), “Dementia is not a single specific disease, it is an overall term used to describe a syndrome associated with more than 100 different diseases that are characterised by the impairment of brain functions, including language, memory, perception, personality and cognitive skills”. Whilst the total financial cost of dementia to the UK has been estimated at £26.3bn (Prince et al., 2014), the human cost is considerable. On a daily basis, people with dementia, even in its earlier stages, may experience major challenges presented by them losing track of conversations (Holst and Hallberg, 2003), losing track of time (Nygård and Borell, 1998), and forgetting names and events (Keady et al., 1995).

Introduction

Television viewing

There is strong potential for development of programme content that meets the needs and demands of people with cognitive impairments (Knall and Östlund, 2009). A study by Bakker (2003) found that...
people living with dementia can sometimes confuse fiction with reality, especially during television viewing. Lund et al. (1995) found that programmes which some viewers with dementia find calming can have the opposite effect on others, causing confusion and distress. Yet the Dementia-friendly Technology Charter (Alzheimer’s Society, 2014) identified television as a social activity having potential to enable people to live independently for longer, potentially enhancing the quality of life for both people with dementia and for carers. Therefore, it may be prudent to fine-tune television programmes for people with dementia to best meet their needs. De Medeiros et al. (2009, p. 639) suggest “News programs, game shows, and commercials were identified as the most problematic; comedies, soap operas, and dramas, as moderately problematic; and nature programs, sports, documentaries, and music programs, as least problematic” for people with dementia to watch.

Knall and Östlund (2009) viewed local news programmes as being preferable to national news programmes. Similarly Topo and Östlund (2009) observed that, when watching television, people with dementia in a care facility preferred to watch local news programmes compared to national news. The media that contained people and locations recognised by viewers who had dementia led to higher levels of response. Used correctly, the active use of information and the media can promote healthy ageing (Niemela et al., 2012), whilst a further claim is that people with dementia that live alone could be helped to stave off loneliness (Andrews, 2016) by enhanced connectedness to the outside world through local news and current affairs programmes.

User-friendly television

People with dementia may struggle with distractions due to a decrease in concentration and a reduced attention span, resulting in stress. Memory problems may also cause them to lose focus whilst watching television as they become lost in the narrative (Andrews, 2016). Family carers may be relied upon to repeat storylines or recap characters for the person with dementia, which may negatively affect their own viewing. Furthermore hearing is often impaired amongst people affected by dementia whose ability to interpret sound accurately reduces, resulting in confusion, illusions, frustration and agitation (Hayne and Fleming, 2014). These sensory challenges may be in addition to those incurred through age-related conditions that further affect sight or hearing (for further information, see www.pocklington-trust.org.uk/treatment-and-diagnosis-2/). These factors can be further compounded by other sensory impairments experienced by people with various forms of dementia (see examples at www.lifechangestrust.org.uk/publications/dementia-sensory-challenges).

Television therefore needs to be user-friendly (Andrews, 2016), both in content and accessing the content. Present-day televisions are often very complex, whilst remote controls used to operate them can have too many buttons that are very small and difficult to read (Logan et al., 1994), with functions that are very rarely used. Various manufacturers have developed easier to handle and use TV remote controls and consumers can find help in selecting what works best to meet their needs from organisations such as Living Made Easy (for more information see www.livingmadeeasy.org.uk/). Biswas (2012) recommended that when designing television applications, user-friendly content should be adapted for people with disabilities or age-related impairments, including large fonts and colour combinations (e.g. white text on a black background).

Broadcasting

The scheduling of broadcast television programmes allows for the broadcasters to target a particular audience (Armstrong et al., 2014) and there are several access services which can benefit people with sensory impairments, enhancing their viewing. These include closed access services (e.g. sub-titles for hearing impaired people) and audio description (for those with visual impairments) whereby viewers have the option to turn them on or off (Digital Television Group, 2017). Some people with cognitive disabilities find that audio descriptions are useful as it allows them to better understand the programme (Digital Television Group, 2017).

Recent developments in object-based broadcast allow a user to personalise the audio and video content of a television programme to their individual preferences and accessibility requirements (Armstrong et al., 2014). Additional audio and video objects could be broadcast alongside television programmes, which would enhance the experience of users. Whilst the use of additional video objects is currently in the early stages of research, there is a potential for object-based broadcast to
include additional features such as alternative camera angles, variable levels on specific sound objects and even variable programme length (Armstrong et al., 2014). Shirley and Oldfield (2015) found that there is potential for users to have complete control of the relative levels of all aspects of audio and have demonstrated an object-based audio solution for people who are hard of hearing (Shirley et al., 2017). This would be particularly beneficial in view of hearing losses which are thought to be linked with dementia (Hardy et al., 2016), with one of the main effects of hearing loss being the increased difficulty to separate dialogue surrounded by other background noises in television (Silva, 2016). Whilst our review of available literature has shown that there is currently limited research into what people with dementia struggle with whilst watching television, there is also a lack of research on how requirements could then be addressed.

Previous research has focussed on technological aspects of television viewing such as recognising and manipulating remote controls, sensory impairments or issues relating to agitation of viewers with dementia. What contributes to the originality of the research presented here is its focus on the design of TV news programmes and viewing experiences of those programmes, which we believe to be the first study of its kind. Having considered the needs of people with dementia and the current state of the evidence base for dementia-friendly television, a study focussed on informing dementia-friendly news programme design was carried out.

Study design

Aims

The purpose of the study was:

- to explore how people with mild to moderate dementia view and consume television programmes on a day-to-day basis;
- to identify barriers and facilitators for people with mild to moderate dementia when watching television;
- to investigate ways in which improvements can be made to current television programmes for people with dementia; and
- to identify design requirements for dementia-friendly television news programmes.

Public involvement approach

A two-stage approach drawing on best practice principles of public involvement was employed. First, an Advisory Group was formed with help from an experienced dementia researcher. An initial meeting in November 2016 explored advisors’ thoughts and feelings of the problems people with dementia experience whilst watching television. Eight volunteers, including five participants with early stage dementia and three family carers from two community dementia support groups, met with the researchers. A facilitated discussion enabled the advisors to explain their experience of the problem under study (Moyle, 2002).

Overall, the group were very enthusiastic about the study as a research priority as they felt television significantly affected each of them either directly, or affected the people they cared for. The discussion also revealed that the most challenging aspects of television viewing related to use of graphics, sound, content and cameras.

At a second meeting, the advisors made suggestions as to the specific design of the planned study and identified topics which they felt were particularly important to explore. As indicated by the literature and as suggested by advisors, this second Advisory Group meeting in January 2017 focussed specifically on aspects of news television programmes as the priority topic to research. The membership had expanded to eleven members. The focussed discussion that followed helped fine-tune the design of the data collection plan.

To gain initial views linked to television news programmes, archive news footage was obtained from both Box of Broadcasts and YouTube. These allowed for a range of clips of varying length to be shown to the group. The clips explored four different sections of news television programmes: “what’s
coming up”, studio, weather and news packages. The group were asked to provide constructive criticism on current video clips from news television programmes. The clips shown were recent archive footage from Salford University’s student channel Quays News, Quays News Friday First, BBC Newsroom Live, ITV News London, Sky News, Channel 4 News, BBC Sport and BBC World News. The style and content of these clips varied significantly even though they were all news based programmes. This allowed variation in television programmes to be explored. Feedback from both Advisory Group meetings informed subsequent study design and all discussions were filmed.

**Ethical approval**

Approval was gained from the University of Salford Research Governance and Ethics Panel. Ethical requirements including risk assessment, written and verbal informed consent to be interviewed and filmed, explanation of right to withdraw and data storage were adhered to.

**Theoretical underpinnings**

As the study is unique, several theories have been considered to identify a suitable theoretical framework to underpin it. First, the work of Shakespeare et al. (2017) talked about a social model of disability that differentiated between dementia being seen as an illness or impairment (medical model) and it being a disability (social model) helping to illuminate the exclusion that persons with those impairments may experience. This social model had as its foundations the insights of Oliver (1983), who considered there to be social inequality between people with and without a disability that was evident in interactions between individuals and in behaviours within social institutions, e.g. hospitals and in physical environments. Shakespeare et al. (2017) identified limits of the social model in not acknowledging the complexity of the disability dimension of dementia, and went on to suggest that social relations are as important as the condition itself:

> The tendency to over-medicalise dementia, and people with dementia, has obscured the importance of social conditions that contribute to disabling people with the condition. (Shakespeare et al., 2017)

As the social model was conceived in relation to persons with static physical impairments, it is not as fitting for persons with degenerative conditions such as dementia and a more inclusive approach is proposed (Shakespeare et al., 2017). These authors go on to say how a relational model of disability places more emphasis on people’s experiences of living with impairment and illness such as dementia and counters the weakness of the social model at conceptualizing cognitive impairments. A further relevant concept is that of “malignant social psychology (Kitwood, 1997) whereby certain traits and behaviours effect an impact on a person’s sense of self. A negative impact will be experienced by persons with dementia where there is a lack of respect and trust from caregivers leading to a state of undermined personhood. The relational model of disability can be considered compounded by malignant social psychology which may result in some persons feeling disrespected and undervalued. Providing television programmes for persons with dementia to watch, which are not tailored to meet their social needs or physical and cognitive abilities, restrict opportunities for inclusion and meaningful occupation and reducing those individuals’ sense of worth.

Television programme designers can take steps to make news programme viewing more accessible for people with dementia, and optimise television news viewing as a social activity and as a means of keeping persons’ with dementia informed about current affairs. To focus simply on easy-to-use TV remote controls and sub-titles is, in our view, insufficient for making television viewing “dementia enabled” and there is a need to better understand people’s experiences of living with dementia in relation to TV viewing.

**Methodology and methods**

A qualitative methodology was chosen to elicit detailed understanding of people with dementia’s response to media and carer’s views of their loved ones experiences with television. A participatory design approach comprising three stages drew on principles of public involvement in research (Hayes et al., 2012). These were: Stage 1, patient and public involvement with lay advisors aimed at exploring the research focus and design; Stage 2, a meeting with lay advisors to explore issues that needed to be investigated and to inform development of news clips for use with fieldwork; and
Stage 3, data collection comprising a video-recorded group interview with people with dementia and family carers to identify views and preferences concerning mock news clips shown to them. This was complemented by observation of the participants viewing and commenting on sample news clips. Stages 1 and 2 provided secondary data, and Stage 3 provided primary data.

The semi-structured interview guide was developed in light of literature review findings and advice from the study advisors. Interviews sought feedback about each news clip played to participants. As some people with dementia struggle with direct questioning, views were drawn out in a conversational manner using “invitation to respond” (Six Degrees Social Enterprise, 2017), a technique that provides participants the opportunity to join in. A group interview was considered to be more appropriate than individual interviews to encourage group interaction and prompt quieter participants to speak (Kitzinger, 1995).

**News clips**

The mock news clips used in Stage 3 were created with media students at the University of Salford’s MediaCity UK student TV channel “Quays News” studio. Clips were structured to represent the same four sections of news programme as in the second Advisory Group meeting (“what’s coming up”, studio, weather and news packages). Each section comprised a “control” clip and other clips providing alternatives with various elements added, changed or removed, based on feedback from the Advisory Group meetings. For the “what’s coming up” title, the control sequence contained elements such as animation and graphics. This clip was 30-s long and included cutaways to videos, presenters sitting behind a desk, a music bed and wipe transitions with accompanying “stab” sound. Four alternative versions of the 30-s long “what’s coming up” segment were produced: presenters introducing themselves/no wipes; still images instead of videos for the cutaways; presenter simply speaking to camera with no effects added; and a split-screen graphic (presenter on one side and text revealed on the other) with text following the presenter’s speech.

**Sample and recruitment**

The focus group sample was made up of eight participants (n = 4 people with dementia, n = 4 family carers). Most participants were the study advisors who believed it was their right to take part in the study they had co-created. Others were known to the university and regularly took part in research. They also advised that it was better to utilise them as participants as they were oriented to the study rather than start afresh with participants who would struggle to grasp the purpose of the focus group discussion.

Secondary data originated from two Advisory Group meetings of 8 and 11 participants.

**Data collection**

Data collection took place in a suite of rooms within The Salford Institute for Dementia. Whilst not a natural environment to watch television in, it was a familiar and comfortable environment for the participants. Once informed consent had been obtained video clips were shown to participants before requesting feedback. Field notes were taken at the time and video footage reviewed following the interview to ensure all participants’ views and reactions were included in analyses.

**Analysis**

Audio recordings and video footage were transcribed and detailed field notes made during and after the focus group interview. These were reviewed and the transcription coded and grouped into specific themes (Braun and Clarke, 2006) prior to seeking patterns, gaps and aspects in need of further interrogation.

**Findings**

The four themes presented here are: Theme 1, content (including general comments, context, type of media and pace); Theme 2, presenter (including body language, clothing and accent);
Theme 3, background (including location and studio appearance); and Theme 4, technical aspects (including graphics, sound, colours, camera transitions and studio appearance). Themes 1–3 are detailed below in no particular order, whilst Theme 4 is summarised as follows:

Theme 4 – technical aspects affecting news programme viewing:

Graphics:
- simplified title;
- prefer split-screen text graphic (weather as well as map);
- prefer split-screen text to appear simultaneously with speech;
- text needs to match actual wording of presenters;
- font (Neo Pro Tech) considered acceptable;
- name tags preferred large with no animation;
- dislike scrolling text; and
- prefer analogue clock to digital clock.

Sound:
- dislike background noise;
- dislike sound effects;
- music considered unnecessary; and
- prefer more upbeat music to slow music.

Colours:
- prefer brighter colours;
- dislike (yellow) in lower third of screen clashing with (red) studio colour scheme;
- dislike too many colours at once; and
- colours of presenters clothes needs to contrast with studio set background.

Camera:
- dislike camera movement;
- mixed preference on shot of one presenter or of both; and
- prefer closer (head and shoulders) camera shot of presenters.

Transitions:
- dislike wipe transition; and
- dislike pictures displayed in studio before being taken full screen.

General:
- dislike spelling mistakes; and
- news programmes need to be less serious.

Theme 1: content

General
Comments were varied but most centred on the idea that the news clip content should be as simple as possible. When shown the simplest variation of the “what’s coming up” section, one carer said:

Just plain and simple and what it’s all about.
One carer suggested that the person with dementia they care for would prefer a more upbeat approach. The reason given for this was an anecdote about when musicians perform for dementia support groups and play old-fashioned music which is slow and causes the people with dementia to fall asleep. The carer also mentioned that the same applies to colour and that it should be bright and eye-catching.

**Context**

Many comments indicated that it was an essential requirement to give some background details to enable people with dementia to relate new information to prior knowledge. When given the comparison between two alternative versions of a story featuring International Women’s Day, the participants agreed that it was better to have a visual reminder of what suffragette Emmeline Pankhurst looked like. One carer said:

> That was definitely better because you can see the face of who it’s talking about […] people have memories of who she is then.

When participants were shown alternative versions of a report on “Brexit”, the term needed further explanation:

> That little bit more information for me is helpful […] Just a little bit more so I can get my head around, rather than it being just short, sharp. (Person with dementia)

During the weather section, a carer made a suggestion about using a background indicating the season in order to serve as visual reminder of what to expect from the weather forecast. Advice from a carer was to look into using a standardised set of symbols that are easier to see and understand.

When shown a further clip which contained archive footage of Manchester before moving onto modern footage, the response was that it should be more obvious when the transition happens so that there is no confusion about what is old and what is new.

**Media**

When including media, such as video clips and photographs, the majority of the participants preferred to have some sort of visual indicator to separate the different segments or to give more context to a news story. One response from a carer was that for a story about a church fire (used in the programme), the point of the story was lost unless pictures of the fire were shown. There was also a suggestion from a participant with dementia that, in this particular case, there should be images of the church before and after the fire because it helps to tell the story.

**Pace**

A shared view was that presenters spoke too quickly. It left participants feeling that no sooner had they focussed their attention, the presenters had moved onto the next piece of information.

Changes in images shown were also found to be challenging. For example, in one of the control clips (focussed around International Women’s Day), multiple carers and people with dementia commented that the rate at which images appeared was too fast. A carer suggested that it would be better to have one montage containing all six images that could be displayed for longer. A further comment which was made by a carer during a clip featuring a split-screen graphic and descriptive text was that the text needs to be synchronised with the verbal description, otherwise it could be distracting and confusing. In general, using a split-screen graphic was seen as positive, but the participants stressed that it would only work if the text was revealed in time with and identical to the presenter’s speech.

**Theme 2: the presenter**

**Body language**

There were many comments from people with dementia, and from carers, who found the way the presenters moved their arms distracting. One frequently raised issue was that presenters were
viewed as sitting too rigidly. A participant who has dementia described them as “clinical” and “a bit cardboard”. However, there was a clarification that they did not want the presenters to be too relaxed either. One participant with dementia detailed that they would like it if, when one presenter was talking, the other one could turn and look at them because it would look more relaxed and also help to show where attention should be focussed.

**Clothing**

The participants made remarks about the clothes worn by the presenters on multiple occasions. They generally found the most faults with the female presenter’s outfit, which consisted of a coral coloured blazer on top of a shirt with birds printed on it. The participants felt that the colour was too close to the mostly red studio background and one person said that the presenter seemed to merge into the background.

**Accent**

During the Advisory Group meetings, advisors had stated that they liked clear, not broad local accents. In the clips, one of the presenters had a clear accent whereas the other presenter had a strong Irish accent. The overwhelming general response was that accents should be as clear as possible and ideally not too “local” or strong.

**Theme 3: background**

**Location**

Generally, it was thought by most participants that filming of the weather section should be done as locally as possible, however, one person with dementia said that they became distracted and were unable to pay attention because they were too busy trying to recognise the buildings and the locality. When asked if they would prefer the weather section to be filmed outside or in a studio, the consensus was that it was better done outside. However, one clip of ripples on an open expanse of water was a distraction as they found it confusing and eye-catching.

**Studio appearance**

When it came to the appearance of the studio, the set and lighting were the two major components that stood out to participants. The first was the shiny reflective desk and the second was movement on the projected display behind the presenters as it was considered too distracting.

**Theme 4: technical aspects**

The list “Theme 4 – technical aspects affecting news programme viewing” summarises key technical aspects affecting viewing.

**Discussion**

These findings clearly suggest that there are distinct features of television news programmes which can be made more dementia-friendly. The study identified programme design features around content and delivery which significantly affected participants’ ability to comprehend meaning and follow a story. Other aspects were distracting from what was being shown or said and similarly limited comprehension. Factors included content, its ordering and pace of delivery along with the location of filming and studio appearance. Presenters’ appearance, clothing, accents and mannerisms were also key issues which could facilitate or distract good quality viewing for people with dementia. Technical aspects included unhelpful use of graphics, unnecessary camera movement, inappropriate use of music and background sound, and use of dull colours and jerky transitions.
The findings we present have illuminated how some people with dementia consume television programmes on a day-to-day basis and barriers to viewing television. A common barrier was the need to reduce distraction through keeping presentation as simple as possible; this links with the research carried out by Andrews (2016) that states that distractions can result in stress. This factor extended to the presenters’ appearance, the studio, the location of reports, e.g. weather bulletin being filmed outdoors, and graphics used. Key elements such as the speed of transitions and presenters’ speech, body language and use of variable symbols during weather reports, further hampered viewing. Background noise, from the environment, music or sound effects, was not found to add anything positive to the viewing experience.

Another barrier was the challenge presented by a lack of context within the news items, whether delivered through speech or media such as photographs. Within the Parliament themed control clip, one participant complained that they were unable to understand the information due to not knowing what a term meant (Brexit). This was also prevalent in the International Women’s Day clip when the participants preferred to be shown a photo of one of the key figures in the story. A further hindrance was the difficulty in differentiating between historical information and present-day information, due to timeframes not being indicated.

The findings of our study also identify improvements that can be made to make television programmes more accessible for people with dementia, with particular emphasis on requirements for dementia-friendly news programmes. Additional techniques beyond reducing distractions were identified as necessary to enhance viewing including the use of bright colours, keeping discussions upbeat and improving presenter interaction. Our evidence suggests these techniques could facilitate focus and engagement with the programmes, due to their being attractive, attention grabbing and, in terms of presenter interaction, natural and therefore easier to follow. Backgrounds can help understanding when they are commensurate with the content of what is being presented yet too much activity or movement in any background can be distracting. There is a balance to be made between maintaining interest and reducing distractions.

Context is similarly an aspect that can be addressed to maximise the viewing experience of people with dementia. Making sure that the information is presented visually, in an appropriate order and supplemented by text and speech is helpful in setting the scene and leading the viewer through a story. Speech and text need to be simultaneous and not too rapid, with text that is identical to what is being spoken. Clear differentiation between old and new footage would be advantageous and it may also help to prevent the family members’ own television viewing experiencing being impacted as described by Haynes and Fleming (2014).

A further aid to comprehension is to allow time for people with dementia to process information. An example of how this can be achieved is by using images to illustrate and separate news stories or sections, enabling the viewer to pause and assimilate information. Clear delivery through presenters not having a broad accent was also found to be beneficial.

Our study uncovered that when designing a dementia-friendly television news programme, viewers may benefit from having the programme presented in a specific format that reflects that which they may have become accustomed to over their lifetime. Therefore, in order to keep a programme easily recognisable as “the news”, it was found to be necessary for elements such as the presenter’s clothing to be formal and smart. Furthermore, it would be prudent to ensure that the colour of individual presenter’s clothing does not clash or merge in with the background as well as careful use of graphics. Over 100 types of dementia are known to exist and some of these have particular association with impaired vision such a Lewy Body Dementia (Royal National Institute for Blind People, 2018).

Our findings indicate a few simple steps which, if adopted by news programme producers, could enable them to create television news programmes which are more accessible to people with dementia. Furthermore, a range of steps can be taken to make programmes optimally dementia-friendly, which we suggest should not affect production costs unduly. Some of these steps will require changes to presenter’s styles of presentation and they may have training...
needs which need meeting to equip them for this. Training may also benefit staff involved in
television production to help them better understand the needs of people with dementia, that
they may then create bespoke programmes, or at least reduce the inaccessibility of
programmes generally.

Some aspects identified in this study, such as presenter appearance and delivery style, would
require alteration to broadcast media production to make it more acceptable to people with
dementia. Others may be open to personalisation based on viewer requirements using
forthcoming object-based media formats. Background pictures, graphics and on-screen text
and logos are all elements that were identified as problematic, and are all items that could be
broadcast as media objects in an object-based media broadcast. BBC research has developed
example personalisation for weather graphics that could be personalised by the viewer
(Leonard, 2015), radio that can adapt the level of content detail based on listener preferences
(BBC, 2015), and have proposed tools and workflows for scalable object-based media
production (Cox et al., 2017). It seems likely that such methods could be used to personalise
broadcast media for people with dementia, particularly in the case of augmented elements such
as graphics and on-screen text.

The issues discussed here are relevant to people without dementia who view television news
programmes; however, we found that for people with dementia, the challenges are amplified. It is
therefore important to consider carefully, how to prevent people with dementia from becoming
distracted whilst also maintaining their focus and attention.

Limitations of the study pertain to the modest sample size which included people who were in the
relatively early stages of dementia and family carers speaking on behalf of people with more
advanced dementia. The approach to sampling was in response to patient and public
involvement good practice and the advice given by study lay advisors with experience of
dementia. New methodological insights have been made possible by advisors’ recommendation
that they comprised most of the participant sample. They believed their prior orientation to the
study design was critical to successful participation. Another insight was that participants did not
realise how much they did not like something until they were given the option to see a clip without
it; hence, the use of control clips and variations on the same clip proved to be an effective
approach to determining participant views.

The key strength of this study is that it provides valuable insights into a subject area about which
no substantive research has been found. Second, it is a good example of public involvement in
research amongst an “easy to ignore” population who are often excluded from research (Taylor
et al., 2012). The results provide the basis for future development of best practice guidance
for programme creators developing dementia-friendly television news programmes.
The evidence we have developed may also be used in facilitating media personalisation for
people with dementia.

Conclusions

Overall, many of the factors that constitute dementia-friendly television are related, such as
capturing attention and preventing distraction. This research has indicated the production
elements that limit people with dementia from successfully comprehending television news
programmes including extras which distract from the key points, not enough stimulation to
maintain attention, lack of sufficient context in photos and speech, not making changes
obvious enough which can create confusion, not maintaining the expected format of the news
and not taking into account age-related conditions that many people with dementia may also
have. This study has evaluated how people in the early stages of dementia view and consume
media and explored the reactions of people with dementia when viewing a standard television
news programme in comparison to altered versions. It has also identified ways in which
improvements can be made to current television news programmes in order to help make them
more accessible to people with dementia (see Guidance for developing dementia-friendly
television (news broadcasts)). In summary, the production and technical elements of a
television news programme for people with dementia need to be as simple as possible, whilst
still containing enough factors to hold their attention. Object-based media is identified as having
the potential to provide personalised broadcast that could facilitate improvement in some of the areas identified.

Guidance for developing dementia-friendly television (news broadcasts).

Dementia-friendly television requirements are as follows:

- no background noise (unless necessary to the news item) or sound effects to be used;
- simplified titles without the use of fast moving images;
- split screen in the “what’s coming up” section with the text appearing as it is spoken as well as directly matching the presenter;
- the weather presented in a split-screen format with weather symbols only for that day;
- use of an analogue clock displaying the time as well as the day of the week;
- bright and cheerful colour scheme with colours that do not clash or introduce too many different colours at once;
- tight-framed camera shots of only the presenter’s head and shoulders;
- no camera movement;
- no use of wipe transitions; and
- light-hearted and not too heavy-going.

Recommendations and future research

Future research is needed to replicate this study design with larger numbers of participants, especially those with dementia, carefully separating out the views of carers to identify the most important factors in need of addressing by television producers. Future enquiry could focus on the variation of individual design components, e.g. nature of transitions (preferred speed, frequency, design, etc.) and music that is acceptable (type of music, loudness, duration, etc.). Further research could produce object-based broadcasts which will allow a user to customise the audio and video content of a television programme to their individual preferences and accessibility requirements, rather than aiming to achieve “a one size fits all” approach.

References


Further reading


Corresponding author

Tracey Williamson can be contacted at: t.williamson@worc.ac.uk
Conversation Analysis (CA) as a tool for exploring interaction in an online video-conferencing based support service

John Chatwin and Phil McEvoy

Abstract

Purpose – Around 60 per cent of people with dementia in the UK live at home. The experience of caring for a family member with dementia can be rewarding and positive, but it can also be significantly stressful. Current healthcare policy is encouraging greater provision to support family carers. Along with respite-care, day-care and support group-based initiatives, there has also been a focus on developing dementia-specific communication training. The paper discusses this issue.

Design/methodology/approach – The authors outline a new initiative “Empowered Carers” which is being piloted in the North of England. Empowered Carers is an online support and communication training service for family carers who are caring for someone with dementia at home. It utilises online video conference-calling technology to connect carers with support workers, and also allows for simultaneous interactions involving other family members. A central tenet of the approach is a theoretically grounded support model, based on the concept of mentalisation.

Findings – The authors describe the background to Empowered Carers, and how a conventional evaluation strategy for the initiative is being used alongside a socio-linguistic approach (Conversation Analysis – CA). This aims to provide empirical evidence about how the assimilation of mentalisation is reflected in the structuring of speech patterns in carers during support sessions.

Originality/value – The authors explain the CA method, how it has been applied to similar talk-based therapeutic settings, and why its ability to explore sequential linguistic patterns across extremely large data-sets is particularly suited to studying interaction in emerging online arenas.

Keywords Conversation Analysis (CA), Carer support, Video-conferencing, Real-time online support services, Mentalisation, Family carers, Dementia

Paper type Case study

Background

Nearly two thirds of people with dementia in the UK live at home (Department of Health, 2013). But while the experience of caring for a family member with dementia can be rewarding and positive, for the majority of carers it can also be significantly stressful (de Vugt and Verhey, 2013; Robertson et al., 2007). Family carers of people with dementia are often required to provide high levels of assistance, commit a large proportion of their time and manage a range of challenging behaviours in the people they care for. These can range from repetitive speech, wandering and sleep disturbances, through to refusal of care, argumentation and violent outbursts (Gitlin et al., 2010; Schulz and Martire, 2004). If unaddressed, these behaviours have been shown to accelerate disease progression, worsen functional decline and result in earlier nursing home placement (Gitlin et al., 2012). They will also have a broader impact on the quality of life of both the person with dementia and the family carer.

For many family carers the perception that they are not properly equipped to deal with what may be a new and unexpected role can also be a considerable strain (Fauth et al., 2006; Ballard et al., 2000), and it can be difficult to reconcile the role of caregiver with that of spouse,
child or sibling (Wenger, 1997). Social isolation for family carers can also be a problem because, although social attitudes towards dementia are changing (Burgess et al., 2003), the condition is still widely associated with negative stereotypes such as the fear of losing one’s independence and being a burden to others (O’Connor and McFadden, 2010). As the family member with dementia becomes progressively more dependent and the demands placed upon the caregiver’s time and emotional resources become more consuming, family tensions arise that can be difficult to talk about (Kramer et al., 2006), not least because of the damaging and unpredictable effects that dementia can have on communication and cognitive processes – even in its early phases.

In the light of ongoing dementia-focused policy initiatives (Department of Health, 2009, 2013, 2016) support for family carers is becoming more of a priority, and there has been considerable interest in developing communication-focused training-interventions for carers of people living with dementia.

Many of these have sought to take advantage of the possibilities offered by online and web-based delivery. McKechnie et al. (2014), for example, examined computer-mediated support services for family carers and found that they often reduced levels of carer burden/stress and depression. Levels of anxiety were also reportedly reduced, and appreciation of the positive aspects of caring were increased. However, in a recent systematic review of the field, Morris et al. (2017) found that while many such interventions are successful in terms of improving carers’ knowledge of communication skills and strategies, only a minority actually have an impact on their levels of wellbeing. It has been suggested that one reason for this is that many interventions lack, or fail to adequately integrate, an appropriate theoretical model (Morris et al., 2018), and that this shortcoming can prevent an understanding of the mechanisms through which beneficial effects are realised (Elvish et al., 2013).

In this paper we use the example of a newly developed online carer-support intervention – which importantly, does have a secure theoretical basis – to illustrate how socio-linguistic approaches (specifically Conversation Analysis – CA) can be used to better understand connections that might exist between the language and interactional characteristics of people who have internalised a given system of support, and those who have not, or who are at various levels of adjustment to it. We outline how CA works, and how its ability to track linguistic patterning across extremely large data-sets is particularly suited to studying the extensive corpuses of naturalistic video data that are becoming available in emerging online support arenas.

Empowered Carers
Empowered Carers is a carer support initiative based on the well-established New York University Caregiver Intervention (Gaugler et al., 2011; Mittelman et al., 2004). This approach has been adapted widely and generally consists of an initial course of four or more sessions of individual and family counselling, followed by additional on-demand telephone support. The programme may also include access to a support group or informal support network. In the case of Empowered Carers, the intervention offers two initial face-to-face sessions for the main carer and four sessions for other family members. Ongoing support is then offered via secure online video-conferencing software which can be freely downloaded and accessed on any internet enabled device (Zoom Video Communications, 2018). The dementia communication approach offered by the service is based on the concept of mentalisation (Allen et al., 2008). This is “[…] the imaginative mental activity that enables us to perceive and interpret human behaviour in terms of intentional mental states” (Fonagy and Luyten, 2009, p. 1357). Essentially, support is offered that helps carers to become more reflective, more attuned to their own state of mind and more able to recognise their emotional response to the person with dementia. In practical terms, although carers using Empowered Carers do not necessarily need to engage with mentalisation at a theoretical level, it will give them the emotional resources they need to stay connected, handle emotional stress and navigate their day when they encounter challenging situations.

Empowered Carers is currently a pilot initiative funded by a local NHS Clinical Commissioning Group (see acknowledgements), and as such, its effectiveness will be carefully evaluated using a
variety of established measures. These will assess outcomes including levels of care-giver depression and the quality of life and social health of the person being cared for. In addition to a standard service evaluation however, the initiative will also be providing data for a socio-linguistic study which will use CA to conduct an in-depth micro-analysis of the family carer/support worker interactions that take place on the platform.

Using Conversation Analysis

CA is well-established as a highly effective method for investigating interaction in a wide variety of settings. The approach is largely concerned with the analysis of the verbal communicative practices that people routinely use when they interact with one another. Utilising video and audio recordings of naturally occurring interaction, and a highly-detailed method of transcription which captures the minutiae of speech and aspects of non-verbal behaviour, it provides an analytical method that can expose the underlying “rules” that govern how activities are composed and organised (Drew et al., 2001). From a CA perspective, the study of therapeutic interaction – and we would argue that the carer/support worker interactions we are concerned with in Empowered Carers can essentially be classed as such – aims to illustrate at an empirical level how a given approach actually “gets done” (Georgaca and Avdi, 2009). It can help to uncover and describe skills and competences that therapists or support workers themselves might be using at an unconscious level, and complement and enhance professional knowledge (Peräkylä and Vehviläinen, 2003; Peräkylä et al., 2008). Similarly, it can show how patients, clients, or in this case family carers, are adapting their interactions as they incorporate the theoretical model that underpins their training.

CA data example

One way to illustrate CA is to present an example of how it has been used in a broadly similar context, and describe an interactional effect that is likely to be prominent in the encounters we are concerned with. In their CA based study of telephone delivered cognitive behavioural therapy (T-CBT) sessions, Chatwin et al. (2018) observed that occurrences of extended silence, which in everyday conversation might be regarded as interactionally “troublesome”, are in fact often oriented to by client and therapist as non-problematic, even in the context of phone interactions when both parties are unable to access any visual cues.

By analysing a large corpus of sequential T-CBT sessions it was observed that it is often the issue of how parties switch between and signal orientation to different meanings for their silence that can create interactional misalignment, rather than the silence itself. Across several sessions, clients appeared to become more adept at recognising the interactional implications of different “types” of silence by judging which phase of a consultation they were situated in, and what activity they were engaged in – summarising, reflecting on issues of concern to them, reporting on how they had been feeling and so on.

Extracts 1 and 2 are from the T-CBT study and illustrate how effects such as instances of extended silence can impact on interaction in predictable ways. They are also an example of how the detailed transcription method used in CA (see Box 1 for transcription conventions) conveys information not only about what is actually said, but also about the relative temporal positioning of the turns at talk, the minutiae of speech, and in the case of video-recorded interaction, aspects of non-verbal behaviour (see Box 1 for the meaning of the punctuation symbols used in CA transcriptions).

Extract 1

1 T: So do you think your moods stabilised,
2 do you think now?
3 (1.5)
4 C: Ye::a?
5 (1.0)
6 T: Yea?
7 C: Just er: more positive thinking really.
8 T: The more positive thinking.

Extract 2
1 T: . . . sometimes you’ll stop, but sometimes
2 you’ll carry on
3 working through the pain. Have I got
4 that right?
5 C: Yea. .hh but that’s just cos its not
6 that strong, y’know or else I
7 feel real sorry for myself.

These two basic examples illustrate the influence that the sequential location and duration of pauses and silences can have within ongoing interaction. Although in many counselling and therapeutic settings fairly extended periods of silence are very common (Chatwin et al., 2018), there is a basic CA tenet that in everyday conversation, pauses or silences that are over about 1 s duration can indicate some form of interactional “trouble” (Jefferson, 1989). In these extracts it can be seen that the therapists and clients are orienting to this “everyday” mode of interaction.

In Extract 1, the therapist makes an enquiry about the clients mood (Lines 1 and 2), and the client confirms that it has stabilised (Line 4). Had this been a verbatim transcript of the encounter, little more information could be inferred. However, from a CA perspective, a potential misalignment between what is being claimed by the client, and what is actually conveyed in the structure of her talk is evident. Even though her reply is affirmative, this comes after an extended (1.5 s) pause (Line 3). It is also combined with the elongated delivery and upward intonation of her “ye:a?”, indicated in the transcript by the three colons and question mark (Line 4). These micro-interactional elements conspire to convey that, while it cannot be assumed that what she says is actually untrue, she may well have some reservations or concerns about it. The therapist appears to pick up on this because she also leaves an extended pause before her next turn (Line 5), and then uses a rising intonation (again, indicated in the transcript by a question mark) to prompt the client for more details (“yea?” – Line 6).

Box 1: CA transcription symbols

This is a simplified list of symbols that are often used in the transcription of recorded data (not all of these have been used in the examples we present here). In CA, punctuation such as full stops, commas and question marks, etc. can denote the characteristics of ongoing speech and do not necessarily maintain a conventional grammatical function.

*̊* – degree signs indicate speech that is quiet relative to the surrounding talk.
LOUD – capital letters indicate speech which is louder relative to the surrounding talk.
Text – underlining indicates emphasis on a word (not necessarily a rise in volume).
. – full stops are used to indicating a falling intonation.
, – commas indicate continuing intonation.
.h. – indicates an in breath.
h. – indicates an out breath.
(0.5) – numbers within brackets indicate timings in whole and tenths of a second.
(1) – a full stop within brackets indicates a “micro pause” of less than 2/10ths of a second.
[ – square brackets are used to denote the points at which speech overlaps.
::: – one or more colons after a word indicate an extended sound (e.g. an “Er” sound that is drawn out might be written: “Er: : :”). The more colons the longer the sound.

On the other hand, Extract 2 is far less ambiguous and illustrates another common CA convention: that truly affiliative or confirmatory responses usually come immediately after an enquiry – often overlapping slightly with the last syllables of the previous turn. Schegloff (2000) calls this mode of response a “smooth transition”. Here, the therapist asks the patient to confirm that a summary she has just given is accurate. The patient’s affirmative reply (Line 5) comes immediately after the therapist’s question, and conveys an essentially non-problematic response – although it could be argued that in this case the rest of what the client says suggests there may be other issues, tangentially related to her pain, that need addressing.

These short examples illustrate how CA can describe individual micro-interactional conventions at work in ongoing talk. Importantly however, if large scale longitudinal data-sets are available, including recordings made of consecutive therapeutic encounters or support sessions, it can also provide a bridge between the theoretical assumptions that underlie a particular therapeutic modality, and how these are actually reflected in the structure of the interaction between therapist or support worker and their client. A key feature of the CA approach is that unlike many of the narrative or thematic based methods which are routinely used to analyse therapeutic interaction, it is one of the few naturalistic qualitative methodologies which can work effectively with really large sets of data (i.e. extensive collections of instances within multiple interactions where a given phenomenon occurs). This is important in terms of objectivity and generalisation because the influence of individual participants communication styles, or their particular psychological disposition is effectively removed (Chatwin, 2014; Drew et al., 2001).

What CA can tell us?

In terms of the mentalisation focused support that we are concerned with, CA can provide empirical data on the underlying conversational features that are particular to people who are beginning to engage in more effective dementia communication. For example, although the practical mentalisation processes that underlie the Empowered Carers intervention are necessarily broad; the development of behavioural coping strategies; focused self-reflection and so on, their ultimate goal is still essentially interactional. The family carer and wider family network are being helped to understand and manage their emotionally influenced behavioural responses so they can communicate more effectively with the person they are caring for.

From a CA perspective, the success or otherwise of this will be evident in the construction of their talk. Aside from the higher-level elements of meaning, context and content of what they say, there will also be significant (and largely unconscious) micro-interactional effects that underpin these. These might include changes in the relative timing of utterances as they become more familiar with the mechanics of their training; changes in the use and sequential positioning of certain idiomatic constructions within their talk; or perhaps modifications in the frequency and positioning of instances of overlapping speech. There may be any number of micro-effects that could indicate that a certain interactional perspective has been achieved because, as we showed with Extracts 1 and 2, even something as simple as a variation in the duration or sequential position of a silence can convey multiple meanings.

This is where CA method can be useful, because when applied to a complete data-set (e.g. the several hundred hours of carer/support worker interactions that will potentially be available from the Empowered Carers initiative) it can isolate and describe the basic micro-interactional features that develop in the talk-processes of someone undertaking a particular type of communication training. Then, once these underlying features are identified it can be used in a more focused way to track how assimilation is proceeding in individual cases. This may be where it is of more practical relevance – particularly in terms of evaluating the effectiveness or otherwise of individual carer/support worker encounters that occur on the video-conferencing platform, and judging degrees of progress. Evaluations based on detailed longitudinal micro-interactional data are likely to be far more robust that those based, for example, on self-reported satisfaction scales.

Other CA studies in this and related areas such as counselling and psychotherapy have isolated features including the role of idiomatic expressions in interactions between mental health professionals and their clients (Antaki, 2007), and particular micro-interactional effects, including
reformulations, pausing and abrupt changes of topic, that might indicate a breakdown of empathy between client and therapist (Chatwin et al., 2007; Wynn and Wynn, 2006). Of direct relevance here, Shaw et al. (2019) recently used CA to examine how clients responded to invitations to mentalise in psychotherapy sessions, and suggest that seen from a micro-interactional perspective, the ability to mentalise is not only dependent on a degree of innate ability, but also on how clients are able to use the linguistic resources available to them. In terms of the mentalisation based support encounters occurring with Empowered Carers, we expect to find many of the features outlined in other studies. However, how they mesh, contextualise and become enacted within the additional dimension of a multi-party video conferencing platform is yet to be seen.

Conclusions

Against the backdrop of ever-greater online integration in healthcare and support services, and the growth of real-time interactive interventions, there is a strong argument for these new therapeutic arenas to receive the same level of micro-interactional analysis that has been applied to most other medical and support settings. In this paper we have explored how CA can offer insights into how users engage with online interventions, and how it can reveal how those providing support adapt their therapeutic approach to work more effectively in the online context. We have also outlined how CA can provide a better understanding of the connections that might exist between the language and interactional characteristics of people who have internalised a given system of support, and those who might be at various levels of adjustment to it. Online and web-based services are becoming an integral part of UK healthcare delivery. For a small but significant proportion of people this shift may be difficult to adapt to, and it could be argued that for some already marginalised groups (e.g. those who do not have access to a computer or smartphone or who may choose not to engage with them) it may actually be making healthcare more inaccessible. However, at a broader level, the potential “enabling” qualities of innovative services such as Empowered Carers – particularly in terms of making access to support more convenient and direct for a majority of users – would appear to outweigh this.

References


Further reading


Department of Health (2012), Prime Minister’s Challenge on Dementia: Delivering Major Improvements in Dementia Care by 2015, Crown Copyright, London.


Corresponding author

John Chatwin can be contacted at: j.r.chatwin@salford.ac.uk

For instructions on how to order reprints of this article, please visit our website: www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: permissions@emeraldinsight.com
Building rating system: an instrument for building accessibility measurement for better indoor navigation by blind people

Watthanasak Jeamwatthanachai, Mike Wald and Gary Wills

Abstract
Purpose – The purpose of this paper is to create a building rating system (BRS) with its bottom-up design model that can be carried out manually and in the future automatically.
Design/methodology/approach – The BRS is built on the basis of the structure of spatial representation framework for indoor navigation by people with visual impairment, which was validated with visually impaired people, and incorporated with building design standards and regulations from around the world. The BRS was afterwards validated by three groups of five experts in the related fields such as research and development, accessibility, and building and interior designs. Finally, the user evaluation was carried out by three focus groups of three experts in risk assessment to verify the usability of the system.
Findings – This paper provides the design and methodology of the BRS used for classifying the accessibility in buildings into four levels of classification for people with visual impairment navigating around the buildings. This system is evaluated with system usability scales (SUS), which is found to be in a “Good” level on average (72.2 SUS scores).
Research limitations/implications – Success criteria used in the space classification are mainly created for people with visual impairment at this stage; other disabilities requirements must be taken into account for the next stage of the development.
Practical implications – The system can be carried out in the future automatically in the form of standalone software or plugins that can be integrated in buildings and interior design software to seek recommendations toward a creation of inclusive built environment.
Originality/value – This paper presents a design architecture of BRS with its details, description and success criteria used in the space classification.
Keywords Accessibility, Instrument, Visual impairment, Accessibility assessment, Building rating, Rating scales
Paper type Research paper

1. Introduction and background

People with sight loss have encountered barriers to travel independently inside buildings for a long time, especially the buildings full of unfamiliar features such as universities, hospitals, shopping malls, airports and public spaces (Jeamwatthanachai et al., 2017). Inside the buildings, many problems and challenges are presented in the indoor environments, such as obstacles, noise and other barriers, especially unpredictable objects like people to navigate around, which directly affect their daily activities and navigation (Zeng, 2015).

However, many people with sight loss have identified unfamiliarity of spaces as the main reason for not visiting alone, even though many advanced technologies have been invented and come up with promising results, for instance the indoor navigation systems and wearable computing devices (Jeamwatthanachai et al., 2017). However, this may not be the best solution, since most of them are designed for sighted people. Learning new environments like hospitals, department stores, or large and complex buildings would be difficult due to the lack of accessibility information and navigational cues (e.g. landmarks) (Williams et al., 2013). Therefore, it is very hard
to decide the way to reach the destination in such complex and crowded environments (Ganz et al., 2012). In this case, they would take a long time to familiarize themselves with spaces and to construct a mental map.

Many people with sight loss are afraid of visiting the building alone since they do not know the features in spaces and buildings, which can injure them so they can end up in the hospital. This has resulted from the lack of inclusive design in the built environment. If the buildings are designed to meet the needs of people with sight loss, they would feel more confident to visit. Thus, knowing about a level of accessibility provided inside the building before making a visit to a building is essential and helpful. Toward the inclusive built environment, many building regulations and legislations have been declared and used in most developed countries (e.g. UK HM Government, 2015, 2016, USA Department of Justice, 2010, 2015, Singapore Building and Construction Authority, 2013), highlighting barrier-free, accessible and adaptable buildings and dwellings for all people, regardless of disability.

To provide an access for all people, a number of building designs standards are published, giving recommendations on how to create built inclusive environments for all people. To check how a building performs in terms of access and ease of use, a site inspection is carried out throughout the building from a list of checklists and recommendations to be followed, and it is indeed a time-consuming inspection due to details and specifications given in the checklists and recommendations.

As a matter of fact, this research aimed to create the system that can assess the accessibility in a building, which can be carried out manually and in the future automatically. Thus, a building rating system (BRS), an instrument for measuring a building accessibility, is introduced in this paper. This paper presents the first stage of developing the BRS for measuring a building accessibility by focusing on people with sight loss. This system is novel with regard to its design, methodology (such as classification workflows), and the clear indicators for space-level, floor-level, and building-level classifications. The BRS has been developed on the basis of the use of knowledge from the spatial representation framework (SRF) (Jeamwatthanachai et al., 2017), saying that the spaces are composed of 11 components drawn from cognitive mapping of people with visual impairment. The SRF was validated with 30 visually impaired people and 15 experts who worked closely with visually impaired people, for example orientation and mobility instructors and accessibility experts (AEs).

2. Building accessibility assessment

A system that enables people to rate the accessibility in buildings would be useful, assessing how well buildings and environments perform in terms of access and ease of use (Sawyer and Bright, 2014) plus giving suggestions and recommendations toward the creation and improvement of an inclusive built environment for all people.

As of now, assessing building accessibility for existing buildings and environments (i.e. access audit) and even assessing building construction proposals (i.e. access appraisal) for new developments, refurbishments and alterations are still too difficult due to a number of reasons. For example, the complexity of the buildings results in a number of auditing processes, for example a large number of requirements/checklists (Wu et al., 2007) should be used to determine how well buildings and environments perform in terms of access and ease of use (Sawyer Bright, 2014). Moreover, determining level of accessibility in buildings is also another reason. Both audit processes require thorough building inspection and review of the construction proposals for access audit and access appraisal, respectively.

Many research works have dealt with different methodologies about how building accessibility can be systematically assessed. For example, Kim et al. (2008) used virtual reality with wheelchair users’ movement, collecting 2D/3D images and assessing the building accessibility using building design criteria, accordingly. Another example is a conceptual framework for evaluating building accessibility (Sakkas and Pérez, 2006), using formal methods presented by Church and Marston (2003) in evaluation focusing on accessible paths for wheelchair users, in a structured and detailed way. Similarly, Wu et al. (2007) developed a quantitative building accessibility
assessments model, using the analytic hierarchy process (AHP) to establish multi-attributes, also known as accessibility criteria hierarchy for physical features.

To rate the accessibility in buildings, measuring accessibility in spaces is essential, which will be used in rating overall accessibility of buildings. A number of studies have been proposed regarding the rating scales to be used in space with respect to the meeting of requirements, for example scales of 2 (Sawyer and Bright, 2014) of pass (all requirements are met) and fail (at least one fail); scales of 3 (Jamaludin and Kadir, 2012) in which 2 is Fully comply, 1 is Party comply, and 0 is Not comply/not provide; and scales of 5 (Kamarudin et al., 2013) in which 1 is Poor (facility is not provided), 2 is Satisfactory (most requirements are not met), 3 is Fair (half requirements are met), 4 is Good (most requirements are met), and 5 is Excellent (all requirements are met). However, some studies have created their own rating scales, for example using relative accessibility scores (Sakkas Pérez, 2006; Church and Marston, 2003).

In terms of rating accessibility of the buildings, a percentage approach has usually been used for simplification and interpretation. All above-mentioned studies used percentages as a clear indicator (Wu et al., 2007; Kim et al., 2008; Sakkas and Pérez, 2006, Church and Marston, 2003, Jamaludin and Kadir, 2012) by first calculating the accessibility score of space (with multiplying by the weighted importance (Sakkas and Pérez, 2006)), summarizing scores of all spaces, and later normalizing the summary score into a percentage representing the overall accessibility of the buildings.

However, our study has shown that the use of percentage or averaging approaches is a bad practice, since they cause a wrong measurement in rating the accessibility of buildings. Percentage and average may be too coarse to use, especially in terms of safety. For example, the building may have a high percentage/average score but still have a few spaces that have zero or low accessibility scores such as horizontal circulation in Floor 1 (where the entrance is located). This means there is no accessibility provided in any space of the floor since visually impaired people cannot access the building. Thus, our study presents a new rating scale, which is classified as categorical data, with clear indicators and meanings.

3. Methodology

To construct the BRS, the methodological triangulation method is used for confirmation and complementarity (Denzin, 1978) toward a development of the BRS, consisting of reviews of building design standards and guidelines, expert validation, and user evaluation. The expert validation and review were carried out with face-to-face discussion individually with experts who at least had three-year experience in the required fields. The experts came from one of the three groups; there were five experts in each group, such as research and development, accessibility, and building and interior design.

Group 1: research and development expert (RDE), a group of five experts who were highly experienced in the field of research and developments. The experts were selected for their expertise with a computer science and/or engineering background over three years. This group was asked to validate and review the BRS, especially focusing on the overview of the system toward feasibility in implementing and using this system in reality.

Group 2: AE, a group of five experts who were highly experienced in the field of accessibility or assistive technology design for people with disabilities. The experts were selected for their expertise with extensive understanding on helping people with disabilities (especially people with visual impairment).

This group was asked to validate and review, focusing on the building rating scale (or Conformances A, AA and AAA, in other words) and how to classify each space into a particular conformance level.

Group 3. building and interior design expert (BIE), a group of five experts who were highly experienced in the field of building and interior design. The experts were selected for their expertise with extensive understanding in designing buildings and interiors and, especially designing inclusive built environments to meet the needs of people with disabilities. This group
was asked to validate and review, focusing on the criteria and design specifications that had been used in the space classification such as components and dimensions.

Finally, the user evaluation was done by site inspection with three focus groups of three experts in building risk assessment using the system usability scales (SUS) to assess how system performs in terms of an ease of use (Kortum and Bangor, 2013).

4. Building rating system

4.1 Overview

A BRS is an application extended from the use of SRF. It is an instrument for measuring a level of accessibility provided in the buildings for people with visual impairment. As shown in Figure 1, the BRS can be carried out in both manually operated and in the future automatically operated measurements. To carry out the automatic measurement, the manual measurement must be in place, which is described in this paper.

To measure the building accessibility, many building design standards and guidelines available around the world (e.g. UK, USA, Canada, Singapore and Australia) have been used and reviewed toward the construction of success criteria to be used in the space classification. At the end, the result is generated, consisting of building classification with details of each floor and spaces, and recommendations.

4.2 Design of building rating system

Currently, measuring the level of accessibility provided inside the buildings is still very difficult. For instance, the complexity of the building will result in a number of processes in the auditing process; there is not a set of success criteria to be used for an accessibility classification for building accessibility measurement. However, when it comes to auditing the environment, there is a set of checklists used to guide users in how to create the inclusive built environments (Sawyer and Bright, 2014). Thus, this paper presents the BRS, focusing on the accessibility for people with visual impairment, that can be carried out manually and in the future automatically.

Due to complexity in designing the system, it is essential to think of how the building is going to be rated and how its rating scores and interpretation are used. In fact, buildings are comprised of a number of spaces inside the building, for example entrance, horizontal circulation, vertical circulation, WCs, etc. It is reasonable to classify the building into three levels, that is building-level classification, floor-level classification, and space-level classification, as shown in Figure 2.

![Figure 1: An overview of building rating system](image-url)
With the bottom-up design, measuring the level of accessibility for each space is a sensible starting point and can result in rating the level of accessibility of floors and later the overall building by a use of majority scoring method described in Section 4.5.

4.3 Conformances

Conformance refers to certification and confirmation that goods or services meet or satisfy the requirements, legislations, standards or accepted practices (Caldwell et al., 2008). In the BRS, the requirements are defined as success criteria, which will be used in the space classification. To meet the conformance, a space being measured must meet or satisfy the success criteria; 13 types of spaces are used in the BRS (see Section 4.7).

In order to accommodate different situations that may require or allow greater levels of accessibility toward the building classification, as shown in the big picture shown in Figure 2, the BRS has three levels of conformances (Conformances A, AA and AAA) plus no conformance level, which are all classified as categorical data. Therefore, three levels of success criteria for all 13 spaces must be given (see supplementary material in Appendix 1). The WCAG 2.0 (Caldwell et al., 2008) also uses a similar rating scale for web pages.

For achieving each conformance in the BRS, success criteria for each conformance are designed on the basis of the use of MoSCoW prioritization approach (Hatton, 2008) in which Must Have, Should Have, and Could Have are used to define success criterion for Conformances A, AA and AAA, respectively.

The success criteria to be used in the BRS are organized on the basis of the impact on the design and improvement of spaces and building for better independent indoor navigations by people with visual impairment and accessibility. This means that the higher the level of conformance, the higher will be the level of accessibility provided to people with visual impairment, and the more will be the constraints required in designing of spaces.

However, according to the field study of SRF, the findings have shown that the most important thing in the indoor navigation is safety. People with visual impairment are afraid of visiting places where they do not know the features installed or cannot access the facilities provided in the spaces and buildings. As a result, there are three level of conformance as described with their requirements shown in Table I.
4.4 Space classification

As shown in Table I, to conform to the maximum conformance (Conformance AAA), the space must meet and satisfy all requirements of Conformances A, AA and AAA. In other words, if the space fails at least one requirement in Conformance A, the space shall be classified as no conformance, as shown in a flow diagram in Figure 3. However, in some spaces, Conformance AAA can be given, regardless of the flow diagram if an alternate version of conformance is provided, see an example in the supplementary material in Appendix 1, Section “A.5: Vertical circulation – Ramp.”

4.5 Floor and building classifications

Having mentioned in Section 4.2, a space level is the bottommost level, where many spaces can be combined into a bigger space (e.g. floors and a building). The floor classification is, therefore, determined by the majority scores where the most conformances acquired from space classification are chosen as a level of overall accessibility. Similarly, with a building classification, the same method is used where a building accessibility is determined by the same majority scores where the most conformances acquired from floors classification are chosen.

In cases where a tie happens in the floor and building classification, a special rule shall be deployed where the conformance levels are converted to a score such as 0: No Conformance (N), 1: Conformance A, 2: Conformance AA and 3: Conformance AAA. Afterwards, an average scoring approach is used in order, as shown in Table II.

4.6 Results and interpretation

Once the building (all spaces) is measured, the results will be reported in the form of spider (radar) charts, representing the level of accessibility at one particular floor achieved for each

---

**Table I** Conformance level – definitions and requirements

<table>
<thead>
<tr>
<th>Conformance</th>
<th>Requirements</th>
<th>Definitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>No conformance</td>
<td>–</td>
<td>No conformance level, providing no accessibility in the space due to the failure of meeting the minimum level requirement. In the case of no conformance, people with visual impairment are not advised to visit this space, unless assisted while inside the building.</td>
</tr>
<tr>
<td>A</td>
<td>Space must satisfy all the Must Have success criteria or the Level A conforming alternate version is provided</td>
<td>A minimum level, providing an ability to navigate the space without any hazard to people with visual impairment. In the case of Conformance A, people with visual impairment are likely to need assistance to perform some activities, otherwise they perform activity with caution.</td>
</tr>
<tr>
<td>AA</td>
<td>Space must satisfy all the Level A and the should have success criteria or the Level AA conforming alternate version is provided</td>
<td>A sufficient level of accessibility, providing features in addition to improving the independent navigation by people with visual impairment. In the case of Conformance AA, people with visual impairment may that this level is used as a general policy that all buildings must apply.</td>
</tr>
<tr>
<td>AAA</td>
<td>Space must satisfy Level A, Level AA, and all the Could Have success criteria. The level AAA conforming alternate version is provided</td>
<td>An enhanced level, providing features in addition to enabling an ability to access all of the facilities provided in the space to people with visual impairment. In the case of Conformance AAA, people with visual impairment are unlikely to need any assistance to perform the activities.</td>
</tr>
</tbody>
</table>
category of spaces in four scales, consisting of N: No Conformance, A: Conformance A, AA: Conformance AA and AAA: Conformance AAA. The example of space classification can be seen in Figure 4.

From Figure 4 and Table III, the building is measured by the use of the space classification where Conformance AA is given for all floors and where building classification is apparently determined as Conformance AA due to four ratings of Conformance AA, which is the majority. This means that the building conforms with the Conformance AA, a general policy that all building must conform to. With this result, people with visual impairment may ask for an assistance when navigating around this building.

### 4.7 Success criteria

Success criteria are requirements used in the space classification, measuring the overall building accessibility. In total, 13 types of spaces are considered to be measured in the BRS, with each space classified into one of the three levels of conformance (Conformances A, AA and AAA). This means that there will be 39 success criteria needed toward the building accessibility measurement such as entrances, foyer, passageways and corridors, stairs, ramps, lifts, ambulant disable WCs, accessible washroom, bathrooms and shower rooms, bedrooms, general space (e.g. office, living room, refreshment room), utility spaces (e.g. kitchen, laundry and storage room), and hall and stadium (e.g. lecture room, conference room, auditorium and stadium).

Determining the success criterion to be included for each conformance for each space inevitably requires an understanding of an inclusive built environment design for buildings to meet the needs of people with visual impairment. A number of building design standards, guidelines, and regulations have therefore been studied and reviewed such as UK, USA, Canada, Singapore, Australia.

All success criteria will be first used in the manually operated audit as a pass/fail checklist for measuring the level of accessibility. In the auditing process, there will be four options that users can select, which will affect the score at the end of the process, such as Pass: a feature met the success criteria; Fail: a feature failed the success criteria; Cannot Tell: a feature cannot be measured due to technical difficulties, which will require further (visual) inspections indicated by (*) asterisk in the spider chart. It should be noted that the option of Cannot Tell shall not be provided in the Must Have success criteria. Not Applicable is a feature that not present and is ignored in the accessibility measurement.

<table>
<thead>
<tr>
<th>Tie combination</th>
<th>Average scoring approach</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 in a tie</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N + A</td>
<td>(0+1)/2 = 0.5</td>
<td>A</td>
</tr>
<tr>
<td>N + AA</td>
<td>(0+2)/2 = 1</td>
<td>A</td>
</tr>
<tr>
<td>N + AAA</td>
<td>(0+3)/2 = 1.5</td>
<td>A</td>
</tr>
<tr>
<td>A + AA</td>
<td>(1+2)/2 = 1.5</td>
<td>A</td>
</tr>
<tr>
<td>A + AAA</td>
<td>(1+3)/2 = 2</td>
<td>AA</td>
</tr>
<tr>
<td>AA + AAA</td>
<td>(2+3)/2 = 2.5</td>
<td>AA</td>
</tr>
<tr>
<td>3 in a tie</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N + A + AA</td>
<td>(0+1+2)/3 = 1</td>
<td>A</td>
</tr>
<tr>
<td>N + A + AAA</td>
<td>(0+1+3)/3 = 1.33</td>
<td>A</td>
</tr>
<tr>
<td>N + AA + AAA</td>
<td>(0+2+3)/3 = 1.66</td>
<td>A</td>
</tr>
<tr>
<td>A + AA + AAA</td>
<td>(1+2+3)/3 = 2</td>
<td>AA</td>
</tr>
<tr>
<td>4 in a tie</td>
<td></td>
<td></td>
</tr>
<tr>
<td>N + A + AA + AAA</td>
<td>(0+1+2+3)/4 = 1.5</td>
<td>A</td>
</tr>
</tbody>
</table>

Notes: Although the average score is 0.5 (below 1: Conformance A), it is still above 0 (No Conformance), meaning that accessibility is still there. Thus, a minimum level of conformance shall be given in this case.
5. Expert validation and review

Three groups of five experts in RDE, accessibility (AE) and BIE were recruited, of which five experts had worked with people with visual impairment, seven experts with general disabilities; and one expert with cerebral palsy; whereas there were two experts in the field of research and development that had not yet worked with disabled people.

In this part, all responses from 15 experts will be quantified in the form of five-scales expert agreement, using a coding system shown in Table IV, and later statistically analyzed (as shown in Table V) with the details given in the face-to-face discussion.

Based on the statistical results shown in Table V, most of components in the BRS and success criteria were successfully validated, whereas some were not due to the ambiguous design and
impractical functionality, for instance floor and building classification that was designed with a use of averaging and percentage approaches to calculate the floor and building accessibility.

Many experts pointed out that the averaging/percentage approach is too coarse, biased, and not accurate to be used, especially in terms of safety measurement, for example the building may have a high average/percentage score but still have a few spaces that have no conformance. Furthermore, some spaces may be more critical than others such as main entrance or restrooms. On the contrary, two experts proposed another approach with the use of an overlapping score method, where the floor and building classifications were determined by using overlapping scores for each space (floor classification) and floor (building classification). Thus, the overlapping score method is not as good as the averaging score method. Similarly, if one floor falls into No Conformance level, the building classification will apparently fall into No Conformance as well. Therefore, a majority of building areas fall in each accessibility level, so (N, A, AA, AAA) is used instead of the average and percentage scoring approaches.

6. User evaluation

The user evaluation was carried out with three focus groups of three experts in risk assessment so as to verify the usability of the system. The process involved site inspections where the Building 53 (Mountbatten) at the University of Southampton was selected. Prior to the focus groups, the experts were asked to assess the accessibility for many types of spaces as shown below. Then, the experts were asked to give opinions based on user experience in using the BRS. In terms of usability evaluation, SUS was used, where all responses were converted into a five-point scale ranging from 1 Strongly Disagree to 5 Strongly Agree (Bangor et al., 2009; Brooke, 2013). The results of the usability analysis can be broken down into overview and details, as shown in Tables VI–VII, respectively:

1. Main foyer (wide-open area).
2. Seminar room (large and movable space):
   - Zepler Student Laboratory (large and fix space) office (small space).
   - WCs – accessible washroom WCs – public toilets.
   - Horizontal circulation (e.g. passageways and corridors); vertical circulation – Stairs.

In Table VI, the results have shown that the overall usability of the BRS was 72.2 SUS score, as classified as Good in the adjective rating scale (Bangor et al., 2009), whereas the acquired SUS scores varied from 30.0 (Awful) to 92.5 (Best Imaginable). By the adjective rating scales, four out of nine experts agreed that the usability of the BRS is in Ok level, whereas others said 2 for Best Imaginable and Good, and 1 for Awful. These indicators have shown that the BRS may not perform the best at this stage, and there must be room for improvement, which leads to a question-by-question in-depth analysis in Table VII.

In detail, the question-by-question (in-depth) analysis was performed and shown in Table VII. Means of each item are statistically tested and compared against the benchmark by Lewis and
<table>
<thead>
<tr>
<th>Category</th>
<th>No. of experts who agree</th>
<th>Mean</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building rating system</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Design of the building rating system</td>
<td>13 (87%)</td>
<td>4.0000</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance</td>
<td>10 (67%)</td>
<td>3.6670</td>
<td>0.027</td>
</tr>
<tr>
<td>Space classification</td>
<td>10 (67%)</td>
<td>3.6670</td>
<td>0.027</td>
</tr>
<tr>
<td>Floor and building classifications</td>
<td>3 (20%)</td>
<td>2.4000</td>
<td>0.033</td>
</tr>
<tr>
<td>Results and interpretation</td>
<td>3 (20%)</td>
<td>2.4000</td>
<td>0.033</td>
</tr>
<tr>
<td>Success criteria: entrance</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>9 (60%)</td>
<td>3.4667</td>
<td>0.048</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>9 (60%)</td>
<td>3.5333</td>
<td>0.006</td>
</tr>
<tr>
<td>Success criteria: foyer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: horizontal circulation</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(passageways and corridors)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: vertical circulation –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>stairs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: vertical circulation –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ramps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>9 (60%)</td>
<td>3.5333</td>
<td>0.006</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: vertical circulation –</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>lifts</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>9 (60%)</td>
<td>3.5333</td>
<td>0.006</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: ambulant disabled WC’s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: accessible washroom</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: bathrooms and shower rooms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>9 (60%)</td>
<td>3.4667</td>
<td>0.048</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>9 (60%)</td>
<td>3.5333</td>
<td>0.006</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: bedrooms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>8 (53%)</td>
<td>3.4000</td>
<td>0.054</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: general spaces</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: utility spaces</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(continued)
Sauro (2018), who provided the average and good scores that each item should achieve. Based on the analysis, the BRS has performed very well in terms of ease of use and its design/workflow, as shown in items 1–3 and 5, whose means have achieved the good score, whereas items 6–7 achieved the average score. However, some improvements are taken into account in items 4, 8 and 10. The findings from three focus groups showed that the metrics/requirements used in the success criteria are architectural jargon that are too technical but always used in the building design standards and guidelines around the world. To create the BRS for all people, some terminology might be changed to make it easier to understand. With this reason, however, the experts have asked a technical person to guide them in the beginning. Based on the observation, the experts were able to use the BRS when they understand a big picture of the system. Otherwise a user manual or training must be provided prior to the use of the BRS.

---

**Table V**

<table>
<thead>
<tr>
<th>Category</th>
<th>No. of experts who agree</th>
<th>Mean</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conformance A</td>
<td>8 (53%)</td>
<td>3.4000</td>
<td>0.054</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Success criteria: hall and stadium</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conformance A</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Conformance AAA</td>
<td>10 (67%)</td>
<td>3.6667</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>

*Note: The proposed element is considered as agreeable if the number of expert agreements is more than half (> 50 percent)*

**Table VI**

<table>
<thead>
<tr>
<th>SUS question</th>
<th>Risk assessor</th>
<th>R1</th>
<th>R2</th>
<th>R3</th>
<th>R4</th>
<th>R5</th>
<th>R6</th>
<th>R7</th>
<th>R8</th>
<th>R9</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I think that I would like to use the BRS frequently when doing a risk assessment for space designs</td>
<td></td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>2. I found the BRS unnecessarily complex</td>
<td></td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>3. I thought the BRS was easy to use</td>
<td></td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>4. I think that I would need the support of a technical person to be able to use this system</td>
<td></td>
<td>4</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>5. I found that the various functions in the BRS were well integrated</td>
<td></td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>6. I thought there was too much inconsistency in this system</td>
<td></td>
<td>2</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>7. I imagine that most people would learn to use this system very quickly</td>
<td></td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>5</td>
<td>3</td>
<td>5</td>
<td>1</td>
</tr>
<tr>
<td>8. I found the BRS very awkward to use</td>
<td></td>
<td>3</td>
<td>3</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>9. I felt very confident using the BRS</td>
<td></td>
<td>4</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td>10. I needed to learn a lot of things before I could get going with this system</td>
<td></td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

*Sum: 36 36 37 31 30 32 33 30

<table>
<thead>
<tr>
<th>SUS score</th>
<th>Rating 1:2</th>
</tr>
</thead>
<tbody>
<tr>
<td>70.0</td>
<td>70.0 57.5 62.5 92.5 80.0 65.0 92.5 30.0</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Adjective Rating</th>
<th>Best</th>
<th>Excellent</th>
<th>Imaginable</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max score</td>
<td>92.5</td>
<td>90.1–100</td>
<td>85.5–90.1</td>
</tr>
<tr>
<td>Average score</td>
<td>72.2</td>
<td>59.0–71.4</td>
<td>50.9–71.4</td>
</tr>
<tr>
<td>Acquired adjective ratings</td>
<td>Best 2</td>
<td>Good</td>
<td>Ok</td>
</tr>
<tr>
<td>1</td>
<td>Good 2</td>
<td>35.7–50.9</td>
<td>Poor</td>
</tr>
<tr>
<td>2 Bangor et al. (2009)</td>
<td>Ok 4</td>
<td>20.3–35.7</td>
<td>Awful</td>
</tr>
<tr>
<td>Brooke (2013)</td>
<td>Awful 1</td>
<td>0–20.3</td>
<td>Worst</td>
</tr>
</tbody>
</table>

*Notes: Ratings 1: Strongly Disagree; 2: Disagree; 3: Neutral; 4: Agree; 5: Strongly Agree*
7. Conclusion

People with sight loss have encountered barriers to travel independently inside buildings for a long time, especially the buildings full of unfamiliar features. Learning new environments like hospitals, department stores, or large and complex buildings would be difficult due to the lack of accessibility information and navigational cues. Many people with sight loss are therefore afraid of visiting the building alone, since they do not know the features in spaces and buildings. Thus, knowing about the level of accessibility provided inside the building before making a visit to a building is essential and helpful.

This research proposed the “Building Rating System: An instrument for Building Accessibility Measurement for Better Indoor Navigation by Blind People” based on the spatial representation framework for better indoor navigation by blind people (Jeamwatthanachai et al., 2017). The system is mainly designed, and can be carried out manually and in the future automatically, with the bottom-up design starting from the space classification, floor classification, and building classification (the topmost), indicating an overall building accessibility. To measure the accessibility of building, success criteria were designed for 13 types of spaces with 3 levels of conformance (Conformances A, AA, AAA) and also No Conformance was used as accessibility indicator. The BRS was validated and reviewed by three groups of five experts who worked in the related fields to confirm the validity of the system, and it was later evaluated by nine of building risk assessors, who had experience in building and space inspections, as three focus groups of three risk assessors. The results have suggested that the BRS has acquired a good level (72.2 SUS score) on average.

8. Future works

The BRS was finally designed and validated, targeting at improving building accessibility for people with visual impairment. Extending the BRS to other disabilities (e.g. physical, hearing and mental) is important to allow access for all.

8.1 Physical disability

The common characteristics of physical disability usually refer to physical functioning such as mobility, dexterity or stamina. Designing spaces and buildings ignoring physical disability concerns would cause them difficulties when navigating some spaces due to the physical challenges. For example, for people with wheelchair if a ramp or stair lift is not provided when there is a change in floor height.

8.2 Hearing impairment

People who are hard of hearing may have difficulties when navigating un-familiar spaces and buildings such as airports and train stations. Moving in these spaces can be frustrating for people

---

### Table VII

<table>
<thead>
<tr>
<th>SUS question</th>
<th>Actual score (n = 9)</th>
<th>Benchmark</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. I think that I would like to use the BRS frequently when doing a risk assessment for space designs</td>
<td>4.22&lt;sup&gt;b&lt;/sup&gt; 0.005*</td>
<td>3.39 3.80</td>
</tr>
<tr>
<td>2. I found the BRS unnecessarily complex</td>
<td>1.67&lt;sup&gt;b&lt;/sup&gt; 0.004*</td>
<td>2.44 1.85</td>
</tr>
<tr>
<td>3. I thought the BRS was easy to use</td>
<td>4.33&lt;sup&gt;b&lt;/sup&gt; 0.004*</td>
<td>3.67 4.24</td>
</tr>
<tr>
<td>4. I think that I would need the support of a technical person to be able to use this system</td>
<td>3.56 0.247</td>
<td>1.85 1.51</td>
</tr>
<tr>
<td>5. I found that the various functions in the BRS were well integrated</td>
<td>4.11&lt;sup&gt;b&lt;/sup&gt; 0.001*</td>
<td>3.55 3.96</td>
</tr>
<tr>
<td>6. I thought there was too much inconsistency in this system</td>
<td>1.89&lt;sup&gt;a&lt;/sup&gt; 0.001*</td>
<td>2.20 1.77</td>
</tr>
<tr>
<td>7. I imagine that most people would learn to use this system very quickly</td>
<td>4.11&lt;sup&gt;a&lt;/sup&gt; 0.040*</td>
<td>3.71 4.19</td>
</tr>
<tr>
<td>8. I found the BRS very awkward to use</td>
<td>2.33 0.111</td>
<td>2.25 1.66</td>
</tr>
<tr>
<td>9. I felt very confident using the BRS</td>
<td>4.11&lt;sup&gt;a&lt;/sup&gt; 0.003&lt;sup&gt;*&lt;/sup&gt;</td>
<td>3.72 4.25</td>
</tr>
<tr>
<td>10. I needed to learn a lot of things before I could get going with this system</td>
<td>2.56 0.312</td>
<td>2.09 1.64</td>
</tr>
</tbody>
</table>

Notes: *Actual SUS mean score has surpassed a benchmark of average score; bactual SUS mean score has surpassed a benchmark of good score. Actual SUS mean score is found to be statistically significant (p < 0.05)
with hearing impairment, and even mild hearing loss, since they cannot hear important messages or the messages are drowned out by ambient noise. It is essential to be able to receive such information while navigating spaces.

8.3 Autism spectrum disorder

Autistic people often have difficulties in reading, recognising and understanding, when interacting with objects and people. Autistic people have experienced over- or under-sensitivity to all perceptions such as sounds, touch, sight, olfaction. For example, background sounds or white noise are unbearably loud or distracting to these people. This can cause anxiety or even physical pain. Thus, it is necessary to include these requirements in the BRS.

In terms of improving the BRS, some feedback is also worth investigating, as shown in Section 5.

8.4 Use of multiple scales of measurement for success criteria

Previous research has often used multiple levels in measuring accessibility in spaces and buildings, but none of them use it on the success criteria. The BRS has used the binary Pass/Fail as its simple design, with which it is easy to perform accessibility measurement. However, the BRS was formerly designed with multiple scales (Fail/Partial Pass/Full Pass) which is more accurate for accessibility measurement. Thus, changing a binary scale to a three-level scale is worth investigating.

8.5 Alternative space classification

The BRS was designed with the space classification using category scales, considering safety in Conformance A, and then accessibility in Conformance AA and AAA. Investigating other approaches might make BRS more efficient.

8.6 Alternative methods for floor and building classification

The averaging approach was used in the BRS with conversion of category data to interval scales. However, the scales may not be equal interval, which needs to be tested. The results arising from this test will make the floor and building classification more accurate and more easily interpreted in a report on recommendations or in a possible building accessibility certificate.

8.7 Success criteria for other types of building

The BRS was introduced with accessibility measurement for general spaces and buildings. Other types of buildings could be explored, such as hospitals and sports centres, whose architectures and layouts are specifically designed for their purposes.

As building legislation around the world gradually introduces equality to society, every building must comply, for example housing and accommodation for disabled people. This system can be extended as plugins integrated into the computer-aided design software, for example AutoCad, to check the design meets the needs of disabled people.

References

Department of Justice (2010), 2010 ADA Standards for Accessible Design, Department of Justice.

Department of Justice (2015), Architectural Barriers Act (ABA) Standards, United States Access Board.


Further reading


British Standards Institution (2010), Design of Buildings and Their Approaches to Meet the Needs of Disabled People – Code of Practice, BSI.

British Standards Institution (2011), Barriers in and About Buildings – Code of Practice, BSI.

British Standards Institution (2013), Design of Accessible and Adaptable General Needs Housing – Code Of Practice, BSI.


Disability Sport NI (2016a), Accessible Sports Facilities Design Guidelines, Disability Sport NI.

Disability Sport NI (2016b), Accessible Sports Facilities Management Guidelines, Disability Sport NI.


Appendix 1. Supplementary material

The supplementary material for this article can be found online at ePrint, the University of Southampton, available at: https://eprints.soton.ac.uk/427177/

About the authors

Watthanasak Jeamwatthanachai is also known as Hall. Hall is Researcher at the National Electronics and Computer Technology Center (NECTEC). He is also PhD Candidate in the Cyber Physical System (CPS) research group. He has been researching on the topic of Human–Computer Interaction and Informatics, specializing in Spatial Representation for better indoor navigation by people with visual impairment. His research is focusing on how to create maps that can be visualized in 3D geography with full detail of information that meets the need of people with sight loss. The motivation is to help people with sight loss to have a freedom in navigation indoors. He is also interested in expanding and utilizing the 3D map into other research areas of autonomous systems, indoor position systems, new enabling technologies and other indoor-based systems. Watthanasak Jeamwatthanachai is the corresponding author and can be contacted at: wj1g14@soton.ac.uk

Professor Mike Wald Leads Research into accessible technologies in the Web and Internet Science Group, ECS, University of Southampton. He has had many years of experience working with disabled users in research, development, support and provision of knowledge in the areas of disability, assistive technology and digital accessibility. He was a Founder Member of the International Liberated Learning Consortium that included leading universities and organisations investigating how speech recognition captioning and transcription could be enhanced. Over 20,000 people in more than 150 countries have enrolled on his online inclusion and digital accessibility courses.

Gary Wills is Associate Professor in Computer Science at the University of Southampton. He graduated from the University of Southampton with an Honours Degree in Electromechanical Engineering, and then a PhD Degree in Industrial Hypermedia Systems. He is a Chartered Engineer (CEng), a member of the Institute of Engineering Technology (MIET) and a Principal Fellow of the Higher Educational Academy (PFHEA). He is also Visiting Professor at the University of Cape Town and Research Professor at RLabs. Gary’s research projects focus on secure systems engineering and applications help people to complete their tasks effectively.

For instructions on how to order reprints of this article, please visit our website: www.emeraldgrouppublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com
SiLearn: an intelligent sign vocabulary learning tool

Jestin Joy, Kannan Balakrishnan and Sreeraj M.

Abstract
Purpose – Vocabulary learning is a difficult task for children without hearing ability. Absence of enough learning centers and effective learning tools aggravate the problem. Modern technology can be utilized fruitfully to find solutions to the learning difficulties experienced by the deaf. The purpose of this paper is to present SiLearn – a novel technology based tool for teaching/learning sign vocabulary.
Design/methodology/approach – The proposed mobile application can act as a visual dictionary for deaf people. SiLearn is equipped with features that can automatically detect both text and physical objects and convert them to their corresponding signs. For testing the effectiveness of the proposed mobile application quantitative analyses were done. Quantitative analysis is based on testing a class of 28 students belonging to St Clare Oral School for the Deaf, Kerala, India. This group consisted of 17 boys and 11 girls. Analysis was also done through questionnaire. Questionnaires were given to teachers, parents of deaf students learning sign language and other sign language learners.
Findings – Results indicate that as SiLearn is very effective in sign vocabulary development. It can enhance vocabulary learning rate considerably.
Originality/value – This is the first time that artificial intelligence (AI) based techniques are used for early stage sign language learning. SiLearn can equally be used by children, parents and teachers for learning sign language.
Keywords Assistive technology, Sign language, CALL, Deaf education, Learning technology, Mobile-assisted language learning
Paper type Research paper

1. Introduction
Children acquire language and communication skills automatically through interaction with other members of the family and society. But deaf children, because of their hearing difficulty could not learn such skills automatically. The communication challenges that they face adversely affect their learning capabilities, slow down their intellectual, mental and social growth and prevent them from actualizing their potential. Falling far behind hearing children in language and communication skills, they lose their confidence and become reluctant to interact with others. To help such children overcome these difficulties and to enable them to live quality life, remedial measures intended to improve their language skills must be taken.

The commonly used method for educating deaf children is to give them training in lip reading (Stokoe, 2005; AYJNIHSD[D], 2013). It is assumed that by watching the movements of the lips and tongue of the speaker, the deaf learner could understand the speaker without hearing. Though lip reading can assist the deaf in communicating with others to a certain extent, uninterrupted or easy flow of communication is not possible as there is scope for misreading and misunderstanding. Besides, children who have not acquired language capability could not learn words through lip movements. Hence training in lip reading alone is not enough for improving their communication skills.

Another alternative for the deaf to better their interactive skills is to learn a sign language, i.e. learn to communicate through visual gestures or signs. There exist different sign languages (Simons and Fennig, 2017) in different parts of the world. Sign language has syntactic and morphological
features like any other language. Bill Stokoe in his seminal paper “Sign Language Structure: An outline of the Visual Communication Systems of the American Deaf” argued that sign language has all the properties of a spoken language. His findings brought about significant changes in the way deaf children are educated.

Learning (Knoors and Marschark, 2014) a sign language is not as easy as learning a spoken language at an early stage. Acquisition of a sizable vocabulary is the first step in the learning of a language. Children with hearing ability pickup words more easily than deaf children causing variations in the quantum of input they receive. The low input that a deaf child receives is one of the difficulties in sign language learning. Studies (Luckner and Cooke, 2010) have shown that deaf children lag behind normal children in vocabulary development. This in its turn will affect their academic development (Marschark and Knoors, 2012; Moeller et al., 2007). Another difficulty in learning sign language is the delay in attending a school for learning it.

The constant interaction with people capable of oral communication makes the learning of sign language nearly impractical. Studies (Lederberg et al., 2000) show that for children to learn sign language, closeness to the signers is necessary. In most cases (Lederberg et al., 2013), the deaf child is the only one of his family who is deaf. It is extremely difficult for such a child to learn sign language. The case of a deaf child with one deaf parent is better. If both parents are deaf, a child could learn sign language just as easily and naturally as hearing children learn spoken language. Even when hearing and speaking parents of the deaf learn sign language to teach their children, their teaching of sign language does not become effective as they have the tendency to lapse into spoken forms. Hearing parents, being novice signers could not use sign language with great proficiency. The errors that they make may put impediments in the learning of sign language.

Another major obstacle in the teaching and learning of sign language is the absence of uniformity in the signs used. Different people and different regions use different signs to represent the same object or concept. When different teachers use different signs to visualize an object, it causes confusion and frustration to learners making the acquisition of sign language vocabulary difficult.

To facilitate sign language teaching and learning, the help of sign language interpreters are also necessary. For example, India does not have sufficient number of interpreters. Figures state that there are only (ISLRTC, 2017) interpreters, i.e. roughly one for every 20,284 deaf people. Difficulty in understanding spoken language and its written forms, limited sign language proficiency of the teachers and the high expense (Price, 2017) parents incur in educating their deaf child are factors that negatively affect sign language learning (Knoors and Hermans, 2010).

Early vocabulary development in children is aided by iconicity. Research has shown that this is true for both spoken language and sign language (Caselli and Pyers, 2017; Ortega et al., 2017). Some studies have shown that deaf people have visuospatial advantages (Marschark and Knoors, 2012; Marschark and Spencer, 2003) over hearing individuals, though there exists research that claims otherwise (Marschark and Knoors, 2012; Marschark and Spencer 2003). Picture dictionaries are very common among children who are learning spoken language. They speed up word learning abilities in children. When visual information is used along with sign instructions, it will be very much easy for deaf students to learn and understand. This leads to the assumption that picture books which use a one on one visual instruction based medium are useful in the teaching/learning of sign language. Sign language teaching in schools is mainly done through manual method and interaction method. Teaching sign language vocabulary is more difficult than teaching spoken language vocabulary (Sung et al., 2016).

Instructions cannot be given through books because of the difficulty in representing signs. Books filled with pictures that represent signs will not be very useful for a first time learner. It will be difficult for the students to learn how signs are used merely by looking at a series of pictures. This will create confusion in students regarding the way a sign is done.

Technology-based solutions have introduced innovative ways for learning. Technology-based solutions because of their high availability, easy to use features and low cost become the favorite choice of educators. The scale of research and availability of assistive technology products in the field of deaf education are negligible when compared to the field of general education. Assistive technology products are gaining in importance in disability space as more and more people started using them. Assistive technology products provide good opportunity for business
too. According to a report from Coherent Market Insights (McCue, 2017), assistive technology product market is expected to surpass $26bn by 2024.

Computer Assisted Language Learning (CALL) is defined as the use of computers to learn a language through an interactive manner. The aim of CALL is to improve the teaching/learning process. In today’s scenario it embraces latest techniques like mobile-based learning, virtual reality (VR) and augmented reality based mechanisms. Mobile-assisted language learning (MALL) (Shadiev et al., 2017) is a special type of CALL, where mobile-based mechanisms (mobile phones, tablets, [...]) are used for learning. Key aspect of mobile-based learning is mobility. It has the additional advantage of providing at low cost easy to use features. Mobile phones have become so smart that its processing power is now nearly equal to desktop computers. With its decent processing power and memory, it facilities both short-range and long-range communication. Since most of these systems are equipped with facilities for easy access to internet, it is possible to carry large tranche of information in the pocket. Other notable aspects of current mobile systems are their efficient operating systems and availability of a large number of applications. Most of the OSs have features to develop applications free of cost, opening good opportunity not only in the education sector but also in other sectors. Android OS, developed by Google, is popular in developing countries and has got a large number of free applications available in its application download center, Google Play Store. Recently (Burston, 2015), MALL-based systems are shown to be very effective as learning tools. Studies (Martin and Ertzberger, 2013; Wu et al., 2012; Sung et al., 2016) have found that mobile-based learning improves students’ learning ability better than the traditional ones. The existing mobile-based sign language learning tools (Table I) do not have adequate number of signs and could provide only very little interactivity.

This paper presents SiLearn, a highly interactive mobile-based sign learning tool that makes the use of AI-based technique to make the learning of sign language easy and effective for deaf children. In SiLearn, as the sign is learned through pre-recorded videos, learners will be able to see the same sign always. The pre-recorded videos of the signs stored in our mobile application provide the advantage of teaching everyone everywhere the same standardized sign. This in its turn will pave the way for the creation of a standardized learning environment. SiLearn, a mobile-based application, because of its portability will make learning anytime anywhere possible. Our study has found that learning rate can be increased significantly by making use of SiLearn.

The proposed tool can equally be used by children, parents and teachers for learning sign language. One of its advantages is that sign language vocabulary learners can use the same vocabulary learning picture books used by spoken language learners. Sign language users can point to words in the picture dictionary and SiLearn automatically shows the corresponding sign making learning more fun and engaging. The automatic object detection facility of SiLearn makes it more useful in teaching/learning than traditional methods. This tool is developed on the assumption that the mapping of a word to its object can increase the vocabulary development skills of learners. Though there are many mobile applications currently available for learning sign language, what makes our mobile-based application different and special is the use of the state of art object detection technology. To the best of our knowledge, SiLearn is the first mobile-based application that used artificial intelligence (AI) for providing better learning experience to sign language learners in the initial stages of learning.

<table>
<thead>
<tr>
<th>App name</th>
<th>Sign Language</th>
<th>Availability</th>
<th>Initial install size (MB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ProDeaf Translator</td>
<td>Libras/ASL</td>
<td>Android</td>
<td>29</td>
</tr>
<tr>
<td>The ASL App</td>
<td>ASL</td>
<td>Android</td>
<td>9</td>
</tr>
<tr>
<td>Hand Talk Translator</td>
<td>Libras</td>
<td>Android</td>
<td>29</td>
</tr>
<tr>
<td>Baby Sign</td>
<td>BSL</td>
<td>iOS</td>
<td>11</td>
</tr>
<tr>
<td>Baby Sign and Learn</td>
<td>BSL</td>
<td>Android/iOS</td>
<td>2.5</td>
</tr>
<tr>
<td>MobileSign</td>
<td>BSL</td>
<td>Android/iOS/Kindle</td>
<td>1</td>
</tr>
<tr>
<td>ISL dictionary</td>
<td>ISL (English)</td>
<td>Android</td>
<td>68</td>
</tr>
<tr>
<td>Indian Sign Language</td>
<td>ISL (English)</td>
<td>Android</td>
<td>2</td>
</tr>
</tbody>
</table>
2. Technology background

Digital technology based mechanisms are increasingly being used to develop teaching aids (Lajoie and Derry, 2013). Artificial Intelligence involves mimicking human intelligence for carrying out various tasks. AI works on the principle that a computer can simulate human brain to do useful work. Abbreviated as AI, artificial Intelligence can be utilized for developing educational tools. In our mobile application, machine learning techniques are utilized for recognizing physical objects and words. Machine learning is a special type of AI where machines learn from already existing data to predict new patterns.

One of the functionalities provided by our application is the automatic conversion of scanned text (word) into its corresponding sign. For this purpose, it makes the use of optical character recognition (OCR) (Smith, 2007). The process involves converting the scanned image into a binary image and then doing a connected component analysis for extracting character outlines. Polygonal approximation is done for obtaining about 50–100 features for each character and then they are fed to the recognition phase. This phase is a two-pass process where in the first pass, words are detected and in the second pass characters are detected based on an adaptive classifier. Words that are not recognized well enough, are rerun through the classifier for recognition.

Another functionality provided by SiLearn is the automatic detection of a physical object (Szegedy et al., 2015) from its camera captured image and conversion of it to its corresponding sign. For example, user can take the photo of a computer mouse and our application will automatically show the corresponding sign. We rely on deep learning algorithms to make this work. Deep learning is a recently developed machine learning technique where vast amounts of data are used to learn a model and based on which decisions are made. Deep learning has found application in healthcare (better disease diagnosis), automotive industry (driverless cars), entertainment industry (better movie recommendations), etc. Mimicking human brain behavior, deep learning algorithm passes its input through a large number of neurons. Unlike traditional neural network based models, deep neural network needs large processing power for training. But for classification purpose it does not need much processing power. Hence Deep Neural Network models could be used in mobiles to do classification work. In SiLearn, we have used a deep learning implementation called Convolutional Neural Network (CNN). CNN has been able to achieve very low error rate compared to peers.

3. Focus group and ISL

The major focus group of our work was school going children who are deaf. The mobile application was also tested on sign language teachers and sign language learners for understanding its efficiency. The subjects were given mobile application for testing. Children who were given mobile application for testing were students of St Clare Oral Higher Secondary School For The Deaf, Kerala. They did not have much exposure to mobile phones. Others who were tested were regular mobile users and had android based phones with them. All the people under this study were from Indian state of Kerala.

According to census 2011, India has 5,071,007 people with hearing disability. This is about 18.9 percent of the total disabled population. The disability census report 2015 by Kerala Government (Disability Census 2014-15, 2017) reveals that there are 60,925 people with hearing disability. This is about 7.67 percent of the total disabled population in the state. There exist no data on the number of sign language users in both of these censuses. Kerala has close to 30 schools for deaf. Our study shows that the parents of only less than 10 percent of the students are deaf.

Though India has its own sign language, Indian Sign Language (ISL), it is not widely used all over India. Like other sign language ISL also uses hand gestures, facial expressions and head/body movements for signing. Most Indian schools have begun to teach sign language based on ISL only recently. First serious attempt to study ISL started in 1977 by Vasishta et al. (1980). It was a complex task because of the social and linguistics variations in India. They found that the vast majority of signs used in India are not related to European Sign Languages. But there is close association between the different sign languages of the Indian subcontinent. Their 1978 study emphasized that there is only one ISL, but acknowledged that there are regional variations. They also observed that ISL grammar is very complex. We could not find any recent study
regarding the number of sign language users in India. Vashishta et al. estimates it at 1,000,000 deaf adults. In ISL, the general rule for signing a sentence is to put participant first and predicate last (Zeshan, 2000).

4. Tools for sign language learning

Not much research has been done on technology-based products for learning sign language in the initial stages. The user interaction provided by current technology-based application is minimal (Cempre et al., 2013; Reis et al., 2015; Mokhtar and Anuar, 2015; Boulares and Jemni, 2012; Kasim and Wai, 2013; De Martino et al., 2017). Most of the existing products available as mobile applications could convert only displayed text/character into the corresponding sign language. They can only select or search the already listed words and convert them into corresponding signs.

ViSiCAST (Bangham et al., 2000) (Virtual Signing: Capture, Animation, Storage and Transmission) is a project funded under the European Union Fifth Framework to improve the quality of life of the deaf citizens of Europe. It was built on the experience gained from two previous projects which used virtual avatars Simon, Tessa and Vissia. eSIGN is a EU-funded project whose aim was to provide information in sign language using avatar. The project has produced software tools which allow website and other software developers to augment their applications with signed versions. A notation system called SIGML was developed as part of the project’s ViSiCAST and eSIGN. DICTA-SIGN (Efthimiou et al., 2010) project explores a human-computer interface for deaf users with the help of sign-wiki project. Its main goal was to utilize Web 2.0 features for the benefit deaf users. It supports British Sign Language (BSL), German Sign Language, Greek Sign Language and French Sign Language. It also proposes a sign recognition module using input from Microsoft Kinect hardware. SignSpeak (Dreuw et al., 2010) project was proposed to develop a new vision-based technology for continuous translation of sign language to text. This will help the deaf to communicate with hearing people.

VR (Kaufmann and Meyer, 2008; Radu, 2014) and game-based mechanisms (Domínguez et al., 2013; Dicheva et al., 2015; de-Marcos et al., 2016) are also explored for teaching new concepts. Nicoletta Adamo-Villani et al. (2006) proposed a virtual learning environment for learning sign language mathematics and its related words. Along with the VR mode, it is also equipped with a gesture tracker for providing more user interaction. Game based (Brashear, 2007; Bouzid et al., 2016) mechanisms are also proposed for sign language learning. Yosar Bouzid et al. (2016) proposed a game-based mechanism for learning sign language notation system SignWriting. A game for deaf children is proposed (Brashear, 2007) to develop their language skills. It provides interactive tutoring and real-time evaluation facilities for learners. It is a game-based system where camera and sensors are used to detect and collect signal data for the American Sign Language (ASL) recognition system. The user wears gloves and any sign made will be captured by the camera. The system then shows a video with a signer demonstrating the correct ASL phrase. The user can then mimic these gestures.

There are many mobile-based applications for learning sign language. They mainly work by showing a sign corresponding to the displayed text. There are also a few applications which teach sign vocabulary interactively. SMART-Sign (Weaver and Starner, 2011) is a mobile application for parents of deaf children for learning ASL. Its features such as sign dictionary, quiz, video recording functionality are helpful in learning. SmartSign-Play (Chuan and Guardino, 2016) is an extension of SMARTSign and provides a game-based mobile application for sign vocabulary learning.

5. Application design

SiLearn provides students with a menu from which they can select two modules:
1. object Detection based learning; and
2. word recognition based learning.

Figure 1 shows the flow of control from the main menu.
In object detection based learning, when the user points to a physical object, the object detection screen automatically displays the corresponding sign. Object detection makes use of deep learning, which is an advanced AI technique. Google inception v3 (Szegedy et al., 2016) is used as the model for detection. Implementation used in SiLearn has a 22 layer deep network. This particular implementation makes use of an architecture which uses very little computational power making it suitable for use in mobile phones (Szegedy et al., 2015). This system needs to be trained for object detection. It will take weeks for training on most powerful computers. In SiLearn, we have used a pre-trained model. Input to the application is a picture of an object taken using mobile camera. Advanced AI techniques are used to detect automatically the object from the picture fed to the application. The output is a set of possible detected object classes. From this class, one with maximum probability score is selected. The selected class is then matched with sign database. If a match is found, corresponding sign is played. If no match is found, error message is given.

In word recognition based learning, the OCR screen can be used along with the vocabulary learning book used by children having hearing ability. The user can also take a picture of the printed text and mobile application can automatically play the corresponding sign. Character recognition is done using Tesseract (Smith, 2007), which is an open source OCR engine developed by Google. OCR part of the mobile application uses a binary image as its input. Word for learning is selected using camera. SiLearn has got features to select the required word. After selecting the word, it is given to character recognition module. The recognized word may contain some unidentified characters. In that case, the extracted word is cleaned and the resulting word is matched with the sign database to find the sign. Cleaning involves removing unidentified characters from the extracted word. Like the previous module, if a match is found, corresponding sign is played. If no match is found, error message is given. SiLearn stores words in their root form and employs a stemming algorithm to convert the camera captured word to its root form. The stemmer employed removes suffixes from the given word and returns the root form. Figure 2 shows the detailed working of both object detection and OCR modules.

An important design choice is the trade-off between internet connectivity speed and memory requirement. In an ideal situation, a mobile application should take only a little memory and should work on slow speed connections. For the application to work on slow internet speed, it should store most of its requirements in memory which would necessitate more phone memory. The policy we have adopted is to store signs corresponding to most commonly used words in phone memory and fetch others from internet.
6. Implementation and evaluation

SiLearn is implemented as an Android based mobile application. OCR feature of SiLearn is implemented using Android library for Tesseract (https://github.com/rmtheis/tess-two). Porter stemmer (Porter, 2001), which is a rule based stemmer is used for converting word to its root form. Object detection is implemented using Android Tensorflow mobile (www.tensorflow.org/mobile/) implementation. Tensorflow is an open source library from Google for machine intelligence. It is a favorite tool among researchers for implementing machine learning algorithms. Tensorflow mobile is TensorFlow implementation tuned for mobile and other embedded platforms. Rather than doing computation in remote systems, as was the case earlier, Tensorflow mobile enables to do computation in the mobile hardware itself. One downside of this is the increased application size. YouTube Android API (https://developers.google.com/youtube/android/player/) is made use of in playing the signs. Plate 1 shows the working of SiLearn on an Android phone. Plate 2 shows a student learning sign vocabulary using SiLearn app with the help of his teacher.

SiLearn includes signs corresponding to 950 words and object detection module is able to detect 15 classes. These 15 classes are objects that can be shown in a classroom setting. Objects selected for detection includes laptop, keyboard, wallet, mobile phone, […] Plate 2 shows object detection module detecting the object “wallet.”

For testing the effectiveness of the proposed mobile application quantitative analyses were done. Quantitative analysis is based on testing a class of 28 students belonging to St Clare Oral School for the Deaf, Kerala, India. This group consisted of 17 boys and 11 girls. Analysis was also done through questionnaire. Questionnaires were given to teachers, parents of deaf students learning sign language and other sign language learners. These 28 students were
Plate 1  SiLearn Working

Notes: (a) OCR scanning; (b) sign corresponding to detected word “World”; (c) object detection; (d) sign corresponding to detected object “wallet”

Plate 2  A student trying out SiLearn with the help of his teacher
selected on the basis on their willingness to take part in the study. Informed consent forms were collected from their parents before the start of the study. No other extra information was collected from these students.

For quantitative analysis, pre-test and post-test were conducted for control group and experimental group. From the group of 28 students, equal number of students were put into both groups randomly:

- Pre-test: in pre-test all students were asked to answer the same set of 20 questions to assess their vocabulary.
- Training: students in control group were trained using normal classroom teaching method and students in experimental group were trained using SiLearn mobile application. It was done with the help of a teacher.
- Post-test: in post-test the same procedure as in pre-test was repeated.

Vocabulary assessments focus on estimating the number of words a child knows. This can be assessed receptively (words understood) or expressively (words produced). We have followed receptive assessment in this study. For testing their vocabulary, students were presented with a series of pictures. These pictures were arranged in such a way that each page had four pictures numbered one to four (same way as peabody picture vocabulary test). A sign was given by the examiner and the students were asked to tell the number that identifies that sign. Based on this, a score was given to each student. For the particular mechanism followed in this study, for each correct answer 5 marks were given. This pre-test was conducted on both control group and experimental group. This test is modeled after Carolina Picture Vocabulary Test (Prezbindowski and Lederberg, 2003), which is used to test vocabulary in hearing children. A.K. Prezbindowski and A.R. Lederberg (Prezbindowski and Lederberg, 2003) successfully applied this test on deaf students (Table II).

For questionnaire based analysis respondents were asked to give a score to the questions, which are on a Likert-type scale of 1–5. For qualitative analysis, responses were collected from a total of 68 people.

7. Results and discussion

Pre- and post-test analysis given in Table III shows that there is improvement in the mean scores of both groups upon completion of study.

<table>
<thead>
<tr>
<th>Table II</th>
<th>Participant details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Deaf by Birth</td>
</tr>
<tr>
<td>Total</td>
<td>25</td>
</tr>
<tr>
<td>Control</td>
<td>12</td>
</tr>
<tr>
<td>Experimental</td>
<td>13</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table III</th>
<th>Pre-test post-test result statistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td>2×pre-test</td>
<td></td>
</tr>
<tr>
<td>Experimental Group</td>
<td>14</td>
</tr>
<tr>
<td>Control Group</td>
<td>14</td>
</tr>
<tr>
<td>2×post-test</td>
<td></td>
</tr>
<tr>
<td>Experimental Group</td>
<td>14</td>
</tr>
<tr>
<td>Control Group</td>
<td>14</td>
</tr>
</tbody>
</table>
A null hypothesis shows that the scores of both groups would be equal, and an alternative hypothesis shows that the score of experimental group would be significantly higher than that of control group were made before the test. Before running $t$-test, normality of the scores was verified using Shapiro–Wilk normality test.

A paired one tailed $t$-test was done to understand the effectiveness of study on both experimental ($t = 4.212$, df = 25.357, $p$-value $= 0.0001401$) group and control group ($t = 2.135$, df = 22.971, $p$-value $= 0.02183$). Results show that null hypothesis could be rejected. This confirms that learning (classroom and SiLearn learning) improves the vocabulary understanding of both groups.

Gain scores for both groups are also calculated and compared. Our study has found that there is statistically significant difference between the gain score of experimental group and the control group. This indicates that SiLearn has an advantage in vocabulary learning. Gain of student marks for control and experimental group is given in Figure 3. Table IV shows the gain score test result for the vocabulary test. One tailed unpaired $t$-test is used here.

Analysis of gain scores shows that experimental group fares better than control group in vocabulary learning.

A set of 20 Likert-type questions were used for questionnaire based analysis. Different set of questions were given to students and parents/teachers/practitioners. A snapshot of survey questions and results are given in Tables V and VI. Survey questions are aimed at checking the ease of use, effectiveness, usability of SiLearn.

Student survey is conducted on the same set of students who used SiLearn. Survey results clearly tell that students prefer SiLearn. The question on the ease of using SiLearn with vocabulary learning book earns the highest average marks. Students find using SiLearn with vocabulary learning book very helpful in learning. The availability of mobile phones and picture books make the learning of new words easy and interesting. Since learning with SiLearn is more like playing than studying students will devote more time for learning. Earlier it was difficult for them to study signs merely by looking at a vocabulary learning book. They agreed that this will help them to learn more words easily. The question on the ease of use aspect of the software records the lowest average marks. This is partly because of the low recognition ability of object detection module. When students tried
Object detection module is trained to detect only 15 classes of objects. If one points to an object which is not in the trained class, our application will show a not found error. Detection accuracy depends on the clarity of the image being captured through the phone. More brightness or blurring of the captured image results in low detection accuracy. Object detection works correctly when the image to be detected fills the captured screen correctly. For the first time user it needs some training to make it work correctly.

Detection accuracy can be improved by feeding the model used for training with more training images. Inception model which we have used achieved 21.2 percent, top-1 and 5.6 percent top-5 error rate for evaluation on the ILSVR 2012 classification. Detection accuracy exhibited by Inception model is the best among its class. Another reason for the low score on the ease of use aspect is the difficulty experienced by the first time learner in selecting a word from user interface. In SiLearn, while using the vocabulary learning book, user has to select the appropriate word using the rectangular box displayed on the screen. For the first time user of smartphones, this process is not easy. As the students gain more experience in using smartphones, these difficulties will diminish.

For the other survey, parents of deaf students, deaf people who already know sign language, sign language interpreters, sign language learners and sign language teachers belonging to various geographical locations and backgrounds are chosen. All of them were sure that the use of SiLearn will help to increase interest in learning. In India, where even printed sign dictionaries are not popular, users find SiLearn very helpful and interesting. Respondents gave very high scores for interest in learning and for the ease in using SiLearn along with alphabet learning book. Discussion with them revealed that the deaf education sector where technology-based products are rare, these types of products can improve learning to a great extent.

<table>
<thead>
<tr>
<th>Table V</th>
<th>Survey for students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Mean</td>
</tr>
<tr>
<td>Increases interest in learning</td>
<td>4.29</td>
</tr>
<tr>
<td>Can study more words as compared to classroom learning</td>
<td>4.00</td>
</tr>
<tr>
<td>Easy to use with alphabet learning book</td>
<td>4.39</td>
</tr>
<tr>
<td>Object detection is interesting</td>
<td>4.29</td>
</tr>
<tr>
<td>Character recognition helps to learn words easily</td>
<td>4.07</td>
</tr>
<tr>
<td>Software is easy to use</td>
<td>3.29</td>
</tr>
<tr>
<td>Easy to navigate in the Software</td>
<td>3.89</td>
</tr>
<tr>
<td>Can be recommended to other students</td>
<td>3.89</td>
</tr>
<tr>
<td>Satisfied with look and feel of this software</td>
<td>3.61</td>
</tr>
<tr>
<td>Overall, how easy to use do you find this software</td>
<td>3.71</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table VI</th>
<th>Survey for others</th>
</tr>
</thead>
<tbody>
<tr>
<td>Question</td>
<td>Mean</td>
</tr>
<tr>
<td>Increases interest in learning</td>
<td>4.20</td>
</tr>
<tr>
<td>Helps to learn new words easily and faster</td>
<td>3.96</td>
</tr>
<tr>
<td>Easy to use with alphabet learning book</td>
<td>4.33</td>
</tr>
<tr>
<td>Object detection is interesting</td>
<td>3.23</td>
</tr>
<tr>
<td>Character recognition helps learning words easy</td>
<td>3.73</td>
</tr>
<tr>
<td>Software is easy to use</td>
<td>3.60</td>
</tr>
<tr>
<td>The mobile application UI is easy to navigate</td>
<td>4.00</td>
</tr>
<tr>
<td>Can improve word learning skill of students</td>
<td>3.93</td>
</tr>
<tr>
<td>Satisfied with look and feel of this software</td>
<td>3.60</td>
</tr>
<tr>
<td>Overall, how easy to use do you find this software</td>
<td>3.57</td>
</tr>
</tbody>
</table>
When open questions were regarding SiLearn, most of the students talked about the non-availability of mobile phones and delay in loading videos. Sign videos corresponding to words have to be fetched from YouTube as only a few signs are stored in the phone in order to control the mobile application size. In SiLearn, we stored only ten signs in phone memory and others are fetched from YouTube. These ten signs are correspond to objects stored in the object detection module. Because of slow internet connection the loading of signs become slower. This problem is reported by respondents of the survey. Since the application can be adapted with offline storage of videos, this problem can be circumvented.

Because of their sign language illiteracy parents could not help their children learn sign language. The difficulty in getting the help of sign language teachers deter them from learning it. But with SiLearn installed mobile phones parents can learn signs independently. Some schools reported that parents who lack sign literacy are not interested in their children learning sign language. The sign dictionary made available by SiLearn, with its large number of signs enables them to communicate with their children in sign language itself. Currently SiLearn is able to show 950 signs. Parents and other sign language learners found character recognition very much helpful. They could use SiLearn to translate words from newspapers and books to their corresponding signs. But the selecting of text from books and newspapers need practice. SiLearn will not be able to translate, if it has more characters in the selected area. With enough practice, SiLearn can easily be used to translate words in books and newspapers to their corresponding signs.

Discussion with school authorities revealed that it is the lack of awareness about the merits of sign language learning that compels the people concerned to stick on to traditional methods. We strongly believe that awareness raising sessions should be conducted for parents of deaf children to make them aware of the need for learning sign language. Orientation sessions for trainers will be helpful. Authorities of a deaf school reported that due to complaints from parents, they had to switch back to lip reading.

Different parts of India use different signs to represent the same word causing confusion to the learners. For example, 35 people who participated in the survey from different geographic locations used different signs for the same word. Of the 50 signs discussed, 20 of them were different from the signs released by ISL Research and Training Centre (ISLRTC). All of them pointed out that SiLearn could bring uniformity in the use of signs. People everywhere in India would begin to use the same sign for the same word. The use of SiLearn would standardize signs which in its turn will simplify sign language learning.

8. Conclusion

This paper describes SiLearn, a mobile application that helps in sign language vocabulary development. SiLearn can be utilized by both deaf/hard-of-hearing people and people with spoken language abilities. The visually enriched application provides a conducive environment for fast vocabulary development. This application can be extended to learn sentences as well. For this, it should include mechanism to process sentence and convert it to corresponding sign language. Since SiLearn makes the learning of standardized signs easy, it can also be used by hearing parents of deaf children to learn signs independently facilitating easy communication with their children. Low cost, everywhere availability and user friendliness make it a helpful assistive technology tool. We plan to introduce an adaptive system which would be easily accessible in case of poor internet connection. One solution would be to store frequently used signs in memory and fetch others from internet. Though AI-based techniques like object detection has a long way to go before being used as a fully functional learning tool, we strongly think that, in the years to come AI will become a very useful tool in developing learning technologies.

References


Corresponding author
Jestin Joy can be contacted at: jestinjoy@gmail.com

For instructions on how to order reprints of this article, please visit our website: www.emeraldgrouppublishing.com/licensing/reprints.htm
Or contact us for further details: permissions@emeraldinsight.com
Economic impacts of changing technologies on New Zealand homecare delivery

Julia Lesley Hennessy and Averyl Rodrigues

Abstract

Purpose – The population of New Zealand (NZ) is ageing; the proportion of people aged 65 and over as compared with the younger age groups is expected to increase from 15 per cent in 2016 to approximately 30 per cent by 2068. This change in demographics is bound to apply some pressure on economic resources due to factors such as superannuation and increased healthcare needs. The purpose of this paper is to explore the use of technology as being economically beneficial for managing the grey tsunami that has commenced in NZ. Though technology is still not being utilised to its full capacity in the healthcare sector, there is a reason enough to believe that it could be used in assisting with ageing in place. However, its cost-effectiveness has not been clearly demonstrated.

Design/methodology/approach – A literature search was performed using search engines such as ProQuest, EBSCO, CINAHL and Google Scholar. Keywords used were ageing in place, technology, assisted living technology, ageing, telecare and telehealth. The papers selected were publicly available. To determine if the cost evaluation literature were of acceptable quality, they were assessed according to a well-recognised economic evaluation checklist by Drummond et al. (2005).

Findings – As is evident from the demographic figures, there needs to be timely intervention to appropriately manage the ageing population given the projected financial and population figures. Technology has proved beneficial especially with positive ageing. A significant reason for it hardly being used is the lack of thorough studies that demonstrate its cost-effectiveness. The studies that have tackled the subject of economic evaluation have provided mixed results with some labelling technology as cost-effective and the others opposing this finding. Studies have shown that even the simplest form of technology such as a phone call, mobile health application or a pedometer can be effective.

Research limitations/implications – The majority of research and funding is directed towards supporting the frail adults instead there should be equal focus on those who are reaching the old age group. Since current data suggest that people are living longer, early intervention is beneficial to reduce the number of years lived with disabilities along with associated costs of disease burden.

Practical implications – Healthcare policymakers need to take more proactive steps through incorporating technology rather than deferring its use until proven beneficial by large studies as this is not feasible given the rate at which technology is developing. Studies have shown that even the simplest form of technology such as a phone call, mobile health application or a pedometer can be effective.

Social implications – Technology increases awareness and allows people to be more disciplined with their health plan which increases good health. Early intervention also means relying and involving the primary level of care to manage the disease which would be more economically beneficial than postponing care until the disease progresses in which case secondary or tertiary levels of care must be sought.

Originality/value – This is an emerging field in the area of aged care and only begins to expand potential horizons. Studies show that a significant number of the population prefer to stay in their own homes as they age and that with the improvement in technology this could become a reality. However, health planners need to be considering technology when developing health and social services.

Keywords Ageing, Technology, Healthcare, Ageing in place, Cost-effectiveness, Cost-benefit

Paper type General review
1. Introduction

In New Zealand (NZ), the proportion of people aged 65 and over is expected to increase from 15 per cent in 2016 to approximately 30 per cent by 2068. This change in demographics will apply pressure on economic resources due to factors such as universal pensions and increased healthcare needs. The Treasury (2016) suggests that this will place additional pressure on the NZ economy as what Treasury perceives as a reduced contribution of this group, increased costs of the universal pensions and health expenditure. One approach to decrease the escalating health costs is by promoting ageing in place supported by technology, thereby reducing the costs associated with residential care and long-term hospitalisation. Carnemolla (2018) describes ageing in place as:

[…] a concept whereby older people are able to continue live in their own homes as they age despite changes to their health and mobility […] to complement ageing in place interventions including home modifications and existing informal and formal care services by working in the following ways:

- to facilitate self-care and autonomy by removing the need for third party intervention in order to complete daily tasks;
- to support older people’s safety in the home by automating tasks and reducing risk; and
- to support confidence levels in conducting daily tasks though increasing safety and reducing risk. (p. 2)

Vanleerberghe et al. (2017) suggest that governments should prompt “aging in place for their rapidly aging population since this policy is a win–win situation for both sides. […] it is seen as cost-effective, and on the other hand, it is the wish of the older generation to stay in the current setting as they grow older” (p. 2905).

1.1 Demographics

Statistics New Zealand has projected that by 2032, 20–22 per cent of the population in NZ will be over the age of 65, reaching 24–33 per cent by 2068 (as compared with 15 per cent (698,400) in 2016). Conversely, the number of people in the age group of 15–24 years is expected to drop from 65 per cent in 2016 to 57 per cent in 2068. The proportion of older people in NZ is increasing due to increased life expectancy, returning migrants and the Baby Boomer generation, born between 1946 and 1965, moving into the “older adult” cohort, causing the population curve to skew (Ministry of Health, 2016; Stats NZ, 2017), as shown in Figure 1.

![Figure 1: Projected population growth – age group comparison](image)

1.2 Healthcare budget

According to Welton (2017), additional health funding needs to align with the demographics, with an estimated $2.3bn expenditure required with only $0.8bn being provided in 2017. This fiscal gap could explain the overstrained health workforce, rising mental health care issues, higher number of people not visiting general practitioners due to rising fees and the reduction in funded elective surgery.

1.3 Aged care and long-term hospitalisation

Older population services are based on a “Needs Assessment”, funded through the Ministry of Health (MOH) to provide services for staying at home or assistance to move to residential care facilities. The extent of support depends on the individual’s condition, age, dependents and financial means assessment (assets and income):

- $983m was spent on support for older people in 2014–2015, of which aged residential care was a major proportion (60 per cent), as set out in Figure 2 (Ministry of Health, 2016). The amount spent by District Health Boards for older people has almost doubled in the ten years since 2005/2006, with almost 42 per cent being used for services for the older population.

- The maximum contribution per week per individual for long-term aged residential care ranges from $973.91 to $1,062.95, depending on the location (New Zealand Gazette, 2017). Stock (2015) reports that the average length of stay in an aged care facility and hospital is 85 and 76 weeks, respectively, with the government spending around $90,000 per individual in an aged care facility if the maximum contribution is considered.

- There are 668 aged care facilities in NZ, with an occupancy rate of 86.9 per cent (33,640 residents) as of September 2017 (Evans, 2017). There are approximately 1.6m people who were 50 years and over in 2017 (NZ. Stats, 2016) with only 2.09 per cent living in care facilities, the majority are living at home without support. The cost of constructing an 80-bed aged care facility is roughly $10.62m while the operating costs per year will be $2.8m (Colegrave, 2011).

Other cost concern issues:

- Chronic diseases: over 75 per cent of the ageing population (defined as those aged 65 and over) has at least one chronic condition. Metzger (2011) suggests that significant savings can be made if appropriate homecare services are accessed early.

![Figure 2: Support service spending for older people](image-url)
Falls: approximately one in three people over the age of 65 has at least one fall per year, increasing for those over the age of 85 (Giordano et al., 2016). Giordano et al.’s (2016) study is consistent with the figures in NZ where 217,000 people aged 50 and over had one or more falls in 2015, with over 11 per cent (25,800) being hospitalised for an average of 10.3 days, with 78 per cent (20,100) hospitalised for more than a day. Over 3,500 suffered hip fractures ($47,000 on an average for hip fracture with 3 days hospitalisation) at an annual cost of $169m. In total, 76 per cent of those with hip fractures required surgical intervention and a quarter of those received bisphosphonate medication following the surgery (HQSC, NZ, 2017).

Hospitalisation: the costs for hospitalisations places significant pressure on healthcare budgets as set out in Table I.

NZ’s health spending in relation to their gross domestic product is comparable to other Organisation for Economic Co-operation and Development countries. Figure 3 shows that a higher budget does not equate to better performance of the health system, more cost-effective and efficient options need to be considered. One option is to raise the pension eligibility age in NZ from 65 to 67 years. However, this does not appear to be an appropriate option as the percentage of Accident Compensation Corporation, the universal accident insurance system, injury claims in the age group of over 65 years is 12.4 per cent the second highest group suggesting that by increasing the age for superannuation will force more in this age group to remain in work and risk being injured (Donovan, 2017).

2. Challenges

Ageing in place is one method of reducing the burden on healthcare costs. Based on the Centre for Social Research and Evaluation’s ageing in place report, a high proportion of people prefer living at home and being part of a community till the end of their lives unless they develop conditions which required very high levels of care (Davey, 2006; Alders and Schut, 2018).

Technology has shown to have a positive effect on functional capacities (Figure 4) of the older adult. Figure 4 illustrates how the use of technology helps in the movement of the functional capabilities graph from below the disability threshold to above it (Deen, 2015).

Technology is now becoming a major focus of NZ’s Ministry of Health’s Healthy Ageing Strategy, 2016 (Associate Minister of Health, 2016).

3. Theory

The decision to approve a policy based on the Pareto improving principle is made even if one person is better off without making another person worse off. This can be undertaken progressively until Pareto optimal is reached where the next person cannot be made well

<table>
<thead>
<tr>
<th>Table I</th>
<th>Cost for hospital services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inpatient costs</td>
<td>Cost per day ($)</td>
</tr>
<tr>
<td>Hospital – Medical ward</td>
<td>1,000</td>
</tr>
<tr>
<td>Hospital – Day stay ward</td>
<td>730</td>
</tr>
<tr>
<td>High dependency unit</td>
<td>3,100</td>
</tr>
<tr>
<td>Intensive care unit</td>
<td>5,000</td>
</tr>
<tr>
<td>Hospital care – Older people</td>
<td>200</td>
</tr>
<tr>
<td>Outpatient costs</td>
<td>Cost per visit ($)</td>
</tr>
<tr>
<td>Physician visit</td>
<td>Initial – 300</td>
</tr>
<tr>
<td>Emergency room</td>
<td>350</td>
</tr>
<tr>
<td>Community services</td>
<td>Cost ($)</td>
</tr>
<tr>
<td>Rest home</td>
<td>130</td>
</tr>
</tbody>
</table>

Source: Adapted from Cost Resource Manual Version 2.2 (PHARMAC, 2015)
off without making the next one worse off, i.e. no more Pareto improvements are possible (Roper et al., 2015). Based on this theory, studies were assessed to check the balance of cost and benefits to assess if technology would be Pareto improving.

Benefits or effectiveness can be measured in varied ways, this makes it difficult to compare, hence quality-adjusted life-year (QALY) is a measurement used to investigate health interventions. QALY is the number of years lived, evaluated by the quality of life (Bergmo, 2014).

---

**Figure 3** Comparison of health system across OECD countries

<table>
<thead>
<tr>
<th>Country Rankings</th>
<th>AUS</th>
<th>CAN</th>
<th>FRA</th>
<th>GER</th>
<th>NETH</th>
<th>NZ</th>
<th>NOR</th>
<th>SWE</th>
<th>SWIZ</th>
<th>UK</th>
<th>US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall Ranking (2013)</td>
<td>4</td>
<td>10</td>
<td>9</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>3</td>
<td>11</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Quality Care</td>
<td>2</td>
<td>9</td>
<td>8</td>
<td>7</td>
<td>5</td>
<td>4</td>
<td>11</td>
<td>10</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Effective Care</td>
<td>4</td>
<td>7</td>
<td>9</td>
<td>6</td>
<td>5</td>
<td>2</td>
<td>11</td>
<td>10</td>
<td>8</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Safe Care</td>
<td>3</td>
<td>10</td>
<td>2</td>
<td>6</td>
<td>7</td>
<td>9</td>
<td>11</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Coordinated Care</td>
<td>4</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>5</td>
<td>2</td>
<td>7</td>
<td>11</td>
<td>3</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Patient-Centred Care</td>
<td>5</td>
<td>8</td>
<td>10</td>
<td>7</td>
<td>3</td>
<td>6</td>
<td>11</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Access</td>
<td>8</td>
<td>9</td>
<td>11</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>6</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Cost-Related Problem</td>
<td>9</td>
<td>5</td>
<td>10</td>
<td>4</td>
<td>8</td>
<td>6</td>
<td>3</td>
<td>1</td>
<td>7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Timeliness of Care</td>
<td>6</td>
<td>11</td>
<td>10</td>
<td>4</td>
<td>2</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>1</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>Efficiency</td>
<td>4</td>
<td>10</td>
<td>8</td>
<td>9</td>
<td>7</td>
<td>3</td>
<td>4</td>
<td>2</td>
<td>6</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Equity</td>
<td>5</td>
<td>9</td>
<td>7</td>
<td>4</td>
<td>8</td>
<td>10</td>
<td>6</td>
<td>1</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Healthy Lives</td>
<td>4</td>
<td>8</td>
<td>1</td>
<td>7</td>
<td>5</td>
<td>9</td>
<td>6</td>
<td>2</td>
<td>3</td>
<td>10</td>
<td></td>
</tr>
</tbody>
</table>

**Notes:** 4Includes ties, 5Expenditures shown in $US PPP (purchasing power parity); Australian $ data are from 2010

**Sources:** Calculated by the Commonwealth Fund based on 2011 International Health Policy Survey of Sicker Adults; 2012 International Health Policy Survey of Primary Care Physicians; 2013 International Health Policy Survey; Commonwealth Fund National Scorecard 2011; World Health Organization and Organization for Economic Cooperation and Development, OECD Health Data, 2013 (Paris: OECD, November 2013)

**Figure 4** Effect of technology on functional capacities

*Source: Deen (2015)*
4. Method

A literature review using search engines ProQuest, CINAHL, EBSCO and Google Scholar was undertaken. Keywords such as ageing in place, assisted living technology, telehealth and telecare were used to guide the process, posing the question as to whether “the use of technology for ageing in place is an economically viable possibility”. A narrative approach to ordering the literature was undertaken. This approach provides a “comprehensive narrative syntheses of previously published information” (Green et al., 2006, p. 103). The literature was then distilled using a thematic analysis.

To determine if the literature were of acceptable quality for this study, they were assessed according to a well-recognised economic evaluation checklist by Drummond et al. (2005).

5. Literature review

There are several studies that provide evidence regarding the cost-effectiveness and benefits of using technology with older populations (Sixsmith, 2013). A range of technologies available to assist older adults are discussed.

5.1 Telehealth

Telehealth is a collection of information and communication technologies used to augment and deliver health services when customers and providers are not at the same location.

Technology integrated with smart computing can be used to continuously monitor ageing adults while at home (e.g. remote monitoring of blood pressure, weight or oxygen levels), quickly detect and communicate emergency situations such as falls or smoke (telecare – alarms and sensors) and transmit data to medical staff and other stakeholders. Figure 5 provides a diagrammatic view of what this may look like. This provides a non-intrusive, long-term care at the comfort of an individual’s home.

The Whole System Demonstrator trial in the UK investigated the effects of telehealth interventions compared with usual care in over 3,000 participants with diabetes, Chronic Obstructive Pulmonary Disease (COPD) or heart failure. Mortality rates were lower in the intervention group as compared with the usual care group (4.6 and 8.3 per cent, respectively).

Figure 5 Integration of technology at home

Source: Deen (2015)
Similar differences were seen with the need for higher levels of care, i.e. Emergency Department (ED) visits (0.54 and 0.68 emergency admissions per head) and hospital bed days (4.87 and 5.68 mean bed days). Overall hospital costs per participant were lower by £188 (~$362) in the intervention group for the duration of the trial (Steventon et al., 2012). A cost analysis of this study conducted by Henderson et al. (2013) revealed that the QALY gained by patients using telehealth in addition to usual care was like those receiving usual care (adjusted mean difference in QALY gain was 0.012) and the cost-effectiveness was 11 per cent based on the threshold value[2]. The total costs associated with the telehealth intervention were lower if costs of the intervention were included (£1,139 and £1,380 for the intervention group and usual group, respectively) and higher if included (£1,596 and £1,390). Telehealth did not seem to be a cost-effective addition to standard support and treatment. Adjusting the values with an 80 per cent reduction in equipment costs and having the teams work at higher capacity brought the cost of the intervention group to £1,342 (from £1,596) and the cost-effectiveness to 61 per cent.

Kenealy et al. (2015) conducted a similar trial in NZ, though the number of hospital visits and costs associated with care were not markedly different in the intervention group as compared with the non-intervention group, telecare contributed to a reduction in anxiety and depression. The participants and their families felt safer and more aware about their health; the care and treatment regimens were imbibed into their daily lives. The same qualitative results were reported in the telehealth research by the Selwyn Foundation (Day and Johnson, 2016). Participants were more confident that they could take care of their own health and were less stressed.

A systematic review conducted by Bergmo (2014) showed that telehealth services increased the number of QALYs gained in the range of 0.001–0.118 across the 17 economic evaluations analysed. Six studies reported a cost-effectiveness of more than 60 per cent while the others either showed lower cost-effectiveness or that they were not cost-effective at all; this cost-effectiveness was dependent on the threshold values of the respective countries. However, this analysis was limited as different methods were used to measure QALYs. A significant observation was that the reduction in re-hospitalisations and improvement in the health of the patient was directly proportional to the intensity of the follow-up by the health team and the sophistication of the telehealth options.

Telehealth encompasses a range of application including e-health and m-health, videoconference and phone calls, remote patient monitoring (telemonitoring) and “Store-and-forward”:

- e-health and m-health tools: includes tools such as text messaging, mobile applications, websites, devices, video consultations and webinars. This is especially the case with applications that focus on healthy lifestyles. There are no studies that consider the cost-effectiveness of these tools in this cohort of people (Kampmeijer et al., 2016). However, the cost-effectiveness of these tools has been studied through a systematic review by Iribarren et al. (2017). Among the high level economic evaluation studies, m-health technologies, especially SMS services have found to be cost-effective in healthier population as compared with chronically ill patients, for example, weight loss, smoking cessation, increase in physical activity and disease prevention.

- Videoconference or phone calls: in a study with COPD patients, the use of teleconsultation via videoconference has proved efficient in reducing the number of hospitalisations and length of stay by 29.5 and 36 per cent, respectively. It was rated 8–9 on 10 in terms of patient satisfaction across various measures (Pope et al., 2013). Similar positive results were seen in a study by Vincent et al. (2006).

NZ already has services in place that make use of electronic means; for example, since 2015, the National Telehealth Service (NTS) has been providing counselling services for the older people who are depressed, anxious or who require further information regarding their health via calls, texts, webchats and social media. This is part of the MOH’s “The Health of Older People Strategy”. NTS receives over one contact per minute per day, the bifurcation for older people is unknown (Ministry of Health and Homecare Medical, 2017).
Research undertaken in 2002 showed that 9 per cent of people aged 50 years and over considered themselves lonely, while 44.5 per cent were moderately lonely. In total, 90 per cent of the participants did not have homecare or support. However, care provided to the minority was paid by the individual, their family and less commonly by the government (Waldegrave et al., 2012). A meta-analytic review conducted by Holt-Lunstad et al. (2010) observed that social contact increases the chances of survival by 50 per cent and it leads to better health practices and reduces the levels of stress and depression that alter health outcomes. NTS is a way of increasing social contact for those living alone.

Telemonitoring: Takahashi et al. (2012) investigated the benefits of using telemonitoring in adults aged 60 years and over with a high Elder Risk Assessment Index score. The study found no significant difference between both groups in the rate of hospitalisation and ED visits, and the average length of stay. The usual care group, however, did have a high standard deviation for the average length of stay which drove up the inpatient costs 40 per cent higher as compared with the telemonitoring group. The mean outpatient costs were 17 per cent lower for the telemonitoring group as participants could be monitored at home which reduced outpatient visits. ED costs, however, were 18 per cent higher as the participants had to follow protocol and visit ED if values went above certain levels. The use of telemonitoring helped reduce the overall mean costs from $21,977 to $19,510 but if the cost of $837 is excluded for the equipment and additional resource use, the costs are effectively reduced to $20,346. A significant benefit was the reduction of the mean cost per participant by $1,868 for the duration of a year for outpatient costs (Upatising et al., 2015).

Several studies considered by Pare et al. (2013) suggest that home telemonitoring has reduced the number of hospitalisations and ED visits as well as shortens hospital stays especially in cases of chronic diseases. In a cost-minimisation study comparing telemonitoring with the usual care, they observed cost savings of CAD1,557 annually per patient which represented a 41 per cent net gain over usual care. This was due to a decrease in hospitalisation visits partly offset by increased nurse home visits. Early intervention made possible by technology has significant cost-minimisation benefits, but its cost-effectiveness still needs further investigation (Pare et al., 2013).

5.2 Assistive technology

Al-Oraibi et al. (2012) studied the benefits of using assistive technology (AT) like motion sensors, pull cords, falls detectors, pressure mats and pendant alarms. Results showed that the number of falls reduced after the use of AT.

5.3 Patient-centred medical home model (PCMH) of care

PCMH includes Health Literacy – Education of patients and caregivers, Teamwork – collaboration with physicians and technology such as electronic health records (HER) for medical management. Several studies in the USA have shown that the PCMH approach improves patient safety and quality of life.

5.4 Tools for healthy lifestyles

The Healthy Steps Trial was undertaken to analyse if devices such as a pedometer would increase the amount of physical activity as compared with a standard exercise prescription. The pedometer resulted in approximately 50 and 27 per cent reduction in the number of participants reporting at least one fall with and without an injury, respectively, though the sample size was not large enough to draw a compelling inference (Kolt et al., 2012). $667 was the additional programme cost for transforming one individual from an inactive to active status over the duration of a year; this is well below the established accepted value of $1,885 from the literature. The incremental cost-effectiveness ratio for the use of the pedometer per 30 min of walking and per QALY was found to be negative ($−185 and −$4,999) implying lower costs and greater benefits (Leung et al., 2012).
5.5 Robots

An audience reception study was undertaken by Trynacity (2015) to gauge the opinion and expectations of including a robotic caregiver in the lives of people aged 70 years and over living in a seniors’ apartment complex. Participants valued the human touch more than the work performed by the caregiver, they believed caregivers were the only constant in their life given that they were living away from their children, had lost their spouses or close friends. Some feared that the robot would make them more dependent.

5.6 User acceptability

A study by Sanders et al. (2012) observed that older people are apprehensive about using technology such as telehealth and telecare for reasons such as:

- disruption to ongoing services and interventions which they are comfortable with;
- threats to privacy of information and independence; and
- perception that high level of competence and knowledge is required to use the technology.

The study concluded that if an adequate understanding is provided to older adults and all their questions are answered, they will be more than willing to use technology (Sanders et al., 2012). Sixsmith (2013) suggests that a better technique is to adopt the user-centric approach with the actual life experiences of users being considered while creating technologies rather than forcing technologies that they might find constraining and intrusive.

Holthe et al. (2018) identified that user acceptability is strongly linked to user involvement in clinical trials of new technology. They also identified that “technology that is simple to use and enables a person with reduced cognitive capacity to cope independently with daily tasks and obligations is classified as being usable and acceptable” (Holthe et al., 2018, p. 882).

A study by Wu et al. (2014) suggests that the uptake by older adults in the use of robotic technology has a “social influence” factor with improved uptake if facilitated by their children or health professional.

Lee and Coughlin (2014) advocated the adoption of technology champions from with the “older adult’s social groups, such as family, friends and community members” (p. 752). This approach is supported by Luijx et al. (2015) who identified that in the socialisation of user acceptability “it is worthwhile to give grandchildren an important role because older adults easily adopt their enthusiasm” (p. 15471). Qingchuan and Yan (2018) reported that while family members can be a positive influence on older adults’ use of technology they can also inhibit this by showing frustration and impatience, which inhibits use, especially so in older men.

6. Analysis

The highlighted studies suggest that technology can support ageing in place though thorough evidence to prove its cost-effectiveness is lacking:

- Reduction in hospitalisations: telemonitoring has the potential to reduce inpatient, outpatient and ED costs. Telemonitoring can save on inpatient costs due to lower number of days in the hospital as clinicians are more confident to send patients home sooner. Though telehealth is currently not considered to be cost-effective, a study by Kenfay et al. (2015) showed significant positive outcomes. E-healthcare needs consideration as the cost of technology continues to decrease.

- Falls reduction: the literature shows considerable reduction in costs can be achieved if technology is installed to help the reduction of falls. Devices such as motion sensors, alarms, wearable devices are available and though not many cost-effectiveness studies have been carried out, any reduction in the number of falls can greatly contribute to huge savings. However, this is found to be more effective in non-dementia participants (Al-Oraibi et al., 2012). Individually tailored strategies targeting risk factors have been found to be more effective (Giordano et al., 2016).
If the number of falls in those aged 50 years and over is 217,000, the cost for just hip fractures-related costs is $169m. If the number of falls reduces by 2 per cent due to interventions, i.e. 4,340, the number of hospitalisations for hip fractures will proportionally reduce by 72 this would save approximately $3.3m. Similarly, the cost of general hospitalisations would reduce by 402 saving $402,000 (considering they are admitted for one day at the cost of $1,000/day). Hence, a significant savings would be achieved with a 30–50 per cent reduction in falls.

- Health promotion: if facilitated appropriately tools such as e-health and m-health can be very useful in promoting health and delaying the onset of illnesses.
- Positive ageing: a healthier life also means that the person will be able to contribute to society through working longer, and or voluntary work.
- Robots could also be studied for the benefits they would add to society for those older adults who currently do not have a caregiver looking after them.
- Psychological effects: the qualitative analysis from the study by Kenealy et al. (2015) showed that telecare increases the feeling of safety and being cared for. It reduces depression, anxiety and social isolation. Technology is useful in terms of supporting long-distance clinical care without the need of disruption to the older adult’s home life being disrupted by the need to attend a medical facility. This would also reduce costs and disruption of family members’ working schedule, cost of travelling and hospital visits.
- Additional expense and maintenance in relation with traditional methods: the cost of using new technology is high but decreases over time.

“Many older adults can remain in their own home if they implement modification to improve safety, security and ease of mobility” (Cream and Teaford, 2013, p. 195). However, in order for this to be a reality, Kingstone et al. (2018) identified the need for health and social services to adapt their provision of services in order to meet the requirements of the ageing population.

7. Conclusions
Timely interventions to appropriately manage the ageing population given the projected financial and population figures is needed. Technology has proved beneficial especially with positive ageing. One explanation for its limited use is the lack of thorough studies that demonstrate its cost-effectiveness.

Healthcare policymakers need to be considering incorporating technology into health planning.

With most research and funding focussing on supporting frail adults an equal focus needs to be given to those entering the older adult group. Early intervention is beneficial to reduce the number of years lived with disabilities along with associated costs of disease burden. Technology can increase awareness and allow individuals to be more disciplined with their health plan in order to maintain good health.

Notes
1. Amounts are in NZ dollars.
2. Incremental cost-effectiveness ratio (ICER) is used to measure the cost-effectiveness of an intervention (difference in costs divided by difference in effect). This is then compared with the threshold value set by organisations or countries to aid in decision making. If the ICER exceeds the threshold, it is deemed expensive.
3. Telemonitoring is the use of peripheral devices, i.e. glucometer. Measurements are sent to the clinical team daily and real-time phone or videoconference.
4. ERA measures hospitalisation or ER visits risk based on participant’s age, gender, prior hospitalisations and existing illnesses, e.g. diabetes.
5. Calculated based on cost required to reach 2.5 h weekly of leisure activity.
References


Trynacity, K. (2015), Close Enough to Care: Replacing Human Caregivers with Robots in Homecare, Royal Roads University, Social and Applied Sciences, ProQuest LLC, Ann Arbor, MI.


Corresponding author
Julia Lesley Hennessy can be contacted at: juliah@ais.ac.nz

For instructions on how to order reprints of this article, please visit our website: www.emeraldgrouppublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com
Journal of Enabling Technologies
User inclusion in health, support, social care and education

Volume 13 Number 3 2019

137 Dementia-friendly design of television news broadcasts
   Liam Funnell, Isabel Gairlock, Ben Shirley and Tracey Williamson

150 Conversation Analysis (CA) as a tool for exploring interaction in an online video-conferencing based support service
   John Chatwin and Phil McEvoy

158 Building rating system: an instrument for building accessibility measurement for better indoor navigation by blind people
   Watthanasak Jeamwathanachai, Mike Waid and Gary Wills

173 SiLearn: an intelligent sign vocabulary learning tool
   Jestin Joy, Kannan Balakrishnan and Sreeraj M

188 Economic impacts of changing technologies on New Zealand homecare delivery
   Julia Lesley Hennessy and Averyl Rodrigues