Computerised help information and interaction project for people with memory loss and mild dementia

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ABSTRACT

People have to perform many tasks and remember many different things during the course of their daily lives. Remembering them all is a challenge for everyone and especially so if a person has age associated memory impairment or some form of dementia. As technologies such as RFID (Radio Frequency Identification) and Near Field Communication (NFC) tags become more cheaply available and more seamlessly integrated into our lives as the Internet of Things (IoT), it makes sense to use these technologies to help people remember information or automate tasks. The CHIIP (Computerised Help Information and Interaction Project) project has created a framework that uses smartphones and sensor technologies to help people perform tasks that are relevant or specific to them quickly and efficiently within their homes or local environment.

1. INTRODUCTION

People perform many tasks each day as part of everyday living. Such tasks might be done at the same time on a daily basis, for example cooking a meal or taking medicine; regularly, such as switching off the iron, or closing windows before going out; or sporadically, such as remembering to send a birthday card to a friend or attend a meeting. It is natural for someone to forget to do, or worry that they have forgotten to do, some things some of the time, particularly if they have busy lives requiring many different and often varied tasks to be done. As people become older they also find that it becomes harder to remember things. This age-associated memory impairment, is a common problem in people over the age of 60, and is not dementia. Dementia, is an umbrella term for the symptoms that occur when the brain is damaged by diseases, such as Alzheimer's disease or stroke resulting in a progressive loss of mental ability and symptoms that may include problems with memory, understanding, judgement, thinking and language (Alzheimer's Society, 2014; Patient, 2014).

The number of people with dementia is steadily increasing. There are currently 800,000 people in the UK, and 35.6 million people worldwide with a form of dementia, figures that are expected to double every 20 years such that by 2050 it is projected that there will be 115.4 million people with dementia worldwide. Established prevalence rates for dementia in the UK are 1 in 1400 at 40-64 years; 1 in 100 at 65-69 years; 1 on 25 at 70-79 years and 1 in 6 at 80+ years (Alzheimer's Society, 2013). Worldwide, the total number of new cases of dementia each year is 7.7 million, equating to one new case every 4 seconds. Not only is dementia a quality of life issue, there is also a huge economic cost associated with the disease of US$ 604 billion per year, and an overwhelming requirement for carers and caregiving (Carers Trust, 2014); all factors recognised in the 2012 report by the World Health Organization which declared dementia as a global health challenge (World Health Organisation, 2012).

People live for many years after the onset of symptoms of dementia and with appropriate support, many can maintain a good quality of life and continue to engage and contribute within society (World Health Organization, 2012). Whilst technology can never replace the value of personal care it can help support a person as they grow older and can be useful for helping them maintain their independence, at least in the early stages, should they develop dementia or experience other memory related problems.

As mobile and sensor technologies mature and converge to become the internet-of-things (IoT) (Technology Strategy Board, 2014), and as people become more accustomed to using smartphones, it seems appropriate to use these technologies to create an app, that can remind people of what tasks need to be undertaken and where possible to assist or automate the undertaking of them.

This paper describes a mobile app, CHIIP (Computerised Help Information and Interaction Project), that works in conjunction with small low cost, low powered sensors that can be placed around a person's home and local environment to provide a ubiquitous and personalized aide to everyday living for people as they age.

2. INTERACTION TECHNOLOGIES

2.1 Internet of Things

The project builds upon the concept of the Internet of Things (IoT) whereby objects and people are provided with unique identifiers such that automatic transfer of data and communication can occur between them without the need for human intervention (WhatIs.com, 2014; IERC, 2012). At the point of definition, RFID (Radio Frequency Identification) was seen as the pre-requisite technology for the IoT (Lahtela, 2009), with the vision that if all objects and people were equipped with identifiers, it would transform their daily lives and the way in which they completed day to day actions (Magrassi et al 2001; Casaleggio Association, 2011).

Subsequently, the list of enabling technologies for creating an IoT has been extended with RFID, barcodes, QR-codes and digital watermarking all able to achieve tagging of items. Another recent technology is NFC (Near Field Communication), an enhancement of the RFID concept, which involves small tags with a chip inside them that can hold small amounts of data. These tags can cause actions to be executed when interaction occurs with an NFC enabled device, such as a smartphone or NFC reader. This technology is now being used in systems such as the contact-less payment systems provided by Google Wallet and Barclaycard platform (BusinessWire, 2012).

With technologies such as NFC tags becoming more cheaply available and a large proportion of smartphones and other devices becoming compatible with these technologies, it makes sense to start using them to automate tasks, or assist people with what they need to know, as they go about their everyday lives.

2.2 Interaction Technologies

The CHIIP project has created a framework that uses mobile phones and sensor technologies to help people perform tasks that are relevant or specific to them quickly and efficiently and in doing so help them to manage busy lives, or to remember how to do things should their memory start to become impaired through age related memory loss or the onset of dementia. The project considered the pros and cons of different sensor related technologies (see Table 1) before selecting NFC technology due to its low cost and accessibility through Android support.

Table 1. *Hardware for Sensor Interaction.*

Hardware Type	Description	Positives	Negatives
Raspberry PI	A credit-card sized computer capable of computer processing similar to a desktop PC	• Many home automation possibilities	• Price • Less mobile
RFID (Radio Frequency Identification)	A wireless contact-less use of radio-frequency electromagnetic fields to transfer data. Available in a variety of types such as tags	• Covers wide distance for interaction • Uses radio waves	• Older technology • Needs additional hardware for scanning
Digital Watermarking	A way of adding digital information to media and other printed material.	• Imperceptible to humans • Easily detected by computers	• Imperceptible to humans • Not easy to do at home
QR-Codes (Quick Response Codes)	A type of two-dimensional barcode that can be read by smartphones and dedicated QR reading devices such as scanners	• Cheap to create • Easy to produce at home via printer	• Difficult to customise • Difficult to produce (print) • Easily tampered with
NFC (Near Field Communication)	A wireless communication technology that allows transferring of data between 2 devices (such as a mobile phone and an NFC Tag)	• Low price • Variety of tags • Android support • Low power	• Close distance for interaction • Memory size restrictions

2.3 NFC (Near Field Communication)

NFC (Near Field Communication) is a wireless communication that allows transfer of data between two devices, such as a mobile phone and an NFC Tag (RapidNFC, 2014). This transfer takes place when an NFC enabled device comes into close proximity of an NFC tag, replacing Bluetooth technology. It can also be extended to perform certain actions based on the data held on the phone such as linking to a website for marketing purposes, flight check-ins at airports, retail item stock checking and even contactless payments between mobile phones and payment terminals. NFC tags come in a variety of formats, for example stickers, wristbands and key-rings such

as those shown in Figure 1. These tags contain a small microchip with a little aerial that can store small amounts of data dependent on the memory capacity of the tag (KimTag, 2014). These data are usually stored in NDEF (NFC data exchange format) format, which is a standard and allows the data to be reliably read by most NFC enabled devices.

Figure 1. *NFC Tags* [RapidNFC, 2014].

2.4 Use of NFC (Near Field Communication)

Another advantage of NFC is the number of management tools now available to assist with the development of applications that can exploit NFC technology either by allowing the app developer to see details of tags (such as size, type and state of the tag) or by providing functionality that allow tags to be configured and written to task lists which are completed upon scanning the tag. Some of the most popular tools available are NFCTagWriter-NXP, NFCTagStore, Samsung TecTiles, with the most commonly used being NFC TagLauncher (Trigger) by Egomotion Corp with over 1 million + downloads (EgoMotion Corp, 2014). However, although NFC TagLauncher is a highly useful application that allows users to very easily setup a tag to complete a certain set of actions upon scanning an NFC tag, it only allows a tag to be used for one set of tasks. This can be a disadvantage for home scenarios as a tag placed in a common room can only be used by one users set of instructions at a time.

Table 2. *Hardware for Sensor Interaction.*

Application Name	Description	Positives	Limitations
NFC Tag Launcher (Trigger)	Tag tasks configuration	Easy to use interface. Large task list & Tasker integration Supports multiple task triggers (NFC, Wifi, Geo-fencing)	One task set per tag
NFC TagWriter by NXP	Tag management	Simple interface Detailed tag description	Amount of tasks available One task per tag
NFC Actions	Tag tasks configuration	Simple interface	One task set per tag Task list
NFC TagStore	Task management	Simple interface Good suggestions of task uses	Limited amount of task functionality
NFC TagInfo	Tag management	Detailed description of tag components	No task selection (only tag data visibility)
Send! File Transfer (NFC)	NFC file sender	Simple interface Quick to setup	No task selection (only sending of files using NFC)
NFC Passport Reader	NFC Passport RFID reader	Simple interface	Limited to application passport scenario
AnyTAG NFC Launcher	Tag tasks configuration	Very simple interface Tasker integration	Advertisements Limited task list One task set per tag
NFC Doctor	Tag management	Simple functionality	No task selection (only tag data visibility)
NFC Launcher	NFC marketing campaign management	Cloud based Login authentication	Limited to application marketing scenario
Microsoft Tag, QR, NFC	Tag scanner	Useful for poster and NFC touch points History of NFC tags scanned Good looking interface	Only makes use of already configured NFC tags and touch points
Samsung TecTiles	Tag tasks configuration	Large task list Uses modes such as (Home Mode, Car Mode)	Recommended for TecTiles tags Interface not easy to use Limited to 3 modes (Home, Car and office).

2.5 Reminder Systems

An important function of the CHIIP project is to act as a reminder system for tasks that people need to undertake or activities related to tasks they have done, for example, people may need to be reminded to take their medicine at a particular time of the day, or asked whether they have switched of the gas after making a meal. In order to help ascertain requirements a number of current reminder systems were reviewed in order to see what features they provide and how they automate cues to complete certain actions including Tamkang University RFID Reminder System (Hsu, 2011) and the LLC Wellness Wizard Voice Reminder System (LLC, 2014).

As a result of reviewing these reminder systems, the following requirements emerged as being important: (1) Making it easy to add reminders. (2) Making use of the user's calendars and alarm clock to manage and present reminders. (3) Using voice, device, SMS and email based reminders for different reminder types, such as voice based reminders to a person when leaving and entering the house and SMS messages to inform friends or family that a person has left or returned home.

2.6 NFC Use in Healthcare Projects

NFC is starting to be used in relation to the healthcare industry and for ambient assisted living (Iglesias et al, 2009; Dohr et al, 2010; Menschner et al, 2011). Some applications, for example, NFC Patient Wristband – (Taiwan Mobile, 2014) and the Homecare Project (Pique, 2013) are being used by healthcare professionals to help manage patient care, whilst others such as the Dementia House (Stirling University, 2012) and FotoDialer (2014) are being used by patients themselves. There appears to be few applications however that assist people to live independently by reminding them of, and/or automating, the numerous different tasks they undertake throughout the entire day, via one integrated application. This is the primary aim of the CHIIP system.

3. COMPUTERISED HELP AND INFORMATION PROJECT (CHIIP)

CHIIP is designed to help in various situations around the home and outside of it, and to be used by many different demographics of people including children, students, parents and busy professionals, but with its greatest potential being to support people as they grow older and experience problems with their memory. The CHIIP project has developed a system consisting of an Android phone app and NFC tags that can be easily set up and personalised by a person, their carer or a health professional in order that a range of support reminders and tasks can be specified that are relevant to an individuals' preferences and activities. For example, it can remind an elderly person to take their medicine, enable them to send emergency messages, or give them instructions of how to make a simple meal. A tag could even be placed in their friend's house for mobile reminders and to tell family members or other carers that they have arrived safely at their intended venue.

3.1 Framework

The range of tasks that can be brought into the CHIIP system is potentially limitless and is extensible. The app provides an easy to use interface and a framework whereby tasks can be added or changed based on user demand or as a person's needs, activity patterns or level of required support change. Reminders and tasks can be specified by anyone, such as an older person's family member or carer as long as they know how to use a smartphone. The older person themselves need then only remember the one simple action of putting their mobile phone close to a tag to initiate a reminder or action. This can be aided using specifically coloured NFC Tags or custom tags with photos of their carer, activity or object in order to aid the recognition process.

3.2 Functionality

Technically the project extends the functionality provided by applications such as NFC TagLauncher, which allow users to quickly configure tags to complete actions, by enabling a single tag to be used by multiple users. This is particularly useful in a home scenario where a tag could be placed in each room of the house. This allows different users within a family, or a husband and wife, to use a single tag for custom purposes, for example a tag placed near the front door could be used by parents to remind them that they need to close the windows before leaving the house, by the children to remind them that they need to have their sports kit for school, and by a grandparent to remind them to take their key or to send an automatic message to someone telling them that they have left the house. If an older person is still able to drive but has problems remembering how to use the phone or satellite navigation system in a car then a single NFC tag sticker can be placed inside a car phone dock that will automatically turn the phone on loud, turn on Bluetooth, open navigation and send a message to say that they are in the car – just by placing their phone near the tag on the dashboard thereby simplifying a potentially complex set of processes into one single step. The system could also be used to open a person's favourite

website, remind them to take their medicine, give instructions for how to make a cup of tea, call emergency services, or turn lights on and off if connected to a home automation system.

4. DEVELOPMENT

The application has been developed using an Android smartphone and NFC tags. The phone stores login details via the Android `SharedPreferences` which allows persistent key-value pairs to be saved and retrieved. `SharedPreferences` are also used to save the custom data for each tag task, for example a task to open a website, requires the website URL to be saved. Storage and retrieval of tag task selection information is provided by an SQLite database. SQLite is included in every Android device, and does not require specific setup.

The application follows a tab style experience that allows the user to setup a tag which then needs to be scanned to complete the allocated tasks. Upon scanning a tag, the application reads the tag name, checks what tasks are assigned to it using the database, and calls the relevant functionality. Each task when executing checks its type and gets extra information from `SharedPreferences`, such as the fact that it is a voice reminder task with custom message text.

Using the tag reference as the lookup value means that many users can use the same tag to perform a different set of tasks personalised to their needs or activities. The storage of this data is very small and so a large number of tags (placed in various locations around the home and local environment) can be programmed and stored in the application to automate everyday tasks.

The application has been designed using recommendations from the Google Developer website (2014) and the inclusion of multiple themes along with a font size changer, make it easily usable and accessible for a large number of users. Figure 2 shows the overall architecture of the system and Figure 3 the flow of activity through the system.

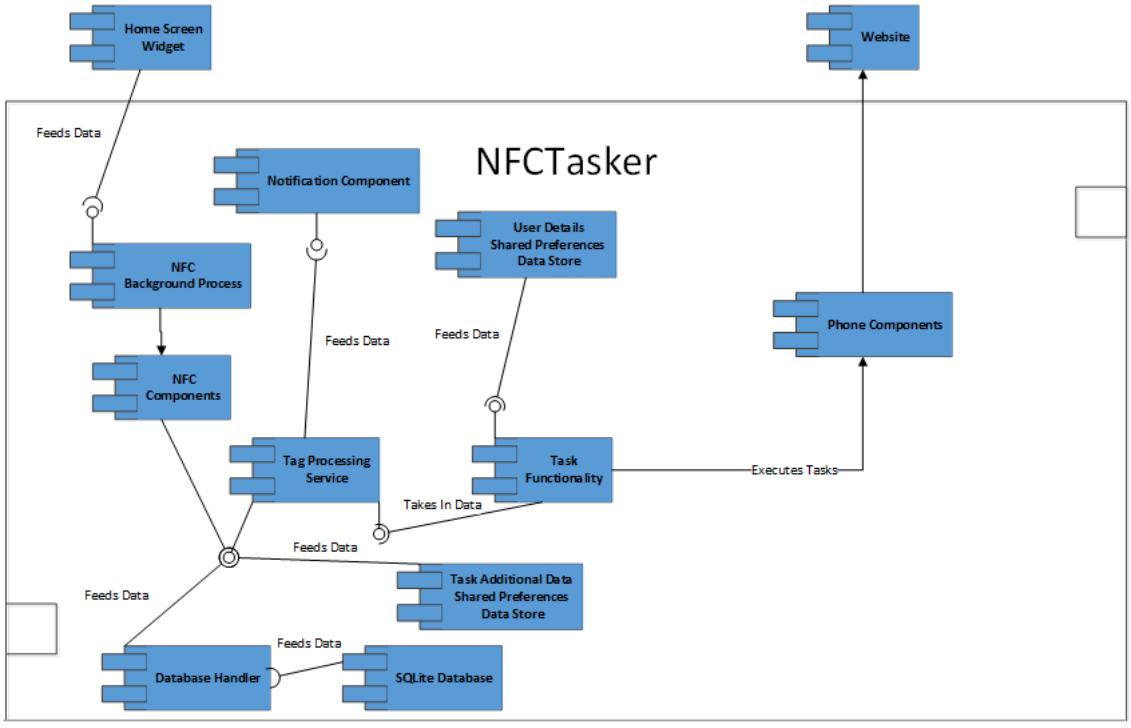

Figure 2. *High level overview of system components of CHIPP system (NFCTasker).*

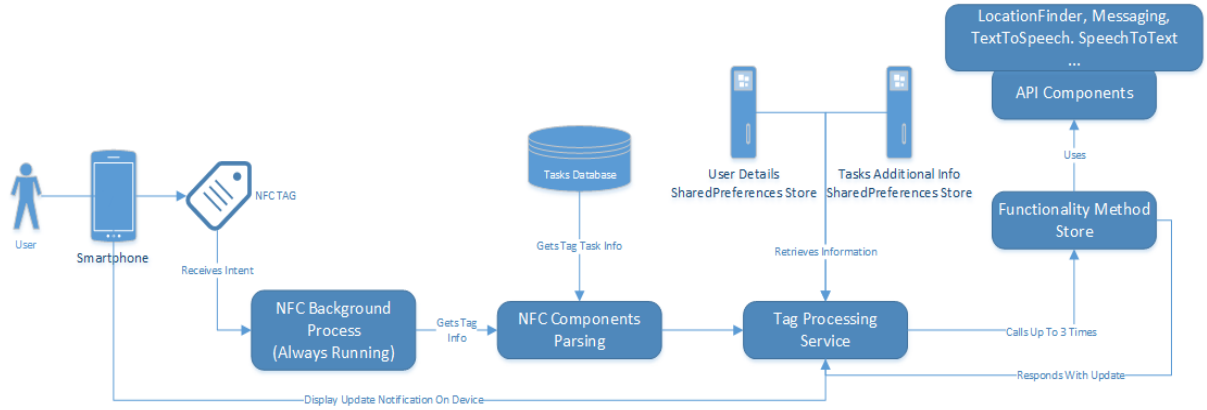

Figure 3. Tag p*rocess flow and data retrieval.*

5. RESULTS - CHIIP USE TO SUPPORT PEOPLE WITH DEMENTIA

The CHIIP system comprises three key components: (1) a smartphone, (2) NFC tags and (3) a software app that is downloaded to the smartphone that acts as an initiator for the interaction and responses. NFC tags can be placed in different locations inside or outside of the home (Figure 4), in a car and on personal items such as key rings. These tags can be given a reference name which can then be assigned tasks in the smartphone application. The user then interacts with the tags by placing their smartphone near them – initiating the actions that the user previously set. Example interactions might include:

- NFC sticker placed near the front door: *Voice reminder to remind about a task when leaving/entering the house. *Recorded voice playback of a reminder message.
- NFC sticker placed in car: *Enable Bluetooth for Bluetooth headset, *switch phone to loud mode, *open maps navigation.
- NFC key-ring / wristband emergency tag: *Send location emergency message to a carer, *call ambulance services.

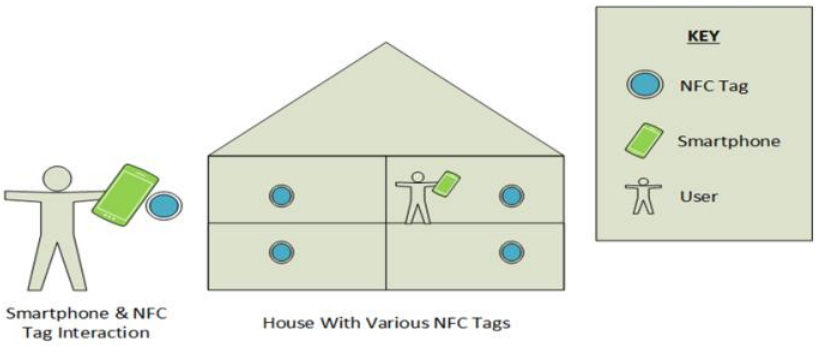

Figure 4. *Home with NFC Tags.*

As well as setting actions to tags, the application allows two types of voice reminders to be set, one using a built in voice library and the other using sound files recorded by the carer, which is particularly useful to aid recognition for the patient as shown in Figure 5.

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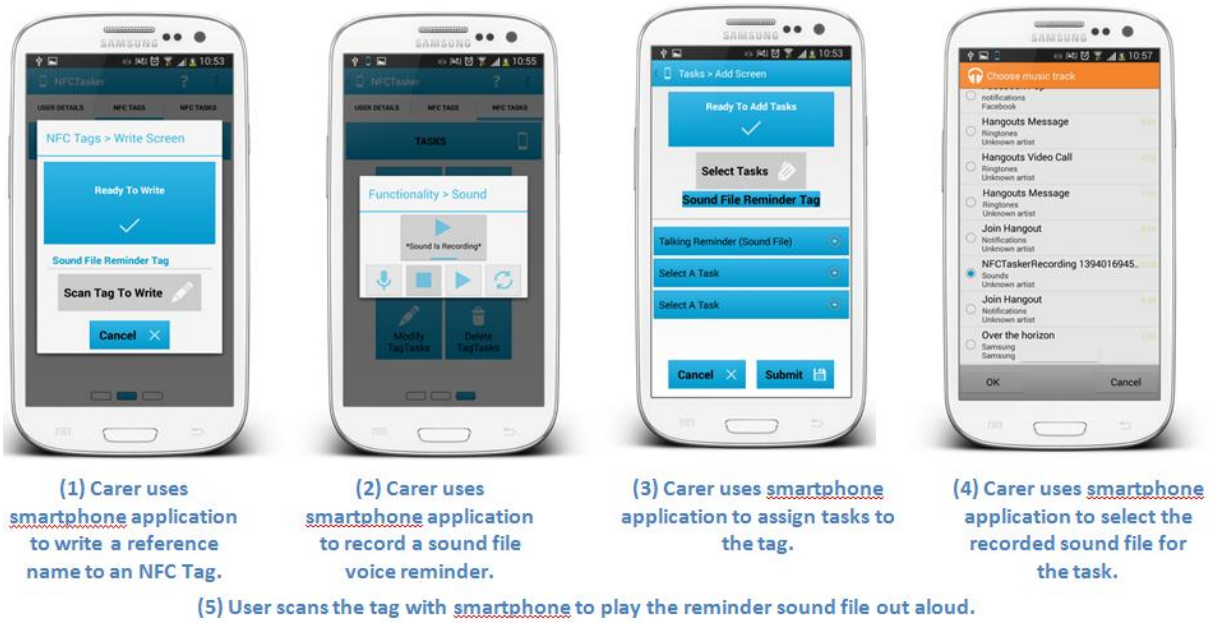

Figure 5. *Phone setup to enable information or actions to be associated with tags.*

A carer could write/record tags to remind a person to take their medication as shown in Figures 6 and 7.

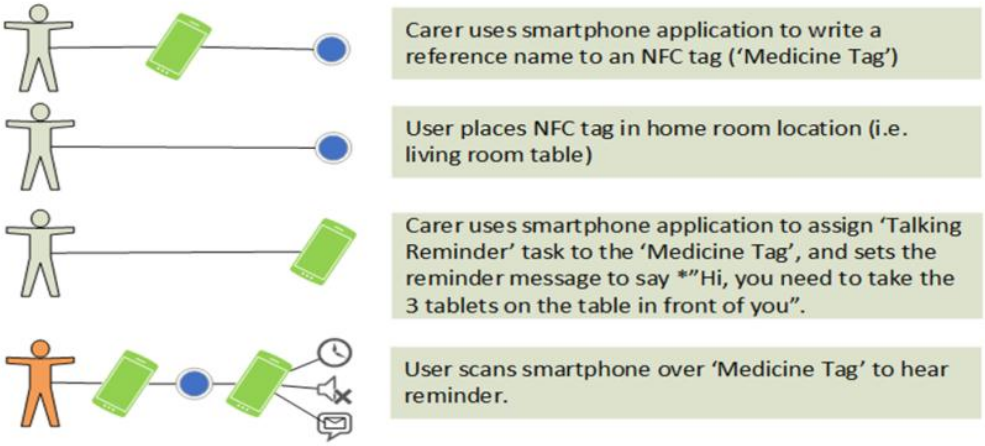

Figure 6. *Carer assigns a medicine reminder tag.*

CHIIP is a complete and fully functional application that can be used by anyone who has an Android smartphone. Tags can be written for any number of information cues, reminders or actions utilising a wide range of NFC tags which can be worn on or carried by a person, positioned within their homes, or in their local environments. The application has been demonstrated to 10 elderly people who were asked to rate the usefulness of various tasks, to suggest further tasks and to give their opinions on the usefulness of the application with results given in Figure 8.

Showcasing of the technology to clinical experts in stroke and dementia has also taken place at an Aphasia Workshop and to members of the public at a Café Scientifique and a University Open Day. The system has been very well received during these demonstrations with resultant useful feedback and ideas for further tasks that would be useful to incorporate in the system for people with mild dementia or memory loss. The technology has been successfully trialed in home environments and more formal trials in the homes of people with early stages of dementia are being discussed. Ways to make the system more widely available are also being considered.

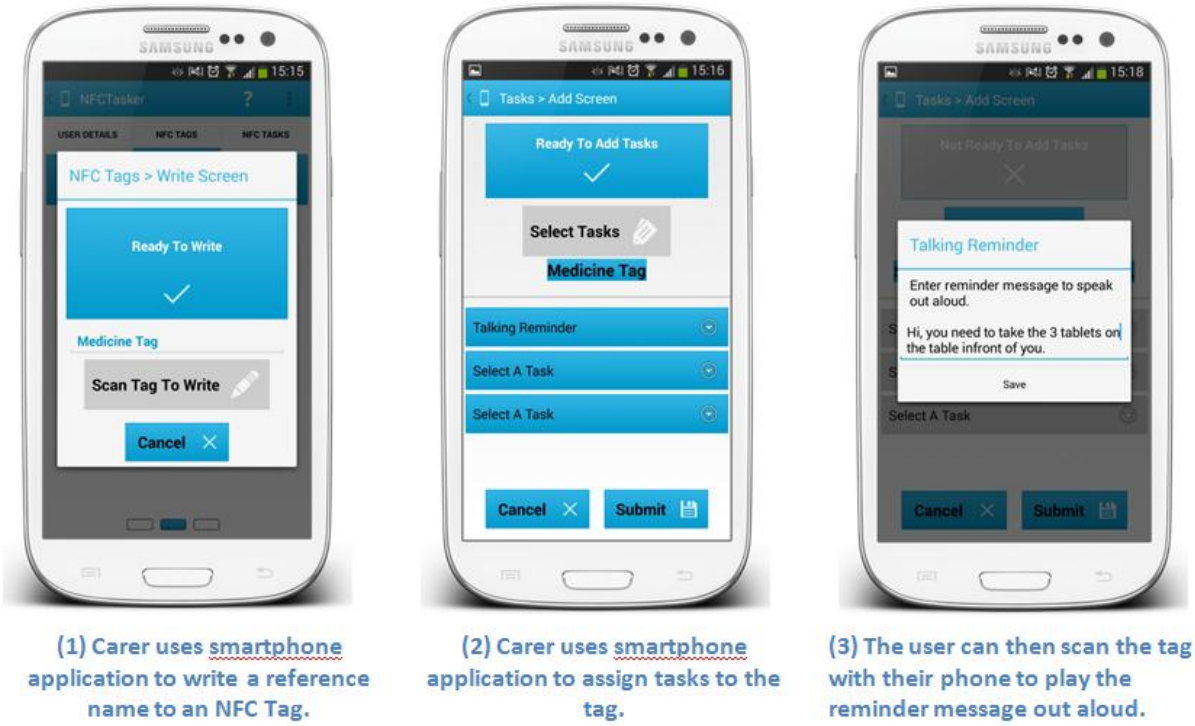

Figure 7. *Phone setup to assign the medicine tag.*

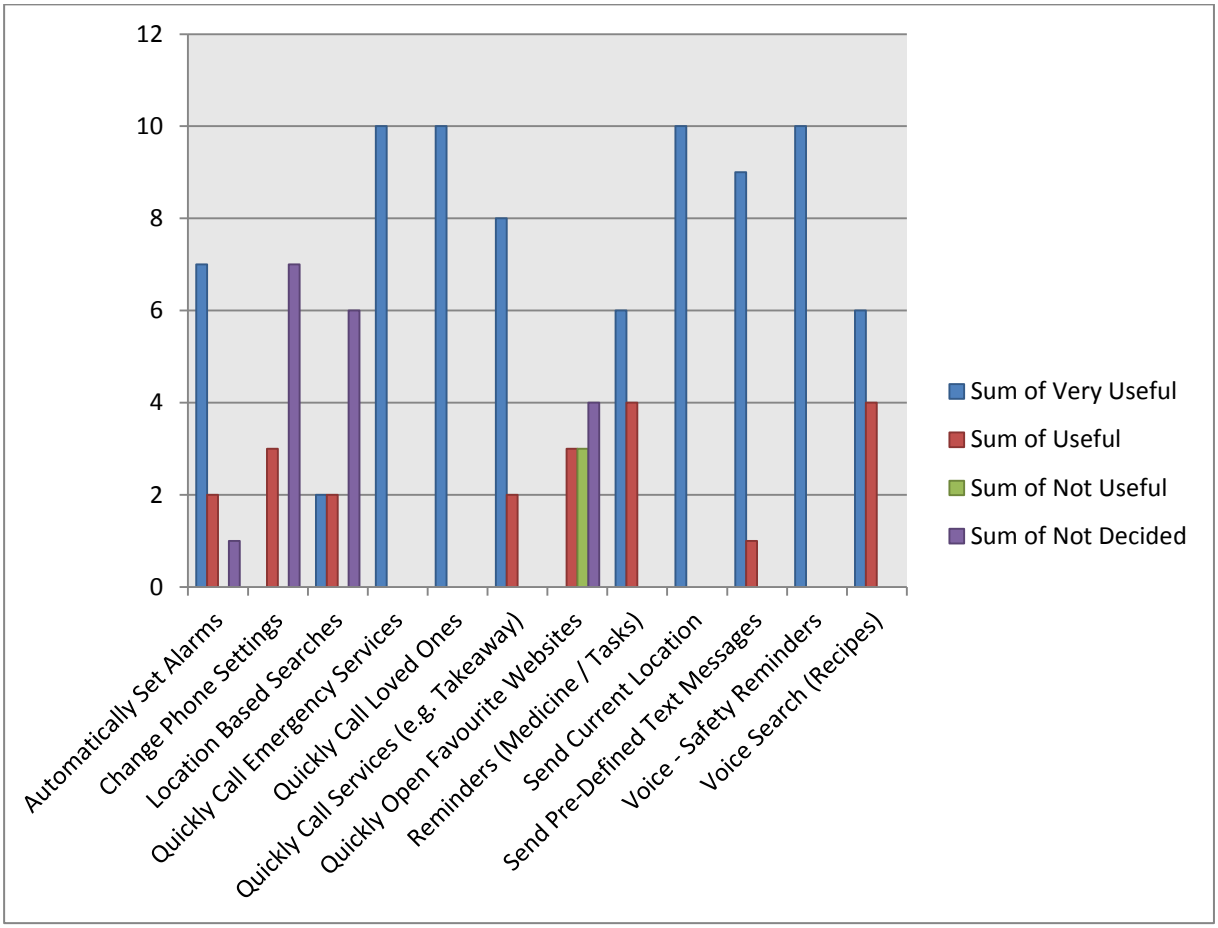

Figure 8. *Chart showing responses for elderly user group questionnaire tasks.*

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5. CONCLUSIONS AND FURTHER WORK

As populations age, the number of people experiencing age related memory decline and dementia increases necessitating increased care and support especially if people are to remain living independently in their own homes for as long as possible. Whilst technology can never be a complete substitute for human contact, it can help and support older people to live safer and more independent lives and give greater peace of mind to those caring for them especially when they are not cohabiting with the person they are caring for. Provision of assistance to people with memory loss or dementia and those who care for them has high individual and societal impacts in terms of safety, security, independence and quality of life.

The CHIIP project addresses some of the stresses and issues related to age related memory loss or mild dementia by providing the ability to set personalised reminders and actions based on a person's needs and lifestyle. These may include, for example, reminders to take medicines, close windows, check the iron is switched off, make a cup of tea etc. The application can also include location based tasks for people who are more mobile including finding a nearby place to eat, directions to a nearby petrol station, and messaging family members when they leave or return home. The key benefits of CHIIP are (1) it is affordable, especially if a person already owns a smartphone; (2) the app can be downloaded and installed within seconds and can be set up for use within minutes by anyone with a small knowledge of how to use a smart phone; (3) it only requires the older user to remember the single action of holding the phone close to a tag in order to be reminded of something or to perform an action; (4) through the NFCTasker functionality of CHIIP, the same tag can be associated with a number of tasks and hence used by different people for responses or actions personalised to them.

Following the evaluations that took place between April and June, a number of extended trials are being planned in the homes of individuals with mild dementia or age related memory loss in conjunction with social care providers. Discussions are also underway as to how to make the system available more widely. The system is also being extended with tags for other user groups including school children, students, working professionals, and individuals with special educational or work needs. Closer linkage of the system to home automation systems is also being investigated. Porting the application to other phones is under consideration; however, whilst most developers have included NFC in their recent phones, Apple has yet to commit, to NFC technology (NFC World, 2014), although it is rumoured that NFC technology will be included in the iPhone 6 (Mac Rumours, 2014).

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