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A Software App to Support Creativity in Dementia Care

Kos Zachos, Neil Maiden, Kristine Pitts, Sara Jones
City University London
Northampton Square, London, EC1V0HB, UK
kzachos@soi.city.ac.uk

Ian Turner, Malcolm Rose, Kevin Pudney
Registered Nursing Home Association , Tunnel Lane
Birmingham B30 3JN, UK
Ian.turner@rnha.co.uk

Julie MacManus
MediaTel Ltd
77 Endell Street
London WC2H 9DZ, UK
Juliemacmanus@gmail.com

ABSTRACT
This paper reports a new mobile software app to support creative thinking by carers for people with dementia. The design of the app was informed by both pre-studies that demonstrated the potential of investigating challenging behaviors in non-care domains to improve person-centered care, and a model of creative problem solving adapted to dementia care. The resulting app implements different versions of the Other Worlds creativity technique to generate then reflect on ideas to improve resident care. An evaluation of the app in one residential home revealed that carers were able to use the app as described in the model, and deliver novel care to one resident in the home.

Author Keywords
Dementia care, person-centered care; creativity support app.

ACM Classification Keywords
D.5.2 [User Interfaces]: User-centered design, voice I/O

General Terms
Design, experimentation, human factors

DEMENTIA CARE AND CREATIVITY

Dementia is a condition related to ageing. After the age of 65 the proportion of people with dementia doubles for every 5 years of age so that one fifth of people over the age of 85 are affected [3]. This equates to a current total of 750,000 people in the UK with dementia, a figure projected to double by 2051 when it is predicted to affect a third of the population either as a sufferer, relative or carer [29]. Dementia care is often delivered in residential homes. In the UK, for example, two in three of all home residents have some form of dementia [29], and delivering the required care to them poses complex and diverse problems carers that new software technologies have the potential to overcome. However, this potential is still to be tapped.

The prevailing paradigm in dementia care is person-centered care. This paradigm seeks an individualized approach that recognizes the uniqueness of each resident and understanding the world from the perspective of the person with dementia [6]. It can offer an important role for creative problem solving that produces novel and useful outcomes [26], i.e. care activities that both recognize a sense of uniqueness and are new to the care of the resident and/or carer. However, there is little explicit use of creative problem solving in dementia care, let alone with the benefits that technology can provide. Therefore, the objective of our research was to enable more creative problem solving in dementia care through new software technologies.

This paper reports a new software app to support creative thinking in dementia care and an evaluation of this app in one residential home. The next two sections report related work in dementia care and a model of creative problem solving in care work that informed app design. Section 4 summarizes two design pre-studies and section 5 describes the resulting software app. Section 6 reports findings from embedded use of the app in one residential home revealed that carers used the app to deliver an instance of novel and useful care to one resident in the home.

RELATED WORK

Creative problem solving is not new to care work. Osborn [1965] reported that creative problem solving courses were introduced in nursing and occupational therapy programs in the 1960s. Le Storti et al. [20] developed a program that fostered the personal creative development of student nurses, challenging them to use creativity techniques to solve nursing problems. This required a shift in nursing education from task- to role-orientation and established a higher level of nursing practice – a level that treated nurses as creative members of health care teams. Arbesman and Puccio [4] also put the case for creative problem solving by nursing administrators who set the tone in a work unit, and how others undertake creative work. Houts et al. [14] proposed a prescriptive creative problem-solving model to help family carers deliver care to people with chronic diseases discharged from hospital. The model was tailored to the healthcare domain from the Osborn-Parnes creative problem-solving model [23]. It distinguished situations in which creative problem solving could be used from situations in which advice needed to be sought from experts. Carers creatively adapted solutions developed for other people to family members in their own care.

There have been calls for creative approaches to be used in the care of people with dementia. Successful creative

problem solving was recognized to counteract the negative and stressful effects that are a frequent outcome of caring for people with dementia [12]. Several current dementia care learning initiatives can be considered creative in their approaches. These include the adoption of training courses in which care staff are put physically into residents' shoes, and exercises to encourage participants to experience life mentally through the eyes of someone with dementia [6]. Caring for people with late stage dementia is recognized to require more creative approaches, and a common theme is the need to deliver care specific to each individual's behavioral patterns and habits.

CREATIVE PROBLEM SOLVING IN CARE WORK

Care work in residential homes has important characteristics that distinguish it from other forms of work in which creative thinking might take place. For instance, it is practical, shift-based and event-driven. It requires its practitioners to balance different care and administrative duties [12]. It is mostly undertaken by part-time staff, most of whom do not have professional backgrounds. And it is poorly paid and afforded low social status, which contributes to high staff turnover [1].

Due to these characteristics, care work does not support the reported project-based creative processes from Synectics [11] to CPS [16]. These processes propose longer periods of idea incubation before generation, often during collocated collaborative tasks under expert facilitation. However, the frequent interruptions that carers encounter can reduce the time available to prepare and incubate ideas. Moreover, most residential homes lack the physical spaces needed for traditional forms of collaborative idea generation [28]. And many carers do not possess the skills needed to run creative problem solving processes.

On the other hand, if we can ground creative thinking in everyday care activities, the resulting changes can offer advantages to dementia care that project-based creative processes cannot. For instance, more stakeholders can potentially be involved in the creative process. A new idea can be implemented straight away, rather than at the end of a project. Ideas can also be evaluated more immediately in work, triggering more idea generation as a result. Quicker implementation and evaluation of ideas can also result in more concurrent idea development than in traditional processes. And, as already reported [12], successful creative problem solving can counteract the negative effects of caring for people with dementia.

Therefore, to investigate how we can exploit these possibilities in dementia care, we developed a model to describe creative problem solving activities in care work. Our purpose with the model was to describe key activities that carers should undertake, the ordering of these activities, and the knowledge consumed and generated by carers during the activities. In contrast to traditional creativity processes [16], our model assumes that ideas are generated and implemented concurrently by different carers. The normal order of activities with which to generate and implement a change in the care of a resident is depicted in Figure 1. The normal sequence of idea incubation then generation in established creative processes ([e.g. [25]) is reversed due to a lack of time for upfront idea incubation. Instead, idea generation happens in one or more periods of accelerated idea discovery. Idea incubation is replaced by longer periods of reflection [7] during which carers learn about, evolve and select between ideas. This reflection can lead to idea combination and refinement that can then be implemented as changes to the care of a resident that can be verified in practice and reflected upon further. Accelerated idea discovery is supported with selected creativity techniques that can result in a large number of ideas. This number falls as the ideas are reflected on and selected until a smaller number of ideas are combined in a care plan and applied to the care of the resident.

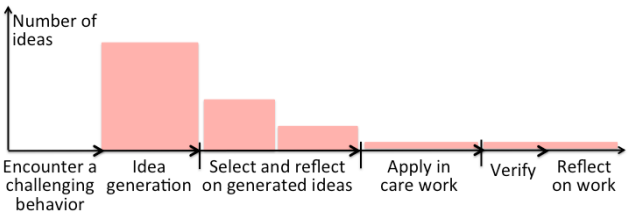

Figure 1: Model of creative problem solving activities in care work, showing normal sequence of activities and number of ideas considered in each activity to reduce an encountered challenging behavior

This means that, in dementia care, an individual or team of carers encounter a situation necessitating an outcome new to the care of the resident and/or carer. After one or more short periods of idea generation, the carer(s) reflect on these ideas to refine and select between them, learn more about them, and use them to plan a change to the resident's care. A first version of the care plan based on the new ideas is then implemented and verified, then further reflection about the ideas in action takes place before an agreed change to the care of that individual is made.

DESIGN PRE-STUDIES

To discover the types of dementia care problem more amenable to this model of creative problem solving, we adopted one residential home in the east of England rated as good by the UK's Care Quality Commission as our pilot site. Observations of care work and interviews with carers in the home revealed different roles for creative problem solving in dementia care. One of these roles was to reduce the instances of challenging behavior in residents. Challenging behavior defined as "*culturally abnormal behavior(s) of such an intensity, frequency or duration that the physical safety of the person or others is likely to be placed in serious jeopardy, or behavior which is likely to seriously limit use of, or result in the person being denied access to, ordinary community facilities*" [5]. Examples

include the refusal of food or medication, and verbal aggression. Carers normally seek to reduce occurrences of such behaviors by understanding them and their causes, often through reflective learning within the person-centered care approach [6].

Interviews with carers revealed that creative problem solving has the potential to generate possible solutions to reduce instances of challenging behavior. For example, if a resident is uncooperative with carers when taking medication, one means to reduce it might be to have a carer wear a doctor's coat when giving the medication. The means is creative because it can be useful, novel to the resident if not applied to him before, and novel to the care team who have not applied it before. Therefore, with carers in the pilot home, we explored the potential of different creativity techniques to reduce challenging behavior.

The first pre-design study took the form of one half-day workshop in which we explored the effectiveness and potential of different creativity techniques to manage a fictional challenging behavior. The carers in the workshop were one activity coordinator, one nurse and four senior care assistants from the pilot residential home. During a three-stage process the carers were presented with the fictional resident and challenging behavior, generated ideas to reduce the behavior, then prepared to implement these ideas. They used different creativity techniques, presented to them as practical problem solving techniques, to reduce the fictional challenging behavior. One transformational technique, *What-if* [15], was used to challenge existing barriers to understanding the resident (e.g. poor hearing*)* from different perspectives to generate new ideas. In the workshop, however, the technique produced few new ideas and was not favored by the carers. A combinational technique, *Brain Writing* [13], was used to combine and evolve ideas previously generated by carers. Although ideas were generated, the carers tended to generate the same, less novel ones, an outcome that they attributed to their common training. Two exploratory creativity techniques were also used. The first, *What/How* [13], used diagramming techniques to guide the carers to discover how to implement ideas, for example *using families* or *word of mouth* to *get volunteers more involved*. It was successful, in that the carers were able to generate action plans with which to implement their ideas.

However, carers demonstrated the greatest potential and appetite for the other exploratory creativity technique, called *Other Worlds* [15]. During the workshop, the carers sought to generate ideas to reduce the challenging behavior in four different, less constrained domains - *social life*, *research*, *word of mouth* and *different cultures*. These ideas were then transferred to the care domain to explore their effectiveness in it. *Other Worlds* was judged to be the most effective as well as the most interesting to carers. It created more ideas than any of the other techniques, and two of the ideas from the session were deemed sufficiently useful to implement in the pilot home immediately. Carers singled out the technique because, unlike others, it purposefully transferred knowledge and ideas via similarity-based reasoning from sources outside of the immediate problem spaces – the resident, residential home and dementia care domain.

So our challenge became how to implement the *Other Worlds* creativity technique in care work. In its standard form the technique requires both facilitated guidance to explore the different worlds and communication between participants to share ideas [15]. Neither was possible on a regular basis in constrained residential home settings. Therefore, we decided to implement software support for the technique. In the place of human facilitation, the software was to retrieve then guide carers to explore concrete other worlds. And in place of face-to-face communication, the software was to support asynchronous communication between carers who would digitally share information about care ideas and practices via the software.

The effective uptake of digital technologies in residential homes has proved challenging. Muller et al. [22], for example, report that parachuting in existing technologies into residential homes is unlikely to be effective. Instead, new designs need to be framed by important socio-technical themes such as sociality and trust. In this context, we undertook a second pre-design study in the pilot home to determine how best to deliver and adapt the *Other Worlds* technique to carers working in a recognized socio-technical context. Observations revealed that the carers maintained electronic resident records on a small number of desktop PCs – a common situation in most residential homes. However, this meant that the carers only accessed and entered resident data at the start and end of shifts, which in turn caused queuing and rushed data entry. Desktop-based software would not fit with working practices. Therefore, to explore alternatives, for one week, we replaced the paper notes of 8 other carers in the same pilot home with mobile iPod Touch devices running commercial apps that could support what is done with the paper notes, for example with a social media app to capture and share observations about residents [18]. The pilot was successful in that the carers carried and used the devices and apps throughout the week, although device use was restricted to quieter shift periods. Therefore, we designed the new app to run on this device and be used by carers in quieter moments during their shifts. The app was named *Carer*.

THE CARER APP

The *Carer* mobile software app was developed to support carers to generate new ideas with which to reduce challenging behaviors using 3 forms of the *Other Worlds* technique. To support the generation of ideas in less constrained worlds as we piloted in the first pre-design study, the app presents different worlds to carers in which such ideas can be generated. To support the generation of ideas that build on knowledge about ideas already generated

in some of these different worlds, the app presents resolutions to the challenging behaviors encountered in these domains in order to encourage analogical reasoning. Moreover, we identified that the app can also support carers to generate new ideas by building on knowledge about challenging behaviors reduced by other carers. Indeed, senior carers in specialized services are known to reuse strategies to resolve challenging behaviors, however these strategies are not accessible to other carers [14]. Therefore, to supplement the first two techniques, the app also presents knowledge about how these challenging behaviors were reduced in other homes.

Based on important constraints that we observed during both pre-design studies, we designed the app to be effective with minimum training and overhead. A carer describes each challenging behavior situation encountered in unrestricted natural language such as:

> *Mrs. X acts aggressively towards care staff and the resident verbally abuses other residents at breakfast. Suspect underlying insecurities to new people.*

using the mobile device keyboard as shown on the left-hand side of Figure 2. The carer can then select to use one of the 3 forms of the *Other Worlds* technique to generate and record ideas, reflect on them, then propose a change to the resident's care that can be shared with other carers, all using the mobile app.

To deliver this level of functionality to carers via mobile devices, we implemented a service-oriented architecture with: (i) an iOS v5 client app that the carer interacts with via an iPod Touch device; (ii) server-side digital repository of descriptions of past care practices shown to reduce challenging behavior, and; (iii) server-side computational services to implement the 3 forms of the *Other Worlds* creativity technique.

The computational services invoked by the app are:

1. An *other worlds* service that uses a randomizing algorithm to retrieve a description of one, less constrained world from a set of over 100 predefined worlds specified in the service because of the importance of relationships between protagonists. The right-hand side of Figure 2 shows the presentation of one such world – *when you are a waitress on a busy Saturday night*. Transferring the situation – aggressive behavior – to the less constrained world of a busy restaurant can support the carer to generate new ideas – ideas such as *providing a slower service to let the aggression dissipate*, and *asking another person to provide the support*. This service is invoked to retrieve a different description each time that a carer flicks the iPod screen;

Figure 2. The Carer mobile app showing how carers describe challenging behaviors (on the left-hand side) and explore other, less constrained worlds (on the right-hand side)

2. An *analogical reasoning* discovery service that matches the description of a challenging behavior situation to descriptions in the repository of challenging behavior cases in non-care domains such as *teen parenting*, *student mentoring* and *prison life*. To do this the service implements a computational analogical reasoning algorithm based on the Structure-Mapping Theory [8] [9] with natural language parsing techniques and a domain-independent verb lexicon called VerbNet [19]. The algorithm computes similarity measures between object-relationships extracted from sentences in the situation description and each case description, from which it computes an overall score of analogical match with each case. The left-hand side of Figure 3 shows one retrieved analogical case description – *managing a disrespectful child* – as it is presented to a carer using the app. Full details of this algorithm are available in [21];

3. A *case-based reasoning* discovery service that matches the description of a challenging behavior situation to descriptions in the repository of challenging behavior cases in dementia care. To do this the service implements term disambiguation and query expansion strategies from information retrieval research [27] to generate complex queries that it matches to case descriptions using text-based search functions and prioritizes using a traditional vector-space model information retrieval. For example, in response to the situation depicted in Figure 2, the service retrieves cases in which carers reduced behaviors such as *physical aggression* and *racial abuse of carers*. Again, full details of this algorithm are available in [21];

4. A *creativity prompt generation* service that automatically generates statements from retrieved good care practices that the carer can use to generate new ideas. Examples of these prompts generated for the *managing a disrespectful child* case are shown on the right-hand side of Figure 3. To overcome difficulties faced reading long paragraphs of text, the service generates each prompt from discrete phrases in the description (e.g. *Think about a new idea based on the rewards*) or from pre-defined creativity prompts adapted to the care domain from the Triz idea generation method [2] (e.g. *Think about how to combine work and resources in your care activities*). Two new creativity prompts are generated each time a carer flicks the iPod screen.

Figure 3. The Carer mobile app showing a retrieved description of good care practice (on the left-hand side) and creativity prompts generated from that description (on the right-hand side)

The case-based and analogical discovery services access a digital repository to retrieve natural language descriptions of cases of good care practice in XML based on the structure of dementia care case studies reported by the Social Care Institute for Excellence [24]. It is implemented using eXist, an open source native XML database featuring index-based XQuery processing that the discovery service queries using XQuery, a query language designed for processing XML data. Each case has two main parts of up to 150 words of prose each – the situation encountered and the care plan enhancement applied – and is attributed to one class of domain to which the case belongs. No other ontology or tags are used to provide additional semantic information about each case because residential homes often lack the resources and expertise to do this. The current version of the repository contains 91 case descriptions, 54 from care domain and 37 from other domains. Most of the cases describe how challenging behavior was reduced, although the repository also contains a small number of cases describing improvements made to the quality of life of residents and others.

Although the *analogical reasoning* and *case-based* discovery services retrieve all case descriptions with computed match scores above a threshold, the client app presents the carer with 3 case names at a time in descending order of match value. At any time, therefore, the carer can click on the name of the case to access the description of each, star the case as a favorite to be revisited, or request a further 3 cases. These features are designed to maximize the browsing and reading of cases by the carers.

When using the computational services, a carer can audio-record a new idea at any time by pressing the red button visible in Figures 2 and 3 then verbalizing and naming the idea. Recorded ideas can be selected and ordered to construct a new care enhancement plan that can be extended with more ideas and comments at any time. The carer can also play back the audio-recorded ideas and care enhancement plans to reflect and learn about them, inspired by similar use of the audio channel in digitally supported creative brainstorming [28]. Reflection about an idea is supported with guidance from the app to reflect on why the idea is needed, what the idea achieved, and how and when the idea should be implemented. Reflection about a care enhancement plan is more sophisticated. A carer can drag-and-drop ideas in and out of the plan and into different sequences in it. Then, during play back of the plan, the app concatenates the individual idea audio files and plays the plan as a single recording, allowing the carer to listen to and reflect on each version of the plan as a different narrated story. Moreover, s/he can reflect collaboratively with colleagues using the app to share the plan as e-mail attachments, thereby enabling asynchronous communication between carers. Data privacy sufficient to meet the needs of the home was ensured using a password-protected wireless network and room numbers to define unnamed residents.

EVALUATING THE CARER APP

This version of the *Carer* app was made available for evaluation in residential homes participating in our research project. One challenge that we faced was to design an evaluation that could be effective in these environments over the length of time needed to demonstrate some creative thinking and reflection. Residential homes and care work impose specific constraints on the techniques that can be deployed effectively to evaluate technology use in them. Carers will often lack the time both during and after work tasks to communicate with researchers. Researchers will not be able to observe most of the care work undertaken due to its mobility and duration, and researcher interventions in the work to collect data will be difficult due to its event-driven nature. Therefore, we designed an evaluation that relied primarily on automatic data collection about app use.

The evaluation took place at one residential home in the English Midlands. The home was not related to the pilot home. It was situated in a 19th century manor house and had 49 residents, some of whom had been diagnosed with the early stages of dementia. The carers worked with a small number of desktop computers to manage the business rather than the care activities. Prior to the evaluation we extended the home's broadband wireless network to all resident rooms and lounges.

Evaluation Method

At the start of the evaluation, 3 nurses and 4 care assistants in the residential home, all of whom had volunteered to participate, were given an iPod Touch for their individual use during their care work over a continuous 28-day period. All 7 carers had come to the UK to work in the care sector, English was their second language, and all but one owned and used a smartphone. In these regards we considered them to be typical of residential care workers in the UK.

All 7 carers consented to participate in the evaluation, and were given access via e-mail and telephone to a help desk manned by the researchers throughout the period. Each device was locked but provided the carers with access to the *Carer* app and Yammer, a micro-blogging app adapted by the researchers for use in care homes. This second app allowed carers to record and share daily care notes about residents in situ, rather than with pen and paper at the end of a shift. Carers were expected to use this app throughout each shift – continuous use that, we hoped, would remove barriers to use of the *Carer* app when challenging behaviors were encountered. More information about Yammer and its use is reported in [17]. All 7 carers received face-to-face training in how to use the device and both apps before the evaluation started. A half-day workshop was held at the residential home to allow them to experiment with all of both apps' features. The carers were also given training and practice with the 3 forms of *Other Worlds* creativity technique through practice and facilitation to demonstrate how it can lead to idea generation. We deemed this training in the creativity technique an essential precondition for successful uptake of the app. Finally, we provided each carer in the evaluation with a bespoke e-mail account with which to share care enhancement plans generated by the app with colleagues.

Evaluation data was collected from 3 main sources. The first was a data log implemented in the app that automatically recorded the date and time that each app feature on each device was used. At the end of the evaluation, the data log from each device was downloaded and analyzed. The second source of evaluation data was the reports from carers of software and hardware errors that they encountered during app use. The third source of data was a focus group with the carers held at the end of the evaluation period. It was audio recorded, transcribed and analyzed in-depth using predefined themes generated from analysis of server-side data about service use during the evaluation. We used the data collected from these 3 sources to answer 4 research questions:

RQ1 Did carers use the app during their care shifts to capture information about encountered challenging behaviors and generate ideas to reduce these behaviors?

RQ2 Did the carers use the app as described in our model of creative problem solving model?

RQ3 Which forms of the *Other Worlds* creativity technique did the carers use to generate ideas to reduce the encountered challenging behaviors?

RQ4 Did the carers use the app to change their care of a resident in useful ways that might be novel to carers and/or care of that resident?

We asked the first question to explore whether carers were willing and able to describe challenging behaviors then generate ideas and care enhancement plans using the app. We already knew from our pre-design studies that carers carried and used mobile devices [18]. In this evaluation we focused on specific uses of the *Carer* app such as to *describe situations* and *generate ideas*. We anticipated infrequent use of these app features due to the infrequent occurrences of challenging behavior in the residents of the home. We asked the second question to validate the model of creative problem solving in care work outlined in section 3. In particular we wanted to determine whether carers undertook the key activities in the order described in the model, and generated care enhancement plans from selected and reflecting on ideas. We asked the third question to understand which form(s) of the creativity technique were more effective for carers during care work. And we asked the fourth question to determine whether software support for the 3 forms of the *Other Worlds* creativity technique led to any changes in resident care in the residential home in the evaluation period.

Evaluation Results

All 3 nurses and 4 care assistants took part in the evaluation. One of the carers, the senior nurse in the home, led the other carers during the evaluation. He was a first point of contact if a carer had a problem with the device or app, and acted as the champion to encourage and motivate app use during the evaluation period. The shift work of the carers dictated that some of them were compensated with longer periods of leave that were to take place during the evaluation period, and this was anticipated to affect volumes of app use during periods of leave. Furthermore, nurse 3 and care assistant 6 worked on the night shift throughout the evaluation period, and we anticipated lower volumes of app use from these 2 carers because of less resident activity at night when they are asleep.

The carers only reported one software error – the app failed to send an email with an attached care plan enhancement to

other carers. We corrected this, and software errors did not appear to impede app use during the evaluation.

Carer App Usage

First of all, we analyzed the app log data to investigate how much each carer used the app during the 4 weeks. The log captured data at the level of feature rather than keystroke use, hence it recorded the number of times each carer invoked a different app feature such as *discover previous cases* (Figure 2) and *view case details* (Figure 3) rather than the number keyboard interactions needed to access a feature. Results summarized in Table 1 revealed that all 7 carers used the app during the evaluation period. The totals of app feature use were consistent with the infrequent occurrences of challenging behavior by the residents, and the corresponding need to create ideas and care enhancement plans to reduce these behaviors. However, there were individual differences in the totals of app feature use, for example care assistant 6 exhibited over 6 times as many app feature uses as care assistant 4.

Nurse 1	Nurse 2	Nurse 3	Assist 4	Assist 5	Assist 6	Assist 7
50	88	30	20	63	110	43

Table 1. Totals of individual app feature uses by carers

The total numbers of app feature use during the evaluation by all 7 carers varied by week. After a first week in which the carers used the app 152 times to support their care work during each of their shifts, levels of app use dropped in the second and third weeks to 53 and 40 uses respectively. This was caused primarily with a problem that emerged in week-2 with the home's technical infrastructure that led an Internet connection failure that took 3 days to correct. More importantly, however, this technical problem undermined carer confidence in the devices during a period when the senior nurse – the champion – was on leave. In particular, several of the carers stated that they believed that the Internet connection failure that arose was their fault, resulting in a breakage of the app, and they did not want to repeat this perceived mistake. The return of the senior nurse in week 4 was instrumental in restoring confidence in the devices, leading to a return to a higher level of app use of 159 uses in the last week.

We analyzed the log data to map the days and times when the carers were using the app to the days and times when they were on shift. Mapping the app usage times onto the on-shift times enabled us to determine how much app use occurred during shifts and outside shifts. A total of 118 uses of app features occurred in shifts, but a total of 286 uses of app features occurred outside shifts. Moreover, each individual carer undertook fewer app uses during his/her shifts than outside of them. Even allowing for local variations in shift start and end times, this result suggests that most app use occurred outside of shifts, when carers were not directly caring for residents. One important reason reported during the focus groups was that most carers lacked the time needed to use the app during their shifts.

Figure 4 reveals the total number of uses of each group of app features by carer in the evaluation period. All 7 carers recorded challenging behavior situations that were used to retrieve previous cases, but their use of the other app features varied. For example, nurse 2 used a larger number of creativity prompts (e.g. *think about how to offer a bath rather than a shower*, *think about how to experiment with different washing patterns for different days of the week*, and *think about how to distribute the care activities*) from the retrieved case *resident refusing help with their personal care*, and generated a larger number of ideas (e.g. *how to distract a resident when care is given*, *have a carer act more like her brother who used to care for her*, and *boosting a resident's self-esteem to reduce rudeness to staff*) that were viewed and played back more than by other carers, but only generated 1 care enhancement plan. In contrast, care assistant 6 used most of the features to create 5 care enhancement plans that were played back on 7 occasions, whilst care assistant 5 viewed the retrieved cases rather than the creativity prompts and other worlds to create a smaller number of ideas and care enhancement plans. In total, the 7 carers played back ideas and plans on 33 different occasions, but 25 were undertaken by just 3 of the carers. Focus group comments revealed one unexpected reason for this – most did not like to listen back to their own voices due to the emotional discomfort it caused them.

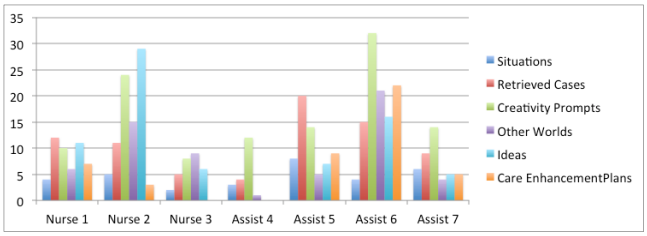

Figure 4. Total uses of different app features by the carers

Idea Generation with the Carer App

Next we analyzed the ideas and care enhancement plans recorded by the carers using the app, see Figure 5. Although the carers documented 28 different challenging behaviors during the 4 weeks, they only audio-recorded 14 ideas and constructed 10 care plan enhancements, each composed of just one idea each Topics of these care plan enhancements included *seeking help from other care professionals*, *diet modification*, *adapting the patterns of care to encourage the resident to sleep at more regular times*, and *means to encourage more independence by residents where possible*. That said, the ideas were on average 46 seconds in length. Most of the challenging behaviors (25 of the 28) were recorded in the first 2 weeks of the evaluation whereas most ideas (9 out of 14) were recorded in the last 2. Explanations provided in the focus group revealed that carers recorded the same idea several times after reflecting and learning about it by browsing retrieved cases.

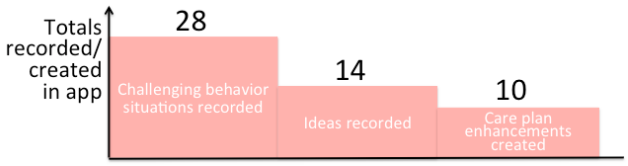

Figure 5. Totals of challenging behavior situations, ideas and care enhancement plans recorded in the app by all carers

Different Forms of the Other Worlds Technique

Carers appeared to use 2 forms of the *Other Worlds* technique to generate ideas. The log data recorded 61 different uses of the *other worlds* service to view a description of a less constrained world. In contrast, there were only 5 uses of the *analogical reasoning* service to retrieve descriptions of cases of challenging behaviors from non-care domains, all in week 1. Rather, the carers appeared to use the *case-based reasoning* service to retrieve descriptions of challenging behavior cases from the care domain – the log data recorded 28 uses of this service, and most of the 114 recorded uses of the *creativity prompt generation* service were generated from these same-domain dementia cases. In the focus group, the carers claimed that most of these retrieved care domain cases were relevant to the challenging behavior in question, and guided them to generate the ideas and care plan enhancements. On the other hand, the focus group revealed that the carers did not use retrieved non-care domain cases because they were unable to recognize analogical similarities between them and the challenging behavior situation, while the other 2 forms of the technique were also quicker to use.

Impact on Care Work in the Residential Home

The focus group revealed that the nurses and carers implemented at least one major change to the care of one resident based on ideas generated using the app. One of the older female residents was frequently violent to the carers when providing care. Carers had resorted to restraining her to provide care. The carers used the app to seek inspiration about how to reduce this behavior in a different way. The *case-based reasoning* discovery service had retrieved one good practice care in which carers had agreed a care plan change with the doctor, care home management and social services to reassure the carers. The enhancement to the resident's care plan included having 2 carers present during essential care to prevent violent behavior and provide reassurance. The care enhancement for that resident was effective in that she became less violent, as well as new to that resident's care and to the carers who implemented it. Some of other care enhancement plans generated for the residents were also considered but not implemented during the period of the evaluation.

RESEARCH QUESTIONS AND LESSONS LEARNED

Even though it only lasted 4 weeks, the reported evaluation of the *Carer* app in one residential home provided valuable data about the use of mobile computing and creativity techniques in dementia care.

The answer to the first question RQ1, whether carers used the app during their care shifts to capture information about encountered challenging behaviors and to generate ideas with which to reduce these behaviors, was *sometimes*. Although the carers did use the app in response to 28 different challenging behaviors encountered during the 4 weeks, only one-third of this use occurred during care shifts due to lack of time. Most app use occurred outside shifts when the carers had sufficient time to create and reflect on ideas and care enhancement plans. This result was a surprise to us, as many residential homes encourage their carers to leave their work at the door, and not let it impact on their personal lives.

The answer to question RQ2, whether carers used the app as described in the model of creative problem solving model was *no*. Although the carers used the app to undertake activities in the order described in the model – encounter a challenging behavior, generate ideas to reduce the behavior, reflect and select ideas, then compose a care enhancement plan to implement and verify – the carers also undertook some other activities, and generated fewer ideas than expected. Whereas the model describes that a carer will generate more than 1 idea per challenging behavior, the carers actually generate fewer, and many of the ideas were re-recordings of the same idea as it was improved with reflection. Rather than compose a care enhancement plan from different ideas, the carers tended to re-record an idea until it had evolved into the plan. This result has implications for potential changes to our model of creative problem solving in care work.

The answer to question RQ3, the forms of *the Other Worlds* creativity technique used to generate ideas, revealed that carers generated ideas from previous challenging behavior cases in dementia care and from descriptions of less constrained worlds, but not from previous resolutions of challenging behaviors in non-dementia care domains. Indeed, the one care enhancement plan put into practice during the evaluation was generated from ideas from a previous dementia care case. The carers claimed to be able to perceive the relevance of these cases to their work, which was not often the case with the retrieved analogical cases from non-care domains.

The answer to question RQ4, whether the carers used the app to change their care of a resident in useful ways that might be novel to carers and/or care of that resident, was a tentative *yes*. The carers reported one example of a novel and use care enhancement plan that was generated using the app and implemented in the evaluation period – an initial success. This was the first rollout of a complex research prototype that changed care work in a complex domain over a relatively short time period, and it resulted in a positive change to the quality of life of one resident in the home.

Of course, the results and our interpretations of them are open to different possible conclusion, internal, external and construct validity threats. A threat to construct validity arose from the single evaluation by 7 carers in just 1 residential home. However, our primary aim at this time was to demonstrate that creativity techniques delivered without human facilitation can enable carers to implement personalized care that is novel and useful, and we believe that the evaluation demonstrated this potential. Moreover, the delivery of this support as a software app demonstrated that carers are able to use mobile devices to support their care work both during and outside shifts. There are also several threats to the internal and external validity of the results. The carers volunteered to take part in the evaluation, and their enthusiasm to work with mobile apps might not be shared by other carers. The carers were aware of the evaluation and its duration, which might have led to increase app use in week 4, although we do report other reasons for increased app use towards the end of the evaluation. The role of the champion senior nurse to encourage app use throughout the evaluation was also important as an agent to bring about the required change in the care work. The standout threat to conclusion validity was whether the one reported change to a resident's care during the evaluation would have happened without use of the app. That said, the senior nurse did report that the use of a second carer to provide reassurance was new in the home, and directly attributable to a case presented by the app.

The evaluation experience also enabled us to learn several important lessons about the mobile creativity support app. The computational services supporting creativity appear to have been effective – the past cases retrieved and the other worlds presented were both relevant, and the generated creativity prompts were usable. However, the different forms of the *Other Worlds* creativity technique did not result in a large number of recorded ideas, especially compared to its facilitated form in the first pre-design study. This outcome raises questions about the effectiveness of the technique. One is whether the *Other Worlds* creativity technique delivered through the app is as effective as through human facilitation. Further studies will be needed to determine what additional capabilities that the app might need. The other question is did the carers document all of the ideas in the app that they cognitively generated when using the app? The incremental re-recording of the ideas until each evolved into a care enhancement plan could be interpreted as evidence that the carers only recorded ideas that had already been reflected on and verified internally. In simple terms, the carers might not have been prepared to record early ideas as our model of creative problem solving in dementia care describes. One possible reason for this might be the low social status of carers – something that renders them risk-averse and might have inhibited idea generation and/or recording.

All carers struggled to recognize similarities between cases from the non-dementia care domains and challenging behaviors of their residents, in spite of the pre-design study with other carer that had revealed their potential for idea generation. One probable reason is that analogical reasoning is cognitively difficult. Studies have shown that individuals are unable to recognize analogical mappings and transfer knowledge across domains without explicit support such as spatial diagrams (e.g. [10]). Therefore, for this form of the creativity technique to be effective, the app will need to offer more explicit support for recognizing the analogical mappings and transferring knowledge across them via the creativity prompts. What we are currently exploring is the explicit presentation of mappings computed by the *analogical reasoning* discovery service to provide the user with all relevant information, and new guidance to infer what characteristics of a source object can be transferred to the mapped target object.

The carers used the app to generate, reflect on and improve ideas to reduce challenging behaviors in residents, however most of this work happened outside shifts due to a lack of time. This finding suggests that creative thinking to encourage an individualized approach and recognize the uniqueness of each resident might need more time in shifts than is available to most carers at the moment. The introduction of apps with the capabilities of *Carer* would appear to necessitate not only work redesign but also a change in the climate of many residential homes. To this end we are seeking partnerships with organizations such as theatre companies that are seeking to change the norms of care work to make it more collaborative and creative by involving residents and carers in play activities.

CONCLUSIONS AND FUTURE WORK

The evaluation results reported revealed that our model of creative problem solving did not describe all observed carer behavior, so we are currently repeating the rollout and evaluation of *Carer* in other residential homes to validate this finding. *Carer* is being extended with new creativity support features that includes more explicit support for analogical reuse of cases from non-dementia care domains.

We are currently enhancing *Carer's* capabilities with other mobile software apps that it will interoperate with to support person-centered care more effectively. One current weakness of *Carer* is that does not use existing data about a resident from care records and health data – all resident information must be included in the description of the situation. This conflicts with good practices in person-centered care [6]. Therefore, we are currently designing and prototyping new capabilities and apps to exploit resident information and data to reduce challenging behaviors. One will provide visualizations of data about the resident who is exhibiting the challenging behavior within *Carer* to supplement creative problem solving with the *Other Worlds* technique. In addition, a new app will draw on resident care made by carers to support a different creativity technique – *Challenging Assumptions* [14] to encourage carers to generate ideas to with which to improve a resident's quality

of life. We look forward to reporting the evaluation of these new capabilities and apps in residential homes in the near future.

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