Positive Design of Smart Interactive Fabric Artifacts for People with Dementia

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***Abstract*—Confronting the expected rise of dementia as a major health care problem raises many questions about the best ways to adapt the health system to deal with it. To the extent that intelligent assistive technologies can help, there seems to be value in comforting fabric artifacts enhanced by electronic games and activities designed to support, engage and entertain people with dementia. Local cottage industries which now support the creation of textile crafts should be empowered to scale up to meet the growing demand for such products. New design concepts are required to accomplish this in the face of rising costs and limited resources. This paper proposes a four-step design process that meets this need, and provides practical suggestions about how it could be applied in this context. A number of examples are included.**

I. Introduction

The aging of the world's population carries with it the inevitable rise of most forms of dementia. But the scale of the problem is sobering: the World Health Organisation estimated that the 2012 population of people with dementia (PwD) was 35.5 million, that this would double by 2030 and more than triple by 2050 [1]. One 2015 estimate put the worldwide associated health costs at US$818 billion dollars and expected a threshold of US$1 trillion to be passed in 2018 [2]. The public health care costs associated with dementia are rapidly becoming unsupportable and the level of informal care will need to increase dramatically to compensate. The WHO report identified dealing with this trend as a major priority. The full social impacts of this iceberg of change can barely be imagined at present.

Dementia is considered an incurable disease, even though its causes are several, and the effects of therapies of various kinds are only in the first stages of evaluation. The course of dementia is divided into early, middle and late stages, with facilities of memory, motion and awareness generally deteriorating over those periods. PwD can suffer impairments including memory loss, executive dysfunction, aphasia, agnosia, apraxia, visuospatial impairment, behavioral, activity, and mood disturbances [3]. It is an example of a "total disease" in that it affects all aspects of health, if that is defined as "a state of complete physical, social, and mental well-being and not merely the absence of disease or infirmity". When patients are treated at home, their chronic and progressive dementia disorders require a cooperative response to patient care, often requiring much of family and age care staff. A lack of such a response reveals gaps in the system inherited from past health and social service systems that were designed primarily to deal with acute illness. PwD are particularly vulnerable to the gaps between the health and social service systems [4].

Among the possible aids in confronting this disorder, Intelligent Assistive Technologies (IAT) are a sophisticated form of assistive technology that compensates for the specific physical and cognitive deficits of PwD. It has been argued that appropriate equipment of this kind could offer the triple benefit of significant cost savings by delaying or eliminating long term institutional care, reducing the burden on formal or informal caregivers and improving the quality of life by improving autonomy, independence, safety, social interaction and the possibility to age in place [5] [6]. Although there is room for embedded machine intelligence in some of the best examples of the art, in practice a wide variety of techniques, often low-technology, seem to be appropriate. In the case of dementia, some solutions can profitably include recent innovations in smart fabrics, and low-cost, modular electronic inserts for wearable devices and off-the-shelf interface and display technologies designed for other purposes, such as electronic jewelry. In particular, soft "ludic artifacts" such as quilts, armchair covers or "dementia aprons" have been demonstrated to have significant wellbeing benefits [7] [8]. A dementia apron is a soft fabric that can be placed across the knees or on a table in front of the patient which they then manipulate. In this paper, we focus on design ideas around dementia aprons. However, the design concepts apply to many other kinds of delivery, such as clothing, tapestries, cushions and plush toys. The focus of this exercise is not high-technology bravuro, but rather innovative and practical solutions designed to amuse, divert, comfort, entertain and stimulate PwD.

II. Can Technological Solutions Really Help Dementia Sufferers?

It would only be worth investing time and money in IATs if we could expect them to return genuine benefits to the PwD community. At a finer granularity than the triple benefit suggested above, possible good might include providing support for daily activities and problem areas of deficit; acting as or supporting another intervention that could slow or avert the disorder; detection of onset of the disorder prior to the early stages; and assessment of the level or profile of deficit at all stages. What hope does the current research afford?

A. *What Devices Can and Cannot Do*

Strong evidence that interactive technologies for the demented are beneficial in supporting daily activities and correcting for particular problem areas is hard to come by. Proposed technologies range in function from low-tech aids (e.g., medication pill organizers, schedules and notes) to higher technology examples (e.g., intelligent assistive devices that are contextually aware and can provide help when appropriate) [9]. Intelligent devices are increasingly trialled by researchers, but according to a rigorous 2014 review of the literature [10], the resulting studies are typically plagued by methodological problems, high dropout rates and technical failures. The review did show some good evidence in favour of electronic memory aids, visual and audio prompting devices for daily activities, but poor to non-existent reasons to believe that home automation for hand-washing, gas-cooker monitors, and wearable tracking aids against wandering were yet efficacious. It concluded that once the evaluation moves out of the laboratory, significant problems, so that as a rule the studies could show little difference to practical outcomes.

Nor is the demonstrated value of devices in the detection and assessment of progress along the course of a dementia prognosis on solid ground. Mild Cognitive Impairment (MCI) is commonly considered to be the first sign. Although the nature of MCI is somewhat controversial with variable application in clinical and epidemiological research, it remains an important construct in terms of targeting interventions to prevent dementia. However, very little is known about how MCI may be recognized during clinical attention in routine practice. According to Stewart [11], population screening for impaired cognitive function and/or informant-reported decline is unlikely to be feasible - or acceptable. Detection will therefore continue to rely on personally-reported subjective memory complaints as a presenting symptom, granted the fact that memory complaints may originate in many causes and poorly predicts medium-term dementia risk. This highlights the importance of developing personal baselines, to determine if any change has occurred. Even in clear cases of dementia, there is still no agreed upon way to measure the attendant deficit. In the United Sates for instance, The Centers for Medicare and Medicaid Services elected not to recommend a specific assessment tool for eligibility because there is no single, universally accepted measure. However a later review of the dementia literature [12] identified at least 11 measures of Quality of Life, or wellbeing. The study's analysis of the pyschometric properties, correlation with other methods, sensitivity to change and practical utility singled out the Greater Cincinnati Chapter Well-Being Tool [13] as best, but noted that the more recently developed AwareCare [14] also showed superior results as well as being freely available online (http://reach.bangor.ac.uk/AwareCare.pdf).

Even if the question of what to measure was settled, there would remain the matter of whether an IAT would be able to help with measuring it. Most of the extant methods are based on personal interviews, questionnaires and daily observations, which could not be accomplished by an IAT. However, this is a labour-intensive activity requiring specialised skills, and the available levels of these resources might not be able keep pace with the growing need. This might force health authorities to consider lower cost methods in future, including carer-assisted self testing using machines.

Can any of the causes of dementia be averted or at least mitigated by known (non-pharmocological) therapies? There is good evidence that the exposure to bright light can improve quality of sleep and reduce behavioural disturbances [15] [16]. On the other hand, experiments with Simulated Presence Therapy, in which the PwD is played audio or video recordings of human voices, as an alternative to music, have so far been able to show only small and short-lived benefits [17]. In any case, these interventions only offer symptomatic relief at best. It is interesting that while several studies suggest the value of Multi Sensory Stimulation (MSS) in terms of cognitive clarity, mood and behaviour [18] [19], the reported quality of delivery of this in specially decorated Snoezelen rooms is usually inadequate [10]. Probably the cost and difficulty of building such environments works against it. One could consider a properly-designed dementia apron as a low cost, portable method of delivering MSS that does not depend on redecoration of rooms, though it is possible that MSS is effective only in combination with the increased social contact with aged care staff and carers the treatment involves.

Whether or not device-driven exercise can actually avert or slows the progression of the disease, it might provide comfort or diversion for a PwD, especially if he or she was not able to engage in more conventional entertainments, games, crafts or social interactions. We do not imagine AITs, even advanced examples, could or should supplant a carer, but specific, well-chosen aids could assist PwD and relieve carers of some of their burden. However, some of the most problematic areas that carers need help with include instrumental daily personal activities, such as showering and going to the bathroom [9]. These more physical services would probably not be deliverable using smart fabrics and wearables, and will likely only be available if and when IAT progresses to powerful and safe aged care robots, such as RIKEN's Robear [20] become affordable.

B. *Ethical Concerns*

In common with other technological devices which may collect, store and transmit information about personal life, IATs can raise questions about privacy and actual use. These concerns are particularly acute in the case of mobile apps or Internet connected devices, where data may unintentionally be accessed by persons beyond the intended recipients. For example, it may become easier for burglars to rob a home if they have had access to a person's personal schedule. Ubiquitous health monitoring technologies, in general, raise important ethical questions. The very designs that promote independence in daily activities not uncommonly involve varying degrees of privacy impingements. However, not all IATs collect data, and even if they do, they not necessarily relay it via Internet connections. If usage data or personal settings are stored locally on an internal logger, and only able to be viewed by a minimum of persons using physically connected devices or by short range wireless services, that would seem more acceptable, if less convenient.

[21] raises three important ethical considerations for research and deployment of such devices. First, there is the problem of obtaining informed consent for experimental trials from PwD. This is a very real problem for experimental research in this field. Extraordinary care and scrutiny of experimental protocols are needed to avoid breaches of ethical conduct for patients with mild to moderate dementia. It might not be possible to obtain true informed consent for late stage PwD, so researchers need to make an honest appraisal on the value of their research relative to the possible harms. Second, success with one or more of these technologies might lead to increased personal autonomy by supporting independence at least partially, with all the consequent implications for health care. For example, would extending the time allowed for a PwD to age in place also increase the risk that they will wander and become lost? Third, there is the risk that these technologies would not be fairly distributed among PwD, depending on their social and financial circumstances. As with other enabling technologies, the problem of further perpetuating the digital divide into old age should not be ignored. Adequate provision of resources for producers and families is part of the general aged care question, and is especially serious in view of the scale of the problem. Section III suggests a possible inroad.

Other concerns have been raised concerning a moral hazard associated with the use of IATs with infirm, elderly or dementia sufferers. This is that such persons deserve special care and genuine human contact for which mere entertaining or soothing gadgets should not be substituted. This argument is similar to those expressed by some critics that mobile games, tablets and computers are being used as ersatz baby sitters by distracted or time poor parents to avoid interacting with their own children. Turkle [22] worries that leaving a (possibly tiresome) aged individual in the care of a "mental commit" robot designed to support such an individual, might improperly salve the conscience of a son or daughter who was anxious to get away. We argue that these concerns are not nonsense, but are overstated. The trouble is that they are usually presented as a choice between an ideal, loving, supportative and unconstrained human relationship and the machine. In reality, the choice may instead be between overworked elderly care staff and the machine, or between poor or missing care from a relative and the machine. This choice can only be expected to become more stark as the epidemic of dementia unfolds. Perhaps a living dog or cat would seem a better choice than a robot seal such as Paro [23], but living pets are not ideal in aged care facilities because of their own needs (which might not be able to be met by aged owners) and because they can bite, scratch, create mess or cause allergic reactions [24]. The Paro evidently offers a great deal to PwD and their carers [25], yet entails none of these drawbacks.

It seems reasonable to put these matters into perspective and assert that devices should not be used as a substitute for human care, but rather to offer practical support in problem areas for patients and carers. The design process described in the next section involves carers intimately in the process of producing customised solutions that are meaningful and helpful to individuals, and indeed the fabrics are made to inform designers when a feature is not. It does not presuppose that great amounts of time, money and patience are available for individualised human nursing care for all PwD. For this reason, we would be more concerned about the cost of a Paro robot (approximately US$5000) than its possible abuses.

III. Design Process

A. Positive Design

Of the many design processes now on offer, we chose Desmet and Pohlmeyer's *positive design* [26] which departs from orthodox design approaches in its focus on three objectives: pleasure, personal significance and virtue. There is the question of how these objectives relate to the matter of supporting dementia patients. The pleasure notion is straightforward we want to provide pleasant tactile sensations and interactive experiences. There is reason to believe that quilts or aprons work better if they are personalised for patients using personal photographs or music for example. It is less clear how the third matter that of supporting personal virtue is to be applied. Desmet and Pohlmeyer meant personal virtue on the part of the product user, yet customarily, we would not make such judgments about PwD. In this application therefore, we must be content with a broader interpretation of this criterion, in which the virtue is to be found in the production of positive experiences for them by others.

[26] suggests that the design process should

- be *possibility-driven* that is, not aimed at reducing bad experience, but looking for new ways to provide subjectively excellent experiences;
- be *balanced* if not equal amounts of pleasure, personal meaning and virtue, then at least reducing conflicts between these, which are to some degree inevitable);
- should strive for a *personal fit*, which means individual or custom design is important, especially since people's goals for flourishing can be so different;
- include *active user involvement* as in user-centred design;
- make a *long term impact* on the users habits and quality of life.

How will these criteria apply to actual creation of smart fabrics for dementia sufferers? First, whatever form the process takes, known possibilities must be supported and the emergence of new possibilities must be fostered. Wherever

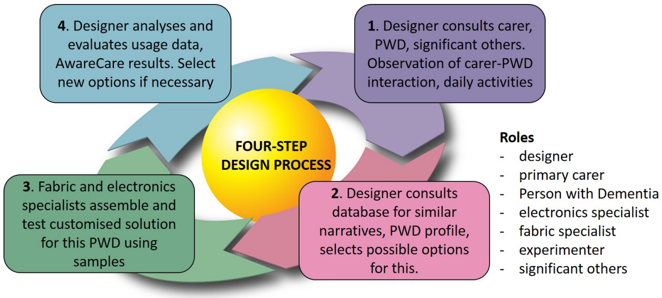

Fig. 1. The four-step design process for smart textile artefacts.

possible, the focus is not on reducing deficiencies, but on bringing out the best a person can be. Second, a one-size-fits-all solution is inappropriate here. The best results for dementia therapy comes from activities that are matched to the capability level and personality of the user [27]. A user-centred approach based on an understanding of the user's context, lifestyle, strengths, values, and goals will be the key to success. Conventional user-centred design presupposes willing and able users who are capable of active user involvement, which might not alway be suitable in this context. To the extent possible, however, it should be striven for. Note that [28] used games and puzzles as a way of eliciting active PwD participation. Third, while it must be realised that the long term impact available to an individual PwD might not be long at all, the development of technologies of this kind might yet aid the community as a whole, and help society deal with the WHO priority. Seen this way, the value of developing a craft community, or maker culture, that finds value even in modest scale innovations becomes clear.

All of this suggests a process orientation. Actively involving the user (and the carer) means that we cannot consider the apron, quilt or wearable as an end in itself. Instead, the process of creating a custom apron must become central if we take positive design seriously. The problem is thus not just how to produce a useful apron, but rather what process can allow the rapid production of a pleasurable, personally meaningful, custom version for each sufferer, the features of which accomplish a balanced mixture of good experience for the patient, and useful outcomes for the carer. Provided that the ethical concerns raised above are kept in mind, then, the virtue of any such system is in caring for the ill, and caring for their carers.

B. Four Step Design Process

It has been suggested that one of the biggest challenges in this approach is in scaling up the production of smart textiles to keep up with the expected increase in dementia patients in future [29] [7]. Workshops in which researchers, technologists and craftspersons come together to create good examples of these solutions exist, but they are neither long-lasting nor ubiquitous enough to create customised textiles in volume. It may be difficult for small groups to have sufficient coverage of the necessary skill set; typically textile craftspersons and sewing experts might have limited experience with electronics, while technologists might lack the ability to work with beautiful, comfortable fabrics. While the age of individualised mass customisation at an industrial scale of such products is on the way [30], the authors believe that for the present, small cottage industries of this type should be the seed from which a new social response to the dementia epidemic should grow. But to deal with the expected volume of of custom products, these groups will need to become much more productive, and so will need as much help as they can get. One primary goal is the rapid creation of low-cost, personalised, meaningful sensory experiences, games, memory aids, or tactile stimulations. Another is to unobtrusively collect usage data not only to help the customisation process, and perhaps also to assist in the difficult task of assessing the health status of the PwD over time, with or without interventions.

A four-step design cycle, adapted from [31] is proposed in Figure 1. It consists of

1) gathering of requirements and preferences
2) creation of alternative designs
3) assembly of a prototype
4) evaluation of the prototype in use

The process continues refining the artifact until some limit is exhausted or some evaluation criteria are met. It is a strongly user-centred process, but might require the primary carer, or significant other, to act as a proxy user, depending on the capacity of each PwD to participate. Other roles include a designer, who conducts the process, an experimenter who could be conducting a study or observation and who might analyse usage data to determine whether and how a given design option had been engaged with over time, an electronics specialist and a fabric specialist. One must be cautious not to require too many participants, though, as this could potentially drive up the cost, production time and complexity of any artifact - and speed and efficiency does matter now. One participant could take on more than one role, provided he/she had the necessary skills.

The process begins with everyone in the project, but particularly the designer, primary carer and PwD, collecting requirements which means recording daily activities, making notes on the likes and dislikes of the PwD, hearing suggestions from all parties about what might help improve their experience. The primary carer and family members might compile a short personal history, noting any hobbies, experiences and favourite activities, colours or textures that might be relevant to the design. It is important to be open to the possibility that meaningful experiences are not only those one might stereotypically associate with sick or elderly persons - they might involve unusual music collections, exotic travel adventures or dangerous sports. A list of ”must-haves, might-haves and don't-wants” should be drawn up within the basic limits imposed by the proposed size of the textile substrate concerned.

C. Library of supported options

The second step of the process requires the generation of one or more design ideas which might deliver, or preferably exceed, these requirements. This could be done on paper, but for efficiency and speed, we adopt the manufacturing principles of standardisation and modularity. The standard design of a dementia apron consists of three fabric layers (Figure 3): an input layer of standard dimensions which incorporates a matrix of switches and connection terminals; a substrate layer which covers the switches and provides mechanical support for the other layers; and a modular customisation layer, which offers a set of personal pockets at the front. A personal pocket is a standard-sized and pre-designed feature, such as a memory game, a fur patch, a music chooser, a vibration area or a video reminder. Customisation can then be as simple as arranging a set of personal pockets suited to the individual user, attached using Velcro or snap fasteners. As well as allowing easy variations on the configuration, this allows the electronic components to be easily separated for maintenance and washing of the fabric.

To further support this, we borrow an idea from the design industry. IDEO industrial designer Dennis Boyle's Tech Box [32] is a library of parts and materials as well as a database and website. It serves as an organisational memory, allowing the company to archive its experience gained from work across many projects and share it readily. Tacit technical and anecdotal knowledge about successes is captured. Physically, it is a chest of drawers holding anything from samples of fabrics to cool mechanisms to clever textile toys, each of which are tagged and numbered (Figure 2). Designers can rummage through the compartments, play with the items, and apply materials used by others in their own project. They can borrow an item to have extended experience with it. Each item is available on IDEOs Intranet through a searchable website, with an entry listing its specifications, manufacturers and prices, together with a possible story about the use of the item in previous projects. A curator runs the library, making new acquistions, maintaining entries in the database and making sure the website is up to date. A similar resource could be built up within cottage industries producing dementia products, and, if networked across convenient wikis, could provide inspiration and purchasing ideas at least, if not actual samples, for production centers anywhere in the world.

The fourth step involves assembling the prototype. This is the task of the skilled textile specialist and electronics expert, who together must realise a practical version of the chosen design alternative(s). Some examples are given in Section IV. Again, information and working samples from the sample library can provide the required techniques. The real test of discipline would come when it was time to go beyond the creation of a new option to sharing it by detailing construction plans in the library's website. Fortunately, contemporary maker culture and ubiquitous web-based practical guides both encourage and enable this kind of activity.

Fig. 2. A design options library such as IDEO's Tech Box could contain not only sample solutions for customising textiles, but also instructions for use, stories about projects and contact persons who can do the needed customisations.

D. Analysis of logged data patterns

The fifth step is about making sense of the logged data retrieved by the designer by USB connection or secure wireless link. Part of the motivation for this is the need to decide on the value of the chosen configuration for the PwD, but careful use of the retrieved data could also serve as clues to the psychological and behavioural status of the PwD. At its simplest, descriptive statistics can easily be calculated from frequency distributions of fabric key presses over time. Provided the logged data was carefully registered with respect to location and time stamped, there need be no difficulty in detecting preferential use of personal pockets using chi-squared analysis on rectangular zones of actual versus evenly-distributed patterns representing no preference. This is important because if a personal pocket fell into disuse, this would be noticed and corrective action could be taken in the next iteration of the design cycle.

Depending on the nature of the manipulation involved, the fabric switches might even record activity in tactile sensory zones which did not involve explicit key presses. It could not however, detect gaze patterns of significant images and care would need to be taken that vibratory motors did not interfere with the results. Sufficient usage of the pockets could be taken as a sign that a good solution had been reached, but this should always be corroborated with a carer's observations, and subject to revision from time to time. Then too, simple button-and-light games (see Section IV) can be made to double as measures of motor deficits or reflex deficiency, such as Simple Reaction Time and the Finger Tapping Test [33], provided the task can be made clear to users.

E. Detecting User Presence

Since it is generally most convenient to power the electronic components of smart fabrics using small rechargeable batteries, there is value in being able to have the device remain in a low-power mode until it is actually in use. Detecting the user's presence can be done in several ways. A simple fabric switch or button would serve, but a design in which the system does not require the user to actively input to the device would more closely fulfill the requirement of an unobtrusive, low-attention design suitable for inexperienced users and users with

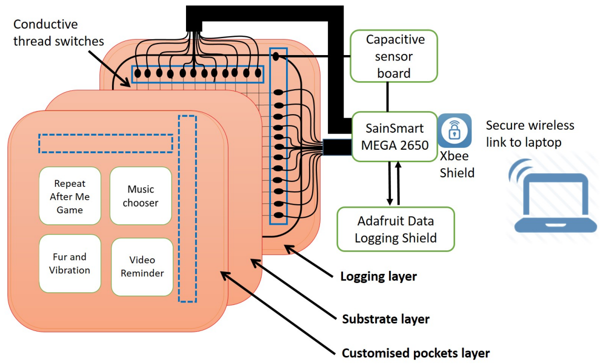

Fig. 3. Basic three layer structure of a smart apron. The rear layer supports a matrix of switches for logging inputs. The middle layer provides mechanical support for a layer to which a personally customised set of pockets is attached. A matrix of tiny coin vibratory motors can also be added to this layer, if desired. The layers are carefully aligned so that the logging switches can be used as inputs for those pockets that need it.

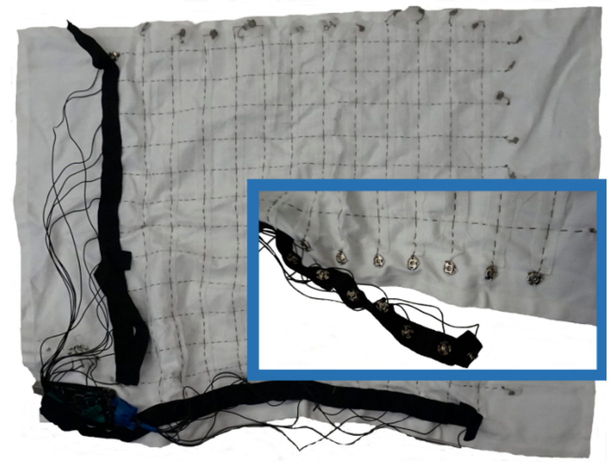

Fig. 4. Logging layer of dementia apron. Insert shows conductive thread attached by metal snap fasteners to the SainSmart MEGA 2560 board.

reduced cognitive function. After some experimentation, the author's chosen solution was a capacitive sensing circuit. The apron itself has an intrinsic capacitance that remains constant regardless of whether the apron is flat, folded or rolled in to a ball. The apron must be connected between two pins on a microprocessor along with a high value resistor. It works by setting a pin to a specific state, either high or low, then waiting for that change to be detected at the other pin. The R-C network sets the time it takes for the state change to appear at the second pin, which alters significantly in the presence of human body [34].

The matter of power consumption is important because changing batteries is a nuisance for carers, and so should be kept to a minimum. Since the apron would likely stand idle for long periods, its circuits should reduce their consumption at those times to extend battery life. With the ATmega2560 microprocessor, on which the SainSmart MEGA 2560 board is based, a presence signal from the capacitative sensor can be made to continually reset a timer while the user is present. If not, the timer expires and the chip switches into a low-power mode from which it can be woken by a fresh signal. This only powers down the microprocessor, however; other circuits remain active. If battery changing becomes a problem on account of too many independently-powered circuits on the apron, it might be necessary to reticulate power wires under the pockets layer from a low voltage DC power supply. These would need to be able to be easily and quickly disconnected.

IV. Design Options for Customised Dementia Aprons

This section presents some examples of personal pockets that might be put into the samples library. We have not yet implemented all of these, but all are practical, inexpensive and able to be adapted or extended easily.

A. Memory Game

Even if mental exercise games are of no value for detection or recovery from cognitive decline (far from an established fact), it might still be decided to include one as an option if the user thought it would be fun. As discussed in Section III, the game should be suited to the user's capabilities and personality; in most cases, it should not involve complex touch screen interactions or fast reflexes. It could be as simple and cheap as a Mintronics Memory Game [35]. That game begins by flashing one LED and playing a tone; the player responds by pushing the button that corresponds to that LED to repeat the flash and tone. Then the game adds a second LED and tone to the sequence, and the player responds with the appropriate sequence of buttons. The game continues adding more LEDs and tones until the player makes an error. The game will then light an LED representing the score: LED 1 for Beginner, 2 for Amateur, 3 for Expert, or 4 for Champion. A maximum sequence of 32 light/tones is available - enough to challenge even unaffected individuals. Progression of scores over time could be logged by transferring data from the Arduino-based Mintronics board to the logger on the input layer if desired, or simply observed from the LEDs from time to time.

Many other possibilities exist, of course. A pocket could contain any of a number of small, cheap and self-contained electronic game units, such as a commercial Pocket Simon. As with the other options, the choice would come down to what was was available from the sample library, and what was meaningful and fun for the PwD.

B. Simplified Music Selection

A review and meta-analysis of 20 studies of music intervention for PwD concluded that it had a moderate effect on anxiety (increasing in studies over 3 months duration) and modest effects on behavioural symptoms of agitation, apathy, elation, and irritability [36]; it concluded that music is effective for managing the behavioural and psychological symptoms of dementia. While group singing and personalised attention from a music therapist is ideal, it would not be available long term in every case. We therefore should consider how

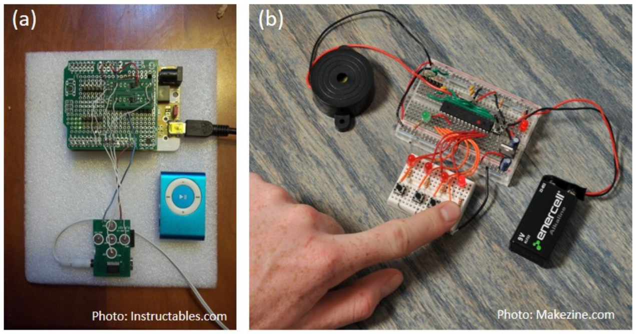

Fig. 5. a) Hacked MP3 player is controlled from an Arduino board used to simplify the interface. (b) Prototype of the Mintronics memory game.

personalised music choices could be enjoyed via the interface that a dementia apron represents.

Many music delivery systems, such as tiny iPod-like MP3 players, are now postage stamp sized and very inexpensive, yet unsuited to this application because their control interfaces are both too small and too difficult for PwD to manipulate. However, using a simple Instructables hack [37], it is possible to control the Prev, Next, Play/Pause and Volume Up and Down control switches of the player with an Arduino board. This enables the interface to be brought out to an array of fabric switches in the pocket (Figure 5a). Each switch is marked with an bold fabric icon or stitch pattern that clearly distinguishes the choice from a set of personally significant songs stored on the device. The sketch running on the Arduino monitors the fabric swiches for closure, and then issues the correct switch presses to find and play that song. The volume controls can also be available via fabric switches, or simply preset to a comfortable level at installation.

Another problem is that of supplying sound to the ears, since most portable MP3 players depend on earphones, which can difficult to manage in high care situations. It is not difficult to add a small amplifier, but speakers can be a problem on textile artifacts: either too bulky and heavy to be stitched onto a flat apron, or else the sound quality of light, flat units is poor. Revealing how innovative the smart fabric craft community has become, another Instructables project offers an answer [38]. With careful stitching, it is possible to sew a tight spiral of conductive thread onto the surface of the fabric. When an audio signal passes through this, fluctuations in the magnetic field around the coil can cause it to vibrate if a small neodymium magnet is suitably placed. Some experimentation is need to produce good sound, and the magnet should be carefully constrained so that it cannot be lost or interfere with other components. The fabric speaker is light, flat and need not be removed for washing.

C. Video Reminder Pocket

One option that might be made available is some way of delivering videos on a time schedule in order to remind patients to take their medicine, attend an appointment or watch a television show. This idea is not new; prior experiments with this have concluded that such systems can be feasible [39] [40] and effective at delivering reminding messages [41]. To save costs and keep things simple for carers, we use obsolete smart phones in a pocket with a transparent plastic window (Figure 6). The idea is not to have the PwD use a smartphone. Rather, it is to use the smartphone as a way to deliver short reminder videos, made by carers or meaningful persons, as timely prompts. An app such as Video Remind or My Video Schedule can play once-off or daily video messages in this window. To make the experience of being reminded a pleasant and personally meaningful one, it is best to have the reminders recorded by members of the user's family, or by their carer. One of the advantages of using a smart phone for this purpose is that it makes recording these messages as simple as using the video function on the device. Other kinds of messages, patterns or music could also be made to appear as part of the sensory stimulation regimen.

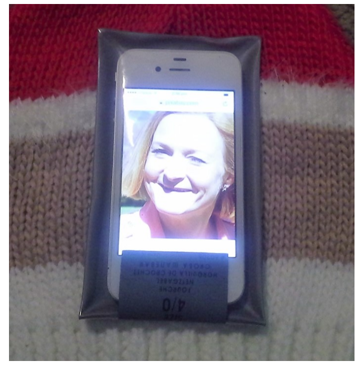

Fig. 6. Video reminder app on an old phone in a plastic pocket offers simple, low-cost support for forgetfulness. The user should not need to manipulate the delivery hardware in any way. Messages can easily be recorded, updated and scheduled by a carer or other significant person.

V. Conclusion

Although the problems that stem from the coming onslaught of dementia cases are many and there are still many questions to be answered about the best ways to adapt the health system to deal with it, there seems to a modest role for comforting fabric artifacts enhanced by electronic technologies designed to support, engage and entertain PwD. Local cottage industries which now support the creation of textile crafts should be empowered to scale up to meet the growing need. If the use of our four-step process can be proven to work well in planned experiments at a local scale, it should be possible to further support the activities of volunteers, or find ways of funding part-time employees. Better than that, these craft workshops could use the same library computer that supports their samples library to network with other such workshops, anywhere in the world. Descriptive narratives, design notes, and images of successful products could be shared with anyone on the network, thus providing more options for everyone that had their own samples library. This in turn could generate a market for products and services of this kind, rising in response to the increasing demand for them.

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