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15 Active Confluence: A Proposal to Integrate Social and Health Support with Technological Tools

Abstract: Ageing demographic structures produce higher rates of physical and cognitive impairments, lack of independence, and social isolation of old people. This poses challenges to general and mental health care. In this chapter, we present a framework for seamlessly integrated, web-based digital systems to enhance active ageing and independent living by unobtrusively monitoring older people's health signs and providing feedback both to them and to important nodes in their social support network.

Keywords: Active Ageing, Confluence, Interaction, Sensing, Symbiosis

15.1 Introduction

The demographic structure of most of the industrialised world and emerging economies, including Europe, North America, and much of Asia, is in an irreversible process of ageing (UN Population Division, 2005). European societies, together with Japan, face particularly marked ageing. As a consequence, they also face growing problems associated with old age, such as cognitive decline, motor impairments and lack of independence (Beard, Biggs, Bloom, et al., 2011). These problems carry additional burdens for families with shrinking younger cohorts and rising financial costs for societies as a whole. Digital technology is currently addressing these impacts of ageing by assisting daily living. Another characteristic of an elderly or impaired population is isolation. Digital media is in some ways fighting back isolation. Best use of digital technology and media requires, however, sufficient technological literacy, and too often technology is not adapted to users' needs. We adopt the view that technology needs to reach the person by being designed to adapt to people's natural behaviours and routines, instead of having people deal with the intricacies of technology. In this chapter, we discuss a conceptual framework advocating personalised services for independent living and active ageing. Our perspective is that digital systems can be unobtrusively incorporated into the daily life activities of communities, e.g. the elderly population, in a seamless, low-cost, immersive way, and we are not alone in this perspective (ICAA, 2014). Smartphones, remote sensors, biofeedback, virtual reality, and intelligent systems can be integrated in a single all-inclusive platform that connects the elderly with their social support networks, providing personalised information and feedback to nodes (people) in the network and acting in a symbiotic fashion. Beyond the practical advantage such a system offers, seamless integration of individuals, technologies, and the social network should be able to reproduce an

embodied perception of social belongingness typical of communal groups such as families, thereby making usage intuitive, pleasant, and emotionally rewarding.

15.1.1 An Ageing Society

Europe enjoyed a steady growth in GDP from 1820 to the end of the XXth Century (Gordon, 2002), and an unprecedented rise in standard of living after World War II. However, this growth has slackened since the 1970s, and unemployment has increased (Blanchard, 2005). At the same time, lower fertility rates, driven by social changes, contraception, and the expansion of female participation in the workforce, have slowed demographic growth and contributed to ageing. Although the population of Europe is still growing, the demographic distribution has been changing, with contractions in the youngest cohorts and expansions in the eldest. The number of Europeans aged 65–79 years old increased from c. 60 to 65 million between 2001 and 2011, and that of 80 years or older from less than 17 to almost 25 million in the same period (Pordata, 2013). This new demographic reality, along with the current financial and economic constraints, has sparked policy debates on health care across the EU. At present, most EU countries are unable, unwilling, or discouraged from sustaining their past levels of investment in their national healthcare systems. There is thus a demand for novel, cost-effective solutions that are still able to provide better and broader responses, but at a lower cost.

15.1.2 Ageing and General and Mental Health

Ageing is a process inherent in every living organism; it is an irreversible biological state, with a progressive decrease in functional ability. One of the main reasons for the increased costs in health and personal care of older populations is the escalation of physical diseases coupled with mental disorders, which implies increased impairments in both physical and cognitive capacities and, thus, a decrease in the autonomy and general quality of life among the elderly.

Depression is the most common mental condition in older people and has been increasing in prevalence in developed countries. Its prevalence also increases with age, with an estimated value of 11% to 13% among the elderly of developed countries (Steffens, Fisher, Langa, Potter and Plassman, 2009). Depression is related to a number of health conditions – such as cardiovascular and cerebrovascular diseases – through its influences on health behaviours and exposure to stress; extreme and prolonged episodes of depression can even lead to death.

The main symptoms of depression are a depressed mood, apathy and hopelessness, which are often chronic among the elderly. Depression is related to deregulation of prefrontal circuits of the brain, resulting in cognitive deficits and executive

dysfunction (Willner, Scheel-Krüger, & Belzung, 2012). Cognitive deficits are also common in older people with depression, being often associated with poor prognosis and decreased response to treatment (Alexopoulos, Meyers, Young, et al., 2000).

Suicide is also a problem related to the elderly, and suicide rates have been increasing (WHO, 2012). People over 65 years have the highest rates of suicide, reaching 20/100.000 in people older than 85 in the U.S., (Hawton & van Heeringen, 2009) and 148/100.000 for men above 85 in France (Ritchie et al., 2004). Older people have difficulties in coping with the effects of chronic pain (which becomes more frequent with ageing), medications and the consequences of organic diseases, which may contribute to increased incidence of depression in the elderly and eventually on suicide rates.

Declining health and cognitive capacity associated with ageing are currently the focus of much research. Epidemiological studies have shown that prevalence of organic dementias, including Alzheimer's, increases with age, from 5% of people aged 71–79 years to 37.4% for people over 90 years (Plassman et al., 2007). In Europe, a recent meta-analysis of studies carried out during the 1990s suggests that prevalence rates double every 5 years for people aged above 65 years-old. This poses a challenge to older people's ability to live independent and happy lives.

15.1.3 Social Support and General and Mental Health

Humans are an incredibly social species, and extremely sensitive to being included in groups, attached to close others, and cared for. Social support therefore has both direct and indirect effects in tackling disease and impairment. On the one hand, social support can be of direct help in solving practical problems. On the other hand, it enhances individual patients' psychological resilience by tackling loneliness and preventing depression.

However, the potential social support that people receive from others varies immensely according to the social relations that they have with those others. Despite the incredible expansion of online social networks such as Facebook, people still rely mostly on the inner circle of their offline social networks – namely family and close friends – for social support. Indeed, family and close friends provide a completely different kind of psychological (emotional, affective) support from that which can be provided by the broader society, by colleagues and acquaintances, or even by professional caregivers.

This is because these different social relations are guided to varying extents by each of the fundamental cognitive, social-relational models that humans use to produce and sustain sociality: communal sharing, authority ranking, equality matching, and market pricing (Fiske, 1992). Family and close friends are strongly guided by a communal sharing model of relation, in contrast to professional relations or even most friendships (Brito, Waldzus, Sekerdej, & Schubert, 2011). The communal sharing

model is defined by closeness, attachment, affection, kindness, and caring for others in the relation, in particular according to their needs (Haslam & Fiske, 1999). This means that it has the double benefit, for the sake of social support, of at the same time being oriented to the satisfaction of actual needs, and of providing emotional support, thus buffering the elderly against psychological stressors that facilitate mental health problems. Conversely, the lack of significant social relationships is the most important trigger for feelings of loneliness in the elderly and, ultimately, depression.

Indeed, the available evidence points not only to the important role of family and close friends in providing social support to the elderly, but also to their direct effect on general and mental health outcomes of those who are supported. For example, a large US study found an important effect of informal support from non-spouse family/friends on lowering depression, and that States supporting Home and Community-Based Services (which substitute informal networks) experienced lower depression rates among seniors with functional declines and low informal support (Muramastu, Yin, & Hedeker, 2010). Recent research in a poor neighbourhood in Brazil also indicated that social support (in mostly unmarried older women) is negatively correlated with depression (Lino, Portela, Camacho, Atie, & Lima, 2013). And, in Canada, another large study (n>1300) found a negative effect of social support on stress, mediated by a sense of self-mastery (Gadalla, 2009).

15.1.4 Ageing and Social Support

Unfortunately, as people get older, they experience an increased likelihood of losing social support and suffering personal loss at the same time through mortality in their network of family (including spouses) and friends. These are ubiquitous events that lead to social isolation and functional problems in older people. The elderly tend to create new friendships, if at all, with people from the same age cohort (Singh & Misra, 2009). But, with advancing age, the opportunity for these new friendships decreases. Other social factors, such as financial difficulty, may also contribute to personal and social dysfunction (Mojtabai and Olfson, 2004).

These problems are compounded by the current demographic dynamics of ageing populations, which are related to smaller family sizes and, thus, to smaller family networks. Greater demographic mobility of the general population also spells greater demographic dispersal of these networks, which means they are spread rather thinly on the ground. Together with the problems that the elderly face in their own mobility, this requires technological support to sustain communication and relational closeness over social support networks.

15.2 Active Confluence: A Case for Usage

To counter the general and mental health problems associated with ageing, as well as social problems associated with an aged demographic structure, policies designed to enhance active ageing have been gaining critical importance across Europe, and are actively supported by the European Commission. Self-managed or home-based exercises and activity programs are a centrepiece of those policies; adherence to and compliance with these programs have been identified as a key factor in the improvement of functional outcomes (Deutscher et al. 2009). In the past few years, technology has been gaining importance in the domain of active ageing, and technological solutions have been suggested and used to promote these outcomes, improving an individual's adherence to self-exercise programmes, and enabling them to engage in simulated activities. However, the gap between the individual and the technology is still too large; technology is still a dark passenger that must be moved from place to place. In order to bridge the gap between users (especially older ones) and technology, symbiotic solutions must be provided.

Until now, technological solutions for monitoring and caregiving have been developed almost exclusively for clinical settings, namely hospitals and other healthcare-oriented facilities, and even there, the results are far from optimal (Olson & Windish, 2010; Uphold, 2012). This means that these solutions require the physical presence and engagement of caregivers. Features such as user-friendliness, ubiquity, and mobility are usually neglected because support is always around. On the other hand, the interaction between user and exercise platform is a mediated one. Pencil, paper, a joystick or a keyboard create a gulf between the individual and the exercise, making the experience far from natural. Considering the need for remote/home solutions for individuals' interaction and monitoring, the criterion of achieving confluent solutions must quickly become a priority in the development of active programs that are concomitantly pervasive and non-intrusive in the elderly's daily lives.

We argue that the way individuals interact within the applications must be similar to the way they interact with the real world. This means that both software and hardware need to be integrated in a seamless fashion so that they can be perceived as a natural complement of individuals' actions, rather than yet another difficult system for individuals to deal with, and this is available in some areas (Sik Lanyi, Brown, Standen, Lewis, & Butkute, 2012). The system also needs to display solutions that are compatible with an individual's physical or psychological status. Seamless devices should feed the system with data so that the status of the user can be inferred and the most appropriate exercise displayed. Thus, the system needs also to be permanently accessible, anytime and anywhere. For this to be possible, it must use off-the-shelf displays and interactive platforms such as tablets, smartphone and TV and mobile sensors, and run over the Internet. Finally, the system should be an integral part of an individual's social world, extending and enhancing the individual's capacity to manage his or her health and daily life.

Here, we describe the most salient aspects of a concept for an integrated technological solution designed to address the needs of active ageing and the shortcomings of current remote/health monitoring systems, based on the symbiotic paradigms of Human-Computer Confluence (HCC) (Viaud-Delmon, Gaggioli, Ferscha, & Dunne, 2012). These paradigms include new forms of improving perception and interaction, on the one hand, and sensing and monitoring, on the other. Our proposal brings these two aspects together and reinforces them with the connection of the system to the social support network of individuals using the solution.

15.2.1 Perception and Interaction

Virtual reality (VR) is probably the best solution for cognitive training to enhance natural perception and interaction. VR provides "close-to-real" experience, allowing users to interact and move around at their will and at their own pace, providing a full and natural perception of the tasks at hand. It can thus be integrated in an engaging and appealing way, much like a realistic game, into users' daily activity.

The 3D perspective enables users a better apprehension of the phenomena under simulation. This is because visual perception processing in the brain relies on different areas in the cortex that are specialized in different aspects of visual information. For example, colour, form and depth are processed in the V1 and V2 occipital areas and motion in the middle temporal cortex. Complete cognitive integration of a real-life four-dimensional phenomena (three spatial – 3D – and one temporal dimension) summons up different areas of the brain. Consequently, cognitive load is distributed. Therefore, the load on cognitive processing can be reduced if the task at hand is performed within a set-up that is perceived as being as close to reality as possible. Gramb, Schweizer & Mühlhausen, (2008) reported higher mental demand and higher perceived workload in a group of participants engaged in a 2D task (controlling a thermohydraulic process of producing particle boards) than in another group engaged in the same task but with a 3D interface.

Once immersed in the virtual world, older people can train and accomplish all the proposed tasks in a similar manner to how they would in the real world. VR has already been applied as a reality surrogate for motor and cognitive exercise purposes. VR settings can be tailored to users' needs (Lange et al., 2012; Ortiz-Calan et al., 2013; Tost et al., 2009), can provide feedback (Sveistrup, 2004), and because they are similar to games (in fact, this type of platform is often associated with Serious Games), they motivate the user in engaging the tasks, facilitating the repetition of the exercises (motivation and repetition are two quintessential requirements for exercise adherence). VR has also been used in combination with Internet wideband in order to provide and support training, as the wideband technology provides mobile and remote application of the 3D virtual environments for tele-rehabilitation (Wang, Kreutzer, Bjärnemoa, & Davies, 2004; Kurillo, Koritnik, Bajd & Bajcsy, 2011).

15.2.2 Sensing

A baseline component of the system we conceive should be a smart, adaptive monitoring system, which aims at assisting the elderly, on a daily basis, in achieving an active life-style and reducing their reliance on the assistance of others. Such a system could help by providing pervasive exercises, meeting the challenging goal of at the same time increasing quality of life and keeping costs low. While implementing the monitoring system, a parallel goal should focus on the integration of the monitoring system within the realm of existing commercial systems (e.g., MediServe[19]) and solutions (e.g., UTS Blood Pressure Monitor Palm OS Software[20]). Existing medical electronic solutions should be employed for acquiring the user's vital signals and converting them into digital data, which could be stored in the monitoring system's local database. The system would be able to display bio-signals' waveforms in real-time, store data locally, or trigger an alert. The system would then transfer these physiological data to a remote workstation in real time (remote monitoring) using an advanced wireless networking platform with ubiquitous access to the database.

Monitoring should be mostly performed by portable devices, wearable devices, smart objects, or devices that are commonly available to the user and that can be accessible anytime and anywhere (i.e. are pervasive) . With a collaborative arrangement of these devices, the system would monitor various metrics related to behaviour and to bodily and brain functions (e.g., activity, sleep, physiological and biochemical parameters). The signals to be collected would include: heart rate, blood pressure, skin temperature, galvanic skin response, and movement (body movement, kinematics, posture, etc.). The GPS data from the smartphone could be used to infer individuals' behaviour. The use of sensors integrated in clothing or weight sensors (integrated in beds) could measure the quality of rest and restlessness during sleep.

The touchstone of the framework would be to provide monitoring and support of older people's active living in a symbiotic fashion. The use of vital signs as data sources would be based on wearable or home-based sensorial devices to gather, process and feed the system with data. The system would become aware of an individual's status through the recognition of vital signs and display the best exercise and care solutions to respond to that status. The services to be provided by such a system would be based on off-the-shelf and-low budget solutions that can be acquired and used by the general public. Devices to be used by the system would consist of an ordinary tablet, smartphone or TV set, with a plugged motion detector (for example, XBOX, Wii or other equivalent product available on the market) and internet connection, which would display an interactive portal where the elderly could work out and

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19 http://www.mediserve.com/ (accessed 28.10.2013)
20 http://www.qweas.com/downloads/home/other/overview-uts-blood-pressure-for-palm-os.html (accessed 28.10.2013)

interact with others. The exercises to help maintain or reinforce active standards of living would be displayed in a virtual reality world so that the users could freely interact with it. 3D games designed to boost cognitive functioning and to promote physical exercises would be available with different levels of difficulty, customized to each user's ability and needs. One important path to be explored consists of developing intelligent systems to act/react according to a user's needs and condition through psychophysiological monitoring.

Usually, the interaction with VR applications is measured by clinically oriented self-reports. Nevertheless, during VR exercises several researchers have also recorded patients/participants psychophysiological activity (e.g. heart rate, skin conductance resistance [SCR] and respiratory activity). The individual status level could, hence, be inferred through the sensing system such as this, but also through tracking previous individual activity. For example, for monitoring the statistics for patients, calculator software of varying complexity is available. Calculators tend to be focused on either practitioner use (MediKit[21]), or patient use (e.g., Glucose tracker[22], Blood Pressure tracker[23]), but some of them offer combined functionality. Evidence-based calculators also exist, especially for mobile phones or PDAs (InfoRetriever[24]), providing a good tool for feeding the system with data.

15.2.3 Physical and Cognitive Multiplayer Exercises

A multiplayer feature is probably the *sine qua non* condition to motivate older people to keep coming back to the system. The social characteristics of the system would be of paramount importance to the reinforcement of the feelings of social support (Gaggioli, Gorini, & Riva, 2007; Lange, Koenig, Chang, McConnell, Suma, Bolas, & Rizzo, 2012; Maier, Ballester, Duarte, Duff, & Verschure, 2014), in particular by peers of their age group, family members, or close friends involved in the system. In this system, the elderly would interact with a TV set or a tablet using only their gestures; the system would respond based on this input and on the input from data collected by sensors and actuators that are incorporated on daily use devises such as smartphones or digital wrist watches. All the technology to meet this purpose is available on the market and is able to "communicate" with each other in a seamless way, allowing for a symbiotic relation between the system and the individual.

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21 http://www.medikit.co.jp/english/ (accessed 28.10.2013)
22 http://download.cnet.com/Free-Glucose-Tracker/3000-2129_4-10454535.html
 (accessed 28.10.2013)
23 http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/HighBloodPressureToolsResources/Blood-Pressure-Trackers_UCM_303465_Article.jsp (accessed 28.10.2013)
24 https://library.mcmaster.ca/news/2484 (accessed 28.10.2013)

15.2.4 Integrated Solutions for Active Ageing: The Vision

What we propose here is a framework for integrated solutions for elderly people who wish to maintain a healthy standard of living, as well as for those whose health is compromised by physical disease or mental disorder or impairment. It is widely accepted that the best way to maintain illness at bay is to exercise both body and mind. Our vision is to offer a comprehensive set of exercises for the elderly to work out and to stimulate their cognitive functions and physical activity, which may serve to either help maintain a healthy status or, for those suffering from disease, slow the progress of disease. Additionally, the selection of exercises would be managed by an automated caregiver function displays alerts on compliance to medication schedules and AI (artificial intelligence) avatars would be devised to answer older people's questions on health issues on demand.

Along with prevention and care facilities, such a system should be designed to promote older people's independence. The proposed platform should thus also nest functions enabling the user to carry out a myriad of real-life activities within the system (e.g. shopping, movies, interacting with friends, focus-groups and volunteering). Such a platform would be presented in the form of a synthetic online world, a TV-based or tablet-based portal gathering the most up-to-date ICT (Information and Communication Technology) services. Internet, multiplayer functions, VR environment, telemedicine, interacting with the system through motion detection, and adjusting the system to an individual's status in a symbiotic fashion would be the central properties of the system. And, because life must not revolve around the disease, an integrated solution for daily life activities such as shopping, socialization and doing "good deeds" should also be included. This platform will enable users to shop online, to get together, to stroll with their friends' avatars in virtual parks, and to engage in online volunteer sites. At this point one should remember that reactive depression is, among the elderly, a common associated condition, which in most of the cases prompted by loneliness reduces the efficacy of treatments (Figure 15.1).

To imagine the possibilities, read our Mrs. Simon and Mrs Garfunkel scenario:

> "Mrs. Simon has just come back from the hospital where she underwent an elbow surgery and spent the subsequent month in rehab. Sitting down on her sofa, she turns on her TV. A rehab app shows up as an alternative to her usual 300-channels choice. Accessing the portal by speaking out her password, a welcome message from her doctor is displayed: "Hi Paula. Everything is going along smoothly. But now you need to attend to your medication – please take a look at the list displayed on the upper right-hand corner of the screen. I know it is a long list. No worries. An alert will be sent to your mobile 5 minutes before you have to take each medicine. And remember, the drugs are not the only thing you need to take! Remember that this app has some juicy menus adapted to your condition for you». After this message, a BOT (digital robot) appears: «Hi Mrs. Simon. How are you today? Ready for some nice elbow exercises?» As the synthetic personal trainer (PT) begins the exercise, the motion sensor attached to the TV is activated and starts detecting Mrs. Simon's movements, reproducing them on the screen. Her wrist device begins to
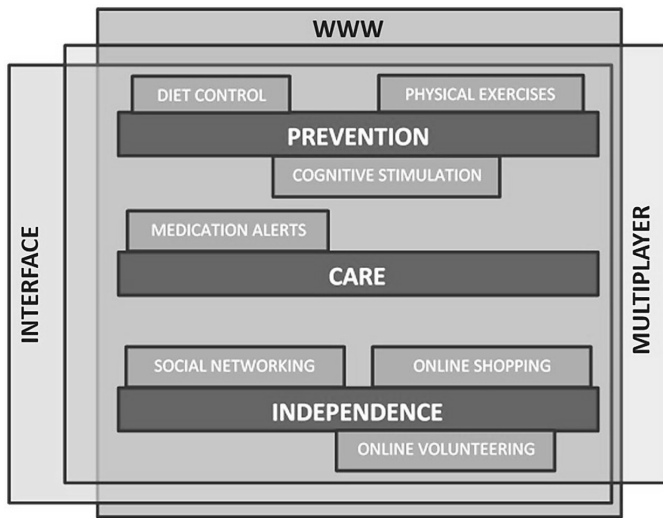
Figure 15.1: The vision: An ICT online platform for preventing and retarding elderly diseases and for promoting older people's autonomy

feed the system with biosignals. As Mrs. Simon is a newbie, the BOT corrects her movements, encouraging and motivating her throughout the exercise, while adapting the exercises to Paula's condition. When the exercises are about to end, a message from Mrs. Simon's friend, Mrs. Garfunkel, pops on the screen: "Hi Paula, can I join you?" Using the voice detector she replies: "Hi, Arthurina. How are you doing? I'm about to finish my exercises. Do you care to join me tomorrow, a bit earlier? Or, how about going shopping together right now? I need to buy something for my nephew's birthday. I've learned that the HippsterMegaStore now has an interactive VR site, where we can shop online». «I'm sorry but I'm not feeling like shopping» – Mrs. Garfunkel replies – «I think that I will log on to Volunteers'R us site and give a hand in raising some funds to the victims of the earthquake in Ramonetii. Bye, now. I'll join you tomorrow for training. By the way, can we change our PT's appearance? I don't particularly like his hair...»"

15.3 Conclusion

As ageing has become an important concern for the European Union and national governments, it has pushed them to design policies to minimize its on society. The importance of active and healthy ageing in Europe is increasing, and this is expressed in the research and development calls of the Framework Program 7 of the EU and even more so in Horizon 2020, its successor programme.

A brief description of active ageing is provided by the WHO (2002), highlighting the importance of promoting physical activity as a way to increase the functional independence of the elderly in daily living activities. The roadmaps of the latest framework programmes for research and innovation in the EU have been focusing

on the use of ICT solutions for successful ageing in our societies. However, most of the current technological solutions are based solely on old-fashioned exercises that do not address the social-emotional dimension of ageing. Nor do they address the problem of adherence to technological solutions that are, more often than not, perceived as "difficult".

Thus, future developments are crucial to a fully operative and integrative solution for monitoring and intervention among the elderly population that meets, at the same time, the principles of an active confluence solution concomitant with pervasiveness, unobtrusiveness, and a socially-friendly approach.

These principles can be met with a service-oriented platform, connecting the elderly, their families, and practitioners, using state-of-the art technology, thus offering innovative and unobtrusive forms of monitoring and exercising.

Closed-loops based on wearable sensors, caregivers' collaboration and decisions, and elderly interaction could produce autonomous support, enabling a first interaction. There would be multiple benefits for the elderly, who would feel supported by the local loop and become more self-confident and autonomous. Another effect is that the elderly would not need to visit practitioners so often, as feedback can be sent by their local sensorial and processing devices. This would be reflected in reduced costs, and enhanced safety and quality of life.

In short, there is a clear need for the provision of both cost-effective tools for active ageing, disease prevention and retardation, and for independent living services at the point of need to provide the elderly with innovative activities and continuous support, and for an ICT interface that melds these tools with a more global lifestyle management system for independent living. Therefore, pervasive and confluent-solution exercises will improve older people's quality of life while assisting in reducing the cost of the process. New ICT-based exercises hold the promise of improving the quality of existing care services, enlarging the scope of exercises and prevention services on offer (e.g. adverse events detection), and providing these services to a broader segment of the population than that which is presently reached. However, there are significant challenges that need to be faced, including older people's adherence to the program. We believe that the most important obstacle to overcome relates to the difficulty of interaction with the available technology. Our concept is a convergent solution that will co-exist symbiotically with the individual.

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