Cognitive Modeling in Human Computer Interaction for Aging: Prior Experience and Perception of Technology – A Pilot Study

J. Antony William[1] and Dr. Ramaswami Murugesh[2]

***Abstract*—** There has been substantial increase in the human population throughout the world. As we age, problems associated with aging is increasing rapidly – medical, biological, psychological, economic, social etc. India is the second largest populated country and one the fast growing developing countries in the world. The advancement of technology and technology-enabled services are proliferating rapidly forgetting the aging population. This paper discusses an experiment investigating the prior experience and perception of technology and technology enabled services in the larger context of designing cognitive model in human-computer interaction for aging. We surveyed and interviewed 25 samples aged between 60-75 years of age, living in Bangalore. The implication of the results are discussed in this paper. We have chosen the Bangalore city for our study because it is known as the Silicon Valley of India which attracts people from across India and abroad due to job opportunities and economic growth. It is the third most populous city and 5th most populous urban area in the country. The current population of Bangalore is estimated to 11.5 crore and the literacy rate is 89%.

***Keywords*—**aging, cognitive model, cognitive aging, human-computer interaction, prior experience, smart technology, technology adoption, perception.

I. Introduction

POPULATION aging has become the most significant social transformation of the 21st century, it has far reaching economic, social and political implications. Population aging is the most significant emerging demographic phenomenon in the world today. The 20th century has witnessed the increased proportion of aging population in all countries. It is going to increase further, owing to the fact that the improvement in life expectancy across the world, particularly public health and medical advancements. By 2050, the elderly population of Asia over 60 years will double by the mid-century reaching to 1.3 billion. At the same time share of aged in total population of the world is increasing due to declining birth rate. In economically developed countries, the aging process began a century ago and currently it is emerging in many developing countries as well. Population aging has become the most significant social transformation of the 21st century, it has far reaching economic, social and political implications.

The 2001 census of India has shown that the elderly population in India accounted for 77 million and the number will rise to nearly 140 million by 2021. Based on the world population projections by United Nations, Department of Economic and Social Affairs Population Division 2015, Indian population can be divided into three major age-groups i.e. 0-14, 15-64, and 65 above as shown in the fig. 1. If we look at the graph, it is very clear that the 0-14 year age-group is declining. Age-groups 15-64 and 65 above have progressive increase and still expected to rise rapidly. The size and composition of age distribution of total population in India has been significantly changing over a period of time. In this context, an important fact which needs to greater attention is that in the developing countries like India, older persons are increasingly living independently and this is going to increase as population continues to age.

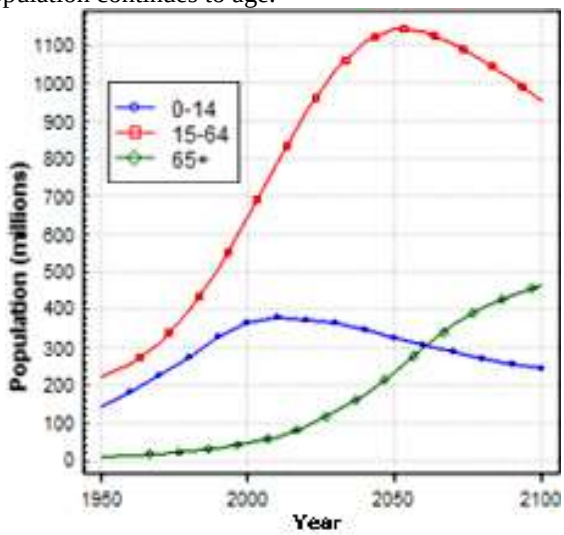

Fig. 1 Total population by broad age group in India

As the society is progressively moving towards digital, there is an increasing risk of excluding elderly people. Among those at risk of digital exclusion are many older people and other differently abled people for whom the technology is difficult to access. Many older people are having difficulties in using modern smart devices due to increased complexity in accessing information both in terms of functionality and interface design. Factors associated with ageing population is essential for to ensure progress in development and sustainability. This pilot study was primarily carried out to understand prior experience and perception of technology in

[1]Senior Instructor, National Institute of Design, Research and Development Campus, Bangalore

[2]Associate Professor, Department of Computer Application, Madurai Kamaraj University, Madurai, India

the larger context of designing cognitive model in human-computer interaction for aging. This study will enhance the further research which will be carried out in the second phase of our research study.

II. Cognitive Modelling

The past research has proven that cognitive models are essential for understanding human learning, problem solving, decision making and supervisory control (Michael G. Shafto). Good cognitive models are essential to describe people's response to different circumstances and understand limitations and ways to overcome. An important question in the cognitive science field is that internal representation cognitive models. The big challenge of human mind is that cognitive process cannot be directly observed and these need to be measured indirectly through their impact on explicit behaviour such as task performance. There are many sources and types of constrains used in cognitive modelling. Constrains are drawn in the following disciplines psychology, neuroscience and computer science. Apart from these there are two new related fields that provide softer constrains are evolutionary psychology and environmental psychology and both are important to understand our brain now. In order to develop human oriented human computer interfaces one needs to have a deep understanding of the structure and representational dynamics of the cognitive system which interacts with the computer. Therefore it is necessary to investigate different methods of representation involved in interaction process between computers and human cognitive systems.

III. Human Computer Interaction (HCI)

The introduction and advancement of technology has had a great impact on the information storage, accessibility and utilization. HCI clearly indicates that it involves the design, implementation and evaluation of interactive system in the context of user performance as a single user or group of users. As we are stepping towards the second decade of the new millennium the challenges facing smart computing and interaction design continue to evolve. Technical capabilities improved significantly and penetration of smart devices also proliferated remarkably. So the big challenge here is the creation of digital ecosystems (Miller et al. 2010). Today every product has embedded intelligent system and it is very much concerned with the user experience and all of the factors contribute to their successful creation. In the context of increasing elderly population adopting technology, it is essential to study academically the cognitive issues and to support them by application of intuitive and natural interaction.

IV. Research Methodology

Quantitative pilot study was based on a series of written questions conducted within this pilot study with a select sample of respondents over 60 years of age using smart phone and living in Bangalore. The survey and interview questions were focused on prior experience perception of technology in terms of activities related to technology acceptance, usage of health monitoring device, usage of digital products and services, familiarities and awareness with control buttons of entertainment system, familiarities and awareness with control buttons of smart phone, familiarities and awareness with control buttons of Windows application and commonly used mobile apps. The number of participants were 25 including 2 females and the language used was English. We had approached all participants in their residence with prior appointment and the survey was carried out individually face to face followed by a semi-structured interviews to investigate the effects of prior knowledge and technology perception in elderly people. All the participants were healthy aged 60-75 years old. The majority of the participants were lived with their spouse and some alone with broad span of socioeconomic status.

V. Results of the Pilot Study

The results of the pilot study and discussion are centered on technology acceptance, usage of health monitoring devices, usage of digital products and services, familiarity and awareness with control buttons of entertainment system, familiarity and awareness with control buttons of smart phone, familiarity and awareness with control buttons of Windows application and commonly used mobile apps. Microsoft's Excel application was used for data analysis and charts generation

A. Technology Acceptance

As expected the results strongly suggest that 100% of the participants accept technology as good and 96% of the participants are open to new technologies. As the world is progressively moving towards digital, the elderly do not want to exclude themselves. Everyone want to keep up with the time and learn new knowledge. They accept that they have to progress and learn to use technology and this becomes need of the hour. This has been depicted in the fig.2.

The reason given by elderly people for saying technology is good are "it improves life if used properly, helpful for day-to-day activities, to be part of change, when judiciously used, very good, younger use bad things, all the technology has brought us easy accessibility, learn lot of things, always good - should not have choice, enhance better quality of life, it helps so many new things every day, the world is going fast with technology and we can learn everything, improves your knowledge and takes you to the current technology, all feature is one service, to update present trend, good for new generation, it makes life easier and simpler, common man benefited by technology, it simplifies everything, it speeds up the process and when used properly".

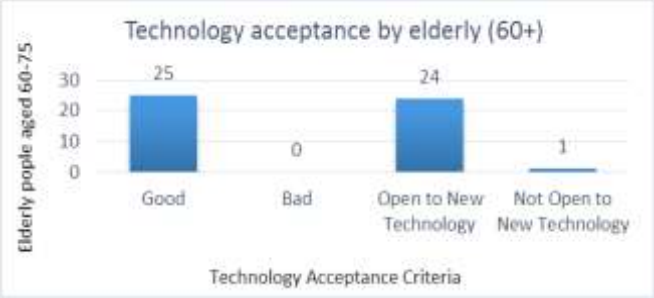

Fig. 2 A chart representing technology acceptance by elderly people

B. *Usage of Health Monitoring Devices*

During the natural process of growing older, they are prone to experience physical and cognitive impairments. As older people are living longer, health monitoring devices play an important role in their lives to monitor health. Here, we wanted to know that how many older people use health monitoring devices and we have looked at the common devices like BP monitor, Glucose monitor and Thermometer. The survey showed 48% of older people use Thermometer, 32% of them use Glucose monitor and 24% of them use BP monitor as shown the fig.3. This clearly indicates the acceptance of digital health monitoring system by the elderly people to improve their quality of life.

Fig. 3 Shows the usage of health monitoring devices by the elderly people

C. *Usage of Digital Products and Services*

Usage of digital technology and services survey result shows that elderly people actively use digital products and services/applications. The fig.4 illustrates that 84% of the older people use and familiar with TV & video player remote, 72% use and familiar with google search engine, 60% use and familiar with internet browser, 48% use and familiar with software application (MS word) and YouTube, 40% use and familiar with printer and digital camera and 28% use and familiar with tablet. Other than the TV & Video player remote usage a significant number of users use online services to learn new knowledge and to support their daily activities. The elderly people very well understand the smart features of the device and the uses of it and thus motivating to use when required.

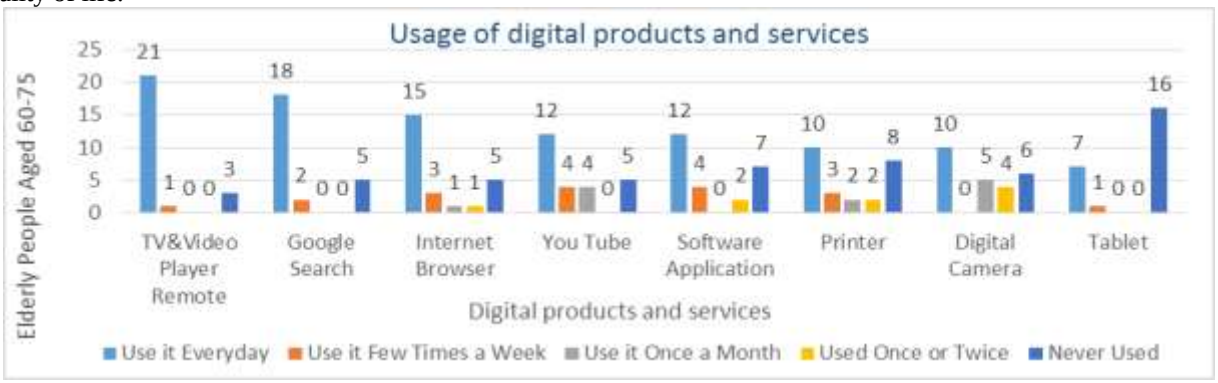

Fig. 4 The chart shows usage of digital products and services

D. *Familiarity and Awareness with Control Buttons of Entertainment System*

The electronic industry is providing variety of products and services. For elderly it is a big challenge to engage themselves in different activities during the day. Spending time with home entertainment systems, like TV and home theatre systems are very prominent today. In this context a survey was conducted to know how the elderly are familiar and aware with control buttons of TV/Music Player/ DTH Remote. The fig. 5 shows that 100% channel and volume buttons, 88% mute button, 76% TV and play buttons, 72% rewind button, 68% power button, 64% fast forward and rewind buttons, 52% home button, 44% favourite, return and navigation buttons, 36% stop button, 32% open/close and source buttons, 25% info button and 12% refresh button. The survey on familiarity and awareness with control buttons of TV/Music Player/DTH remote control indicates that 100% of elderly users are engaged with TV and significant number of users use and familiar with music player and DTH system.

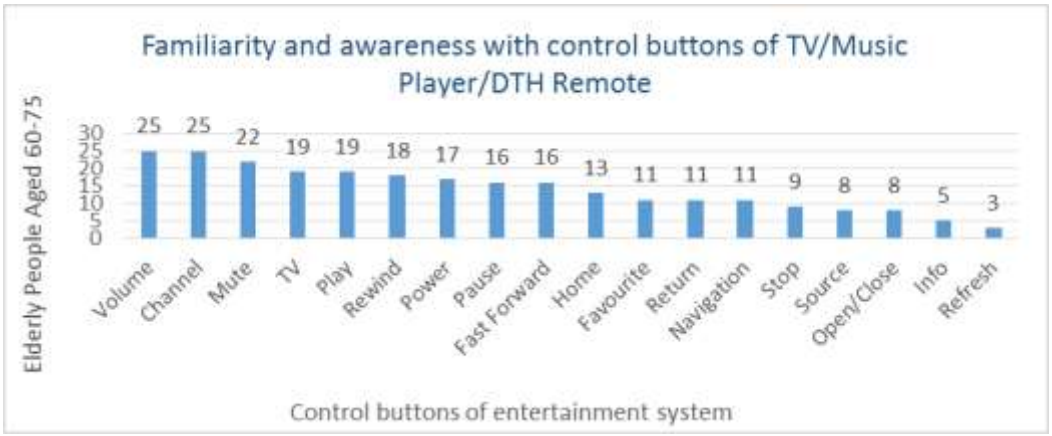

Fig. 5 The chart shows familiarity and awareness with control buttons of TV/Music Player/DTH Remote

E. Familiarities and Awareness with Control Buttons of Smart Phone

Today's trend in society is that increasing capabilities of smaller device and most importantly the convergence of computing capabilities on to the mobile devices. Keeping this trend in mind a survey was conducted to understand familiarity and awareness with control buttons of smart mobile phone. The fig. 6 shows that 100% sound button, 84% network, Wi-Fi, lock and alarm clock buttons, 76% battery, airplane mode and recycle bin buttons, 64% group and Bluetooth buttons, 56% setting button, 53% attachment button, 44% location, home, storage, contacts and function menu buttons, 40% SIM1 and android buttons, 32% auto synch, mobile network, close and do not disturb buttons, 28% keypad lock, add contact and add control buttons, 24% favourite button, 20% more option button and 12% accessibility buttons. The survey on familiarity and awareness with control buttons of mart phone indicates that the significant number of elderly users are familiar and aware of computing technologies and the control buttons of various applications.

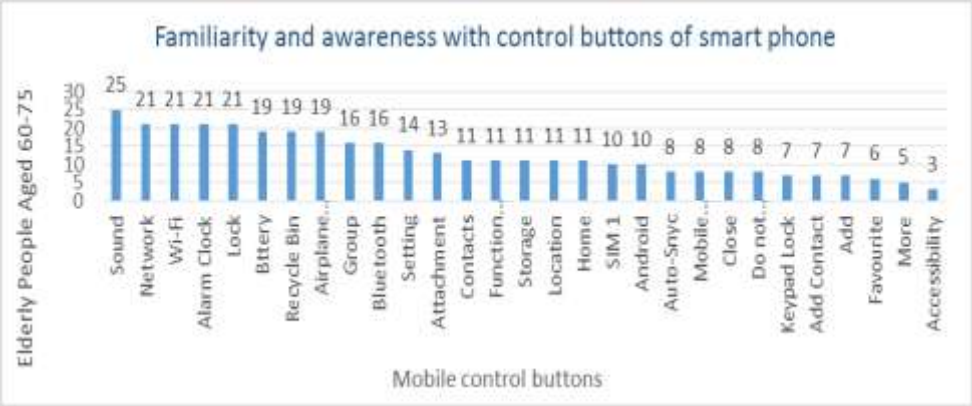

Fig. 6 The chart shows familiarity and awareness with control buttons of smart phone

F. Familiarities and Awareness with Control Buttons of Windows Application

The growth of personal computers in the business sector has paved the way for development of software application. Microsoft Office applications have replaced large paper spreadsheets and contributed to productivity in modern work environments. Keeping this in mind, a survey was conducted to understand the familiarity and awareness with control buttons of windows office applications. The fig. 7 shows that 64% word, undo and redo buttons, 56% spell check button, 52% search and attachment buttons, 44% folder button and 40% save, new file and printer buttons. The survey result on familiarity and awareness with control buttons of windows office application shows that the elderly users have knowledge of working and managing documents.

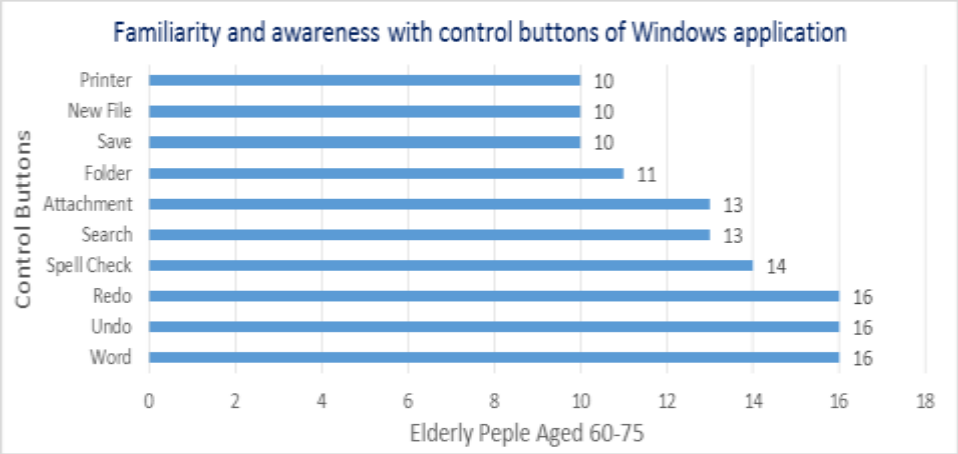

Fig. 7 The chart shows familiarity and awareness with control buttons of Windows Application

G. *Commonly Used Mobile Apps*

A mobile app is a software designed to run on mobile device, like smartphones or tablets. Most devices have pre-installed software. Apps are available through distribution stores called app store. Due to the demand and availability of the developer tools made rapid expansion into every single requirement. The usage of mobile apps is remarkably increasing among mobile users.

A diverse smartphone interactive applications intended to assist elderly in daily life situations and fulfil their needs for information, communication and entertainment. Mobile phone is no longer just a communication tool rather it has become an essential part of people's daily life. In this context, we studied the commonly used mobile apps by the elderly people. The fig. 8 shows that 100% use smart phone and Facebook, 96% use contacts, 92% use messaging, 84% use camera, calculator and WhatsApp, 72% use email and calculator, 64% use google, 60% use music, maps and YouTube, 48% use flash light, 40% use skype, 36% use weather, 32% use sound recording, 28% use FM radio, 24% use twitter and Flipkart, 20% use play music, do it later, voice search and play games. The survey result on commonly used mobile apps by the elderly indicates that they are very much engaged larger part of social network and in one device they are able to fulfil many of their needs.

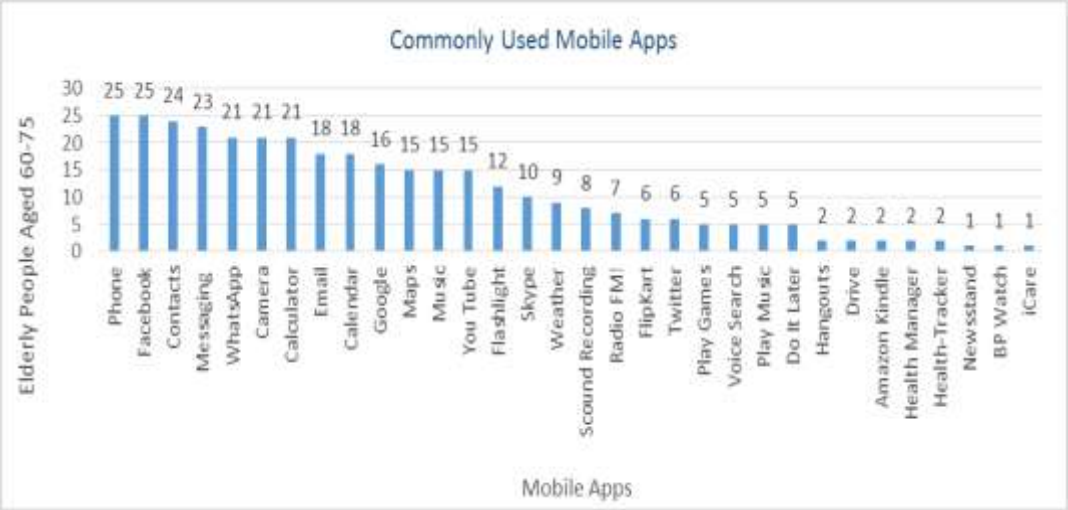

Fig. 8 The chart shows commonly used mobile apps

VI. Conclusion

Elderly people participated in the survey and interview indicated that they are exposed to a wide variety of technology including computers, communications, entertainment, safety and health monitoring devices. In-home health monitoring technology is also being increasingly used. Elderly see the technology as an enabling factor to remain connected to family and friends, especially with those who are distant and expand their social network. We strongly feel that positive attitude towards technology is growing among elderly people. Remarkably, the positive attitudes were typically associated with the technology supported activities, increased suitableness and contained useful applications. In fact, negative attitudes were mostly related to accessibility and usability issues and for non-technically oriented person incomprehensible instructions and guides. Also, some physical limitations in terms of screen size, small icons/symbols were limiting them for the technology usage. The survey and interview results shown in this study emphasize that older people are not scared and hesitant to use technology. They understand the value of new technology and show willingness

to adopt, if it makes their daily life and tasks easier with security. As we age, technology has a great potential for improving quality of life for elderly people. The limitation of our research study was sample size. We were able to conduct only 25 surveys and interviews because our aim was to target elderly people using only smart phone.

Further research has planned to investigate the cognitive abilities in different age groups and to design a cognitive model for aging in order to improve the health, safety and quality of life of older people. A set of simple to complex tasks will be designed for mobile smart phone and will be tested with different age groups using eye tracking application with EEG. The eye tracking metrics may follow visual attention, arousal, gaze points, fixation and areas of interest. Similarly, the EEG metrics may follow attention engagement, distraction, cognitive workload and emotional response.

ACKNOWLEDGMENT

The authors are grateful to Madurai Kamaraj University, National Institute of Design, and elderly who participated in the research for their support.

REFERENCES

[1] Central Statistics Office, Situation Analysis Of The Elderly In India, Ministry of Statistics & Programme Implementation, Government of India, June 2011.

[2] Misha Pavel, Holly Jimison, Tamara Hayes and Jeffrey Kaye, Technology in Support of Successful Aging, The Bridge – Linking engineering and society, vol. 39, no. 1, pp. 5-12, Spring 2009.

[3] Sara J. Czaja and Joseph Sharit, The Aging of the Population: Opportunities and Challenges for Human Factors Engineering, The Bridge Linking Engineering and Society, vol. 39, no. 1, pp 34-40, Spring 2009.

[4] Elsevier B.V., Moving towards inclusive design guidelines for socially and ethically aware HCI, Interacting with Computers, vol. 17, no. 5, pp. 4485-505, September 2005.

[5] Daniel Fallman, The Interaction Design Research Triangle of Design Practice: Design Studies and Design Exploration, Design Issues, Vol. 24, No. 3, pp. 4-18, Summer 2008. https://doi.org/10.1162/desi.2008.24.3.4

[6] Inmaculada Plazaa, Lourdes Martína, Sergio Martinb, and Carlos Medranoa, Mobile Applications in an Aging Society: Status and Trends, Journal of Systems and Software, vol. 84, 2011, pp. 1977–1988. https://doi.org/10.1016/j.jss.2011.05.035

[7] Tracy L. Mitzner, Julie B. Boron, Cara Bailey Fausset, Anne E. Adams, Neil Charness, Sara J. Czaja, Katinka Dijkstra, Arthur D. Fisk, Wendy A. Rogers and Joseph Sharit, Older Adults Talk Technology: Technology Usage and Attitudes, Computers in Human Behavior, vol. 26, issue 6, 2010, pp. 1710–1721. https://doi.org/10.1016/j.chb.2010.06.020

[8] G. Demiris, B. K. Hensel, Technologies for an Aging Society-A Systematic Review of Smart Home Applications, 2008, pp. 33-40.

[9] Sara J. Czaja, The Impact of Aging on Access to Technology, Accessibility and Computing, ACM Publication, no. 83, 2005, pp. 7-11.

[10] Birren, J. E., & Fisher, L. M., Aging and Speed of Behaviour: Possible Consequences for Psychological Functioning, Annual Review of Psychology, 46, 1995, pp. 329-353. https://doi.org/10.1146/annurev.ps.46.020195.001553

[11] Chris Stray and Mark F. Peschl, Representation Still Matters: cognitive science and user interface design, Behaviour and Information Technology, vol. 17, no. 6, 1998, pp 338-360. https://doi.org/10.1080/014492998119292

[12] Baltes, P.B., and Lindenberger, U., Emergence of a Powerful Connection Between Sensory and Cognitive Functions Across the Adult Life Span: A New Window to the Study of Cognitive Ageing, Psychology and Ageing, 12, 1997, pp. 12-21. https://doi.org/10.1037/0882-7974.12.1.12

[13] Cerella, J., Information processing rates in the elderly, Psychological bull., 98, 1985, pp. 67-83. https://doi.org/10.1037/0033-2909.98.1.67

[14] Samir Chatterjee, Alan Price, Meng, "Healthy Living with Persuasive Technologies: Framework, Issues, and Challenges", Journal of the American Medical Informatics Association, vol 16, no 2, 2009. https://doi.org/10.1197/jamia.M2859

[15] Andrew Sears and Julie A . Jacko, Human-Computer Interaction: Design Issues, Solutions, and Applications; CRC Press, 2009. https://doi.org/10.1201/9781420088861

[16] Constantine Stephanidis, The Universal Access Handbook (Human Factors and Ergonomics); CRC Press, 2009.

[17] Margaret W. Matlin – Cognition; Seventh Edition; John Wiley & Sons, Inc., 2009.

[18] Scot M. Hofer and Duane F. Alwin, Handbook of Cognitive Aging: Interdisciplinary Perspectives; Sage Publications, 2008.

[19] Riddle DR, Brain Aging: Models, Methods and Mechanisms, CRC Press, 2007. https://doi.org/10.1201/9781420005523

[20] Matt Jones and Gary Marsden, Mobile Interaction Design, John Wiley & Sons, 2006.

[21] Eshaa M. Alkhalifa, Cognitively Informed System: Utilizing Practical Approaches to Enrich Information Presentation and Transfer; Idea Group Publishing, 2006. https://doi.org/10.4018/978-1-59140-842-0

[22] Karl H. E. Kroemer, "Extra-Ordinary Ergonomics: How to Accommodate Small and Big Persons, The Disabled and Elderly, Expectant Mothers", CRC Press, 2006.

[23] Chown Eric, "Cognitive Modeling", Computing Science Handbook, CRC Press, 2004.

[24] Colette Nicolle and Julio Abascal, Inclusive Design Guidelines for HCI, CRC Press, 2001.

[25] David E. Rumelhart, James L. McClelland and PDF Research Group, Parallel Distributed Processing Volume 1: Explorations in the Microstructure of Cognition, The MIT Press, 1986.

[26] Edward J. Szewczak, Selected Readings on the Human Side of the Information; Information Science Reference (an imprint of IGI Global), 2009. https://doi.org/10.4018/978-1-60566-088-2

[27] Andrew Ortony, Gerald L. Clore and Allan Collins, The Cognitive Structure of Emotions, Reprint Edition, Cambridge University Press, 1990.

[28] Joaquim A Gorge, Adaptive Tools for Elderly New Devices to Cope with Age-Inducted Cognitive Disabilities, 1999.

[29] United Nations, Department of Economic and Social Affairs, "World Population Ageing 2015", 2015.

[30] Simon Roberts, The Fictions, Facts and Future of Older People and Technology, Intel Corporation, ILC-UK, 2009.

[31] Eric Dishman. "Catalyzing Social Interaction with Ubiquitous Computing", Extended abstracts of the 2004 conference on Human Factors and Computing Systems, 2004.

[32] Farah Arab, Yasir Malik and Bessam Abdulrazak, "Evaluation of Phon Age: An Adapted Smartphone Interface for Elderly People", Interact 2013, Lecture Notes in Computer Science, pp 547-554, 2013. https://doi.org/10.1007/978-3-642-40498-6_44

[33] Margaret Morris, Jay Lundell and Eric Dishman, "Catalysing Social Interaction with Ubiquitous Computing: A Needs Assessment of Elders Coping with Cognitive Decline", CHI, Late Breaking Results Paper, 2014.

[34] Alma Leora Culén and Tone Bratteteig, "Touch-Screens and Elderly users: A Perfect Match?", ACHI 2013: The Sixth International Conference on Advances in Computer-Human Interactions, 2013.

[35] Rudolf Kruse, Christian Borgelt, Detlef D. Nauck, Nees Jan van Eck and Matthias Steinbrecher, "The Role of Soft Computing in Intelligent Data Analysis", invited paper".

[36] Tobii Technology, "Tobii Eye Tracking: An Introduction to Eye Tracking and Tobii Eye Trackers", white paper, 2010.