Chapter 11
Robot Programming and Tangible Interfaces for Cognitive Training

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ABSTRACT
This chapter presents the conceptual framework, the research rationale and preliminary outcomes of an innovative research agenda that explores the use of tangible interface and robot programming tasks as a method for providing cognitive training to patients with memory dysfunctions. The main argument of this approach is that when programming tasks and relevant tangible systems are used for cognitive training they activate and practice users’ logical-analytical and visuospatial skills, which may have beneficial impact on patients’ cognitive performance in daily activities. The chapter also presents preliminary outcomes from a pilot study where eleven patients suffering from mild cognitive impairment participated in a robot programming training session using the PROTEAS prototype tangible interface. Results (both qualitative and quantitative) revealed a significant negative correlation between patients’ “Task Completion Time” (TCT) and mental condition (as measured by MMSE index), indicating that TCT provides a measure directly related to patients’ cognitive capacity for analysis and planning.

INTRODUCTION
Research has already focused on the possible benefits from using tangible interfaces to trigger users’ specific cognitive processes and train respective skills (e.g. Sharlin et al., 2004). In the context of the ASPAD project (“Augmentation of the Support of Patients suffering from Alzheimer’s Disease and their caregivers”) we started explore the impact of employing tangible interfaces and
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robot programming tasks as a method for cognitive training (Demetriadis, Giannouli, Sapounidis & Tsolaki, 2013). This research effort lies at the crossroad of important scientific domains ranging from clinical neuropsychology to technology-enhanced learning. In this chapter, we first review major research conclusions relevant to the key knowledge domains that are important in our approach, in order to step-by-step synthesize the rationale of our research perspective. These domains include: cognitive training and assessment, programming as a cognitive activity, educational robotics and tangible user interfaces. Second, we present and discuss some preliminary research results emerging from training sessions where patients with MCI (‘Mild Cognitive Impairment’) were engaged in robot programming tasks using the PROTEAS system, a tangible programming technology that we have developed originally for children introductory programming activities. Finally, we close by commenting on future research efforts and perspectives that this approach advances.

BACKGROUND

Dementia and Cognitive Training

Memory dysfunctions (neurocognitive disorders) constitute a highly interesting research field both for cognitive psychology and for clinical neuropsychology (Lezak, 2004; Ravdin & Katzen, 2012). Cognitive impairment (or dementia) is considered as a general loss of cognitive ability, in formerly healthy individuals, beyond what is expected to be normal due only to aging factors. Dementia is not simply related to memory problems – ability of retention and/or recall of episodic memory -, but it also reduces the patients’ learning and language ability, while there are also problems with reasoning ability and affection perception and regulation in daily activities. These cognitive and behavioral problems have an impact on the quality of life of patients suffering from dementia and, also on the life of their caregivers. Dementia evolves and steadily deteriorates in a time span of several years, causing a progressive change in brain neurons, but mainly causing a non-reversible damage in the functioning of these neuron cells. In aging population (individuals older than 65 years old) the majority of dementia is caused by Alzheimer’s disease, vascular dementia or both.

Alzheimer’s disease (AD) is the most common instance of neurocognitive disorder. Although there is not currently any effective treatment for the disease (which gradually worsens and finally leads to death), during the last years several research programs have proposed various pharmaceutical and non-pharmaceutical treatments, in order to delay the disease progress and keep patients’ situation at the same level. The disease was first described and was named after German psychiatrist Alois Alzheimer in 1906. Most of the time, AD is diagnosed in individuals older than 65 years of age, although the (less widespread) early onset AD might appear much earlier. In 2006 there were 26.6 million patients in the world, and according to Alzheimer’s Disease International today 44 million patients suffer from dementia, while AD is expected to affect 75.6 million people by 2030 and 135.5 million by 2050 (see http://www.alz.co.uk/). The causes and way of evolvement of AD are not completely understood until now. Research provides evidence that the disease is caused by amyloid plaques and neurofibrillary tangles in the brain (Tiraboschi et al., 2004). Current treatment seems to help only with disease symptoms but still there are no treatments available to stop or reverse the disease progress. Of course, patients’ engagement with cognitive training exercises, physical exercise and a balanced diet have been proposed as a means to delay mental problems in healthy aged people, but there are no convincing and reliable evidence until today to document a statistically significant effect (Tsolaki & Kazis, 2005, NIH 2006 report).