

# Multidisciplinary Teamwork in the Design of DailyCog for Evaluating Mild Cognitive Impairment (MCI) in Parkinson's Disease \*

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**Abstract**—This study describes the development of DailyCog: an accessible, practical smartphone application for the detection of mild cognitive impairment in Parkinson's disease. Cognitive impairment in Parkinson's has been capturing researchers interest lately, as it may occur at early stages of the disease, and has a substantial impact on quality of life. In order to find the best markers of the initial stage of the cognitive decline we developed DailyCog - a smartphone application for the detection of mild cognitive impairment. This work focuses on the design considerations while working in a multidisciplinary team, building a common understanding, and bringing together knowledge from Occupational Therapy, Neurology and Computer Science to build an application for evaluating Mild Cognitive Impairment (MCI) in Parkinson's Disease.

**Index Terms**—Mild Cognitive Impairment, Parkinson's Disease, e-health, mobile healthcare

## I. INTRODUCTION

Parkinson's disease (PD) is the second most common progressive neurodegenerative disorder, affecting about 1% of the elderly population and its multifaceted motor and non-motor afflictions have profound effects on patient functioning and quality of life [1]. Among the non-motor symptoms of the disease, both cognitive impairment (CI) and dementia and their implications for the patient's quality of life have been increasing recognition [1]. Studies show that the onset of PD-specific pathology in the nervous system may precede the first appearance of classical motor features by several years. CI in PD patients without dementia may occur at early stages and is present in 25% of newly diagnosed patients [2]. Understanding the point in time of the CI emergence may be essential for the early detection of incident PD, as it may have a great effect on the individual's daily function abilities and thus, patients' emotional social-behavioral status [3]. In cases when MCI develops before the motor symptoms, that is before diagnosis of PD, it may provide a tool for early detection of incident PD.

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However, questions concerning features and definition of MCI, its diagnosis, prevalence and implications among PD patients remain unanswered due to its clinical and pathophysiological complexity [2]–[4]. In 2012, the Movement Disorder Society published new diagnostic criteria guidelines for mild cognitive impairment (MCI) in PD (PD-MCI) [4]. Yet, how to practically apply these guidelines remains unclear. Our clinical experience, including several patient and caregiver interviews, demonstrates that in fact, cognitive decline that influences the individual's daily function may appear a long time before he or his family notices it or feels it is worthwhile to act upon. The focus of this study is on day to day activity performance characteristics as a source of knowledge about the individual's cognitive control ability. To this end a multidisciplinary team from Occupational Therapy, Neurology and Computer Science joined together to design DailyCog.

DailyCog is a smartphone application for capturing and reporting this important information, and enabling home healthcare. Smartphones enable healthcare in the pocket and are becoming an increasingly important platform for the delivery of health interventions [5]. While smartphones have been used to collect data for the study of PD, they focus mainly on the motor skill manifestations of the disease, [6]. However, to the best of our knowledge, no systematic evaluation, nor electronic solution has been developed for the detection/evaluation of PD-MCI using cognitive functional measures. Our application focuses on the cognitive aspects of PD-MCI, while offering a platform for performing and measuring real life functions. Special attention to the question of technology acceptance, adaptability and accessibility among the older population was addressed in the current study, based on previous literature [7] and our teams clinical and experimental experience. DailyCog will enable early intervention to improve the quality of life, prevent secondary socioemotional complications, enable monitoring of cognitive deterioration and transformation to PD dementia, and monitor the response to therapeutic interventions.

## II. METHODS: DAILYCOG DEVELOPMENT

DailyCog is a smartphone application, composed of three 'real world' performance tasks, drink preparation, bag packing and shopping list preparation. In each task the individual is asked to perform a sequence of activities required for completing the task. Tasks are carried out at preset intervals (3 months) between each task. All tasks require similar cognitive abilities in order to accomplish them. This design will enable an analysis of possible cognitive decline along time.

The most important design consideration was that the elderly PD-MCI population usage should be straightforward. Text needs to be large, buttons need to be comfortable to use etc. Another consideration was that the tasks be performed in the home environment and mimic everyday real life tasks. We need scientifically valid measures that are easily obtained, but are also easy to analyze. Most importantly, we wanted measures that had a high chance of being good MCI markers. Design must also consider complexity of tasks and analysis, for example: A task may be complex to analyze, with some answers being *preferred* to others, while others are *right* or *wrong*. However, the measures derived, must have clear criteria, leaving no ambiguity in analysis. Results from DailyCog will be compared to standard measures such as the diagnostic criteria guidelines for mild cognitive impairment (MCI) in PD (PD-MCI) [4].

## III. RESULTS: DAILYCOG APPLICATION

DailyCog is a smartphone application, composed of 3 separate tasks. Participants are required to perform the tasks in their home environment at 3 month intervals. Both the input inserted by the user during performance and other hidden measures i.e. elapsed time are recorded during performance. As an example, we briefly describe one of the tasks and some of its measures. DailyCog accompanies the participant in planning and preparing a hot drink, alongside self report of performance. An example of a screen-shot of this task is shown in Figure 1a. This *ordering* task displays a question "What is the order of actions that you take to prepare a hot drink? (remember that you can drag and scroll items)". The stages displayed are: "Put coffee/tea in cup"," add milk/mint/nothing", "take a cup and spoon out from cupboard". On the bottom there is an "OK" button. Another part of the task is shown in Figure 1b, asking: "How long do you estimate that the task took?", time is in minutes, and again an OK button appears. Time, scrolling etc. are all recorded.

In order to enable ease of use we included the *reading* feature. By pressing on the microphone icon (on the top of the screens) the user can have the text on a screen read out loud. This should help participants that have trouble reading instructions. Use of this feature is recorded as a measure.

The complexity of extracting measures for analysis is demonstrated in the *ordering* task in Figure 1a. Consider the various answers: Putting in water before milk may be *preferred* to other answers, in contrast: pouring water before placing the cup is *wrong*. We defined a 0-1 criteria by deciding which orderings are acceptable and which are not.

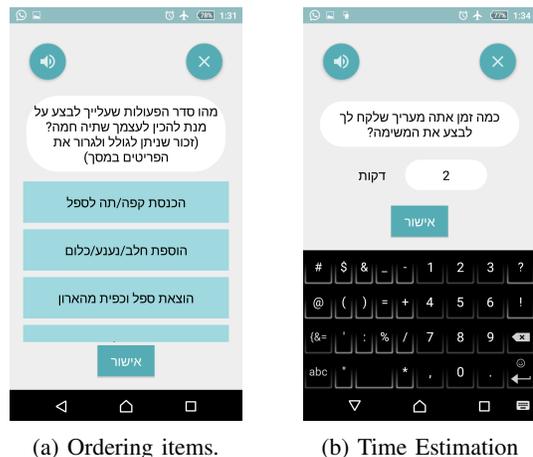


Fig. 1: Examples of DailyCog. See translation in Section III

## IV. DISCUSSION AND FUTURE WORK

MCI is often an early symptom of PD and although it may have a substantial impact on quality of life, it is often overlooked and undetected. To this end we developed DailyCog, a smartphone app, as a tool for finding the best markers of the initial stage of MCI in PD. We were led by the concept that markers are hidden in performing everyday tasks. Therefore, performing tasks at home, noting the time and the way the task is performed, etc. may supply insight into the subjects abilities in real life.

The design considerations we discussed are the result of much multidisciplinary discussion, where occupational therapists, medical teams and information system developers learn to understand each other's terminology and expertise. This ongoing work, includes an experiment with MCI-PD patients. Future work will describe the application in detail, report on the performance of DailyCog, and which of the markers proved most interesting.

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