Exploring the Touch and Motion Features in Game-Based Cognitive Assessments

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1 INTRODUCTION

Common causes of cognitive deficits include stroke, dementia, traumatic brain injury, alcohol and drugs as well as less common causes such as developmental disorders. Often older people with mild cognitive impairment are at higher risk of progressing to more severe cognitive impairment (e.g. dementia) that interfere significantly with individuals' daily life [3]. Early detection of subtle signs of cognitive decline provides a greater opportunity for timely intervention. Similarly, athletes with exposure to accumulative traumatic brain injuries in sports, e.g. boxing, football and rugby require regular monitoring of cognitive changes to determine whether they can safely resume their participation in the game. Hence, there is the underlying need for cognitive measures that allow frequent repetitive testing and self-administration. Despite of being used in clinical practice, the current paper-based approach is not feasible for frequent repetitive measurement owing to the lack of multiple variations of the tests and the ability to self-administer.

To overcome these limitations, computerized assessments have been investigated in a number of studies, arguing the capacity to generate random stimuli and capture highly accurate in task measures of performance as key advantages. However, the potential lack of motivation to carry out boring and repetitive tasks could discourage users from taking frequent assessments as needed to monitor their condition continuously [1]. By contrast, fun elements in game-based assessment can better promote participant engagement and may potentially reduce test anxiety [2].

In this work, we specifically aim to explore if gestural interaction and device-motion parameters coupled with gameplay data can potentially be used to infer cognitive abilities. We also hypothesized that game mechanisms can influence gestural characteristics. Hence, a set of popular and highly engaging mobile games with different game mechanics and cognitive demands (Tetris, Fruit Ninja and Candy Crush Saga) were employed in our study.

2 METHODOLOGY

In order to explore the relationship between gameplay and cognitive assessment, we instrumented a number of popular mobile games, with appropriate scripts to capture touch gestures, and device movement during gameplay. Our aim was to explore potential correlations between the way players interact with the mobile game, and their cognitive abilities as captured through formal cognitive assessment instruments.

Twenty-two healthy participants between the ages of 18-34 years took part in our study. A broad set of cognitive domains were first measured with a series of standard cognitive tests including Addenbrooke's Cognitive Examination (ACE-III), Trail Making Test (TMT) and The Stroop Color and Word Test, followed by a gaming session. The participating individuals exposed a range of cognitive abilities as measured through the cognitive tests. Participants were instructed to play the games while being seated on a chair without armrest. They were also advised to hold the device with one hand and play the game with another hand. Only one finger was allowed to touch the screen at a time. Apart from gameplay activities, information about a user's touch interaction and device motion were passively through built-in sensors including accelerometer and gyroscope.

Figure 1: A screenshot displaying the body positioning, finger placement and hand grasp participants were advised to use during touchscreen interaction while playing the games.

3 FEATURES

The user study produced a dataset consisting of a stream of touch events and gestures that each participant performed during gameplay. We analysed the raw data to extract meaningful features that were then used to identify potential correlations with the participants' cognitive abilities. Due to differences in game mechanics, participants had a tendency to perform distinct touch gesture patterns in each game. Therefore, different subsets of features were chosen from an initial set of touch-based features. For example, in Tetris, as upward swipes have no function in the game, all features in the upward direction were excluded. Similarly, each game has its own gameplay and rules which is very much distinct from each other. Hence, different sets of gameplay features were extracted. With respect to device movement, the same set of device motion features were extracted across all games. Features were compared with ground truth on the cognitive abilities of participants, captured through the standard cognitive tests.

4 FINDINGS

The results from bivariate analysis reveal the presence of correlations between our proposed features and scores obtained from paper-based cognitive assessments. In particular, swipe speed and swipe length have been found to be significantly correlated with cognitive performance in visual search, mental flexibility and response inhibition. These findings show promising potential in using such features for game-based cognitive assessments.

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