Designing a Game for Upper Extremity Motor Function Assessment Using Anki Cozmo, a Desktop Social Robot

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Introduction: Rural areas and third world countries are facing a shortage of rehabilitation workers and as the population demographics shift towards the older generation, this imbalance will be more stressed. The utilization of robots as assessment and/or diagnostic tools has been employed to lessen the consequences of this shortage. And although the use of robots in upper extremity motor function assessment is promising, the robots being used currently tend not to be low cost or commercially available, and they require rehabilitation knowledge[1]. This makes the robotic devices in question somewhat ineffective in alleviating the issue in the rural and remote areas. The Rehab Robotics Lab at the University of Pennsylvania is exploring how to utilize low-cost desktop social robots, such as the Anki Cozmo, to assess upper extremity motor function through gaming.

Figure 1: Anki Cozmo with its sensorized cubes

Materials: To begin creating this interaction, we developed criteria for social desktop robots we believe will be successful in the space of rehabilitation assessment. Attributes such as cost, built-in activities, feasibility of programming novel interactions, inclusion of sensors that gather parameters of motion, and compatibility with other devices are things we consider when choosing a social desktop robot. The Anki Cozmo is a toy robot that may be used as a social companion, a guide, a tool, etc; it was selected because of its low price and the large application programming interface, along with public documentation, that comes with the product, enabling easy setup of navigation, manipulation, and social interactions. The Cozmo also comes with three sensorized cubes (as seen in figure 1) that can receive data useful in rehab assessment: it can register motions such as taps and shakes.

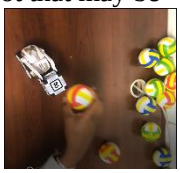

Figure 2: Game space

Methods: We designed a basketball game that involves reaching and grasping like a clinical exercise called the Box and Block. The robot begins the game with a greeting. The experimenter places a cube anywhere in the 2D game space of ~650 in^2. The robot picks up the cube. The subject has 45 seconds to pick up and release as many stress balls on the robot's cube in each of three levels. The stress balls are located on the mid-line of the subject at the edge of workspace. Figure 2 shows the game space in level 1. In level 1, the robot moves, picks up the cube and holds it at the cube's initial position; it remains stationary. In level 2, the robot starts moving back and forth in a horizontal pathway based on its initial orientation. The robot covers 300 mm at a speed of 300 mm/s in each direction. In level 3, the robot with the cube now has the freedom to change orientation randomly (0-360 degrees) and moves in a path of 250 mm at speed of 450 mm/s.

Experiment: To test the similarity between the game and the clinical exercise, we designed a small-scale study of 3 subjects. We had the 3 voluntary subjects wear weighted braces on their non-dominant hand, to simulate impairment, and take a Box and Block Test (BBT). They then took the BBT without the brace on their dominant hand an hour after. The subjects then played the game with the Cozmo with their dominant hand and then played again with the weighted brace on their non-dominant hand. The scores from each iteration were collected and compared. The game scores were across all levels.

	BBT with impaired limb	*BBT with dominant limb*	*Game with impaired limb*	*Game with dominant limb*
Mean	55 blocks	69.333 blocks	91.667 balls	150.333 balls
Standard Deviation	9.848	5.686	7.768	13.686

Figure 3: Table of results

Results and Conclusions: Figure 3 shows the mean scores with the stand deviations for each iteration. The brace appeared to succeed in impairing the arms as seen by the observed decrease in the range of scores from typical to impaired data in the box and block test. The game appears to be discriminatory within individuals as seen by the decrease of each subject's scores when braced. This implies that the interaction could be used to monitor progress during rehabilitation. The drastic difference in the average scores from the game iterations when compared to difference in the box and block iterations is unexpected and will be a focus in our future directions.

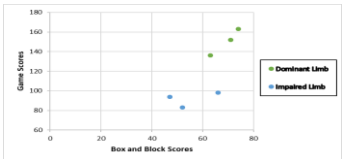

Figure 4: Box and Block vs. Game Score

Future Directions: There appears to be a correlation between the box and block test scores and game scores when the data from the impaired and non-impaired limbs are combined like in figure 4. To further study this correlation, we would need more subjects. This result supports the possibility of a predictive relationship between the two values which implies that interactions between subjects and social desktop robots could be developed further to become alternative upper extremity motor function assessment tools. This will be the focus of our future research and studies.

References: [1] S. Balasubramanian et., "Robotic assessment of upper limb motor function after stroke," *American Journal of Physical Medicine and Rehabilitation, 2012.*