Challenge Point and Task Difficulty Adaptation: Improving Engagement in Robot-assisted Movement Therapy

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Challenge Point: A Trio of Performance, Learning, and Engagement

From a motor learning point of view, to avoid boredom or frustration, one needs to be kept at one's desirable difficulty by meaningful manipulation of exercise challenge [1]. This desirable difficulty can be dependent on both task performance and a person's affective state.

Implementation: Task Challenge and Prediction of Desirable Difficulty

Five Error Augmentation (EA) levels used as levels of reaching task difficulty: control (no EA), low-gain visual EA, high-gain visual EA, low-gain force feedback & visual EA, high-gain force feedback & visual EA [2].

Decay of trajectory error over the training blocks was used to quantify motor performance.

Three physiological signals were used: SCR, breathing rate, and skin temperature.

Hardware used for the study: A participant reaches for virtual targets using the robot.

During practice with challenge, error decays. Variables a, b, and c can be used as performance features.

Physiological responses (SCR shown above) were used to determine users' affective states.

Comparision of all 12 combinations of input sets and machine learning algorithms. Error bars show 95% confidence intervals. The most conservative estimate of the best method (best worst line) is the combination of Neural Network and fuzzy combination of the features.

To predict a user’s desirable difficulty [3]:
1. Which dataset (motor performance, physiological signals, a combination of both) as the prediction variable set returns the highest accuracy;  
2. Which of three machine learning approaches – Neural Networks, k-Nearest Neighbor and Discriminant Analysis – predicts participants’ desirable difficulty more accurately.

Results: Exercising under Adaptive Desirable Difficulty Condition

Able-bodied participants in a comparative study between a control and an experimental group [4].

- A general trend in the questionnaire data showed practicing the reaching task under desirable difficulty condition was less frustrating for the participants. Moreover, the questionnaire data showed the experimental group were willing to continue the training session for approximately four times longer.

- To move this work to the clinical environment, it is important to study the impacts of practice under desirable difficulties on the process of initiating therapy sessions/tasks and patients’ self-efficacy.