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

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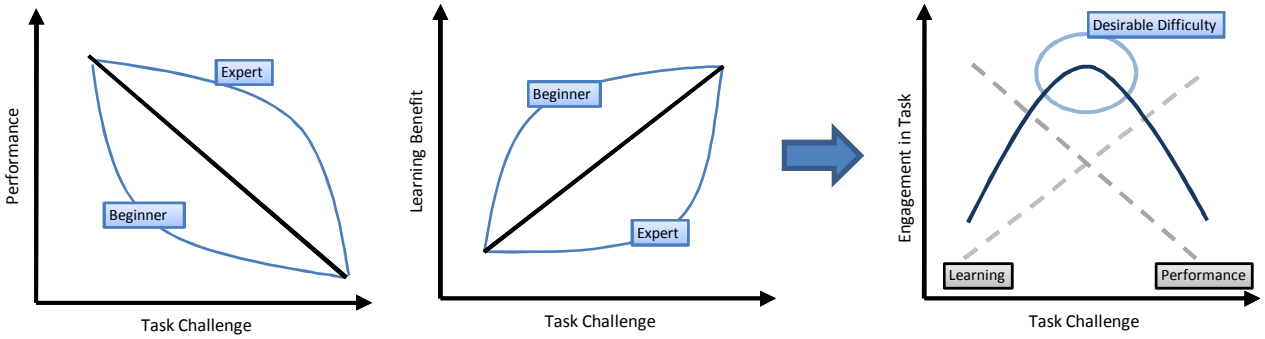
Challenge Point: A Trio of Performance, Learning, and Engagement



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

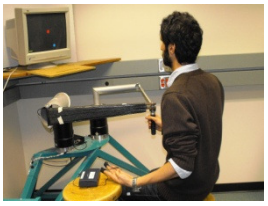
Five Error Augmentation (EA) levels used as levels of reaching task difficulty: control (no EA), low-gain visual EA, high-gain visual EA, low-gain force feedback & visual EA, high-gain force feedback & visual EA [2].

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

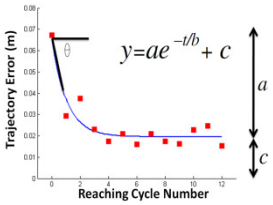
Three physiological signals were used: SCR, breathing rate, and skin temperature.

To predict a user's desirable difficulty [3]:

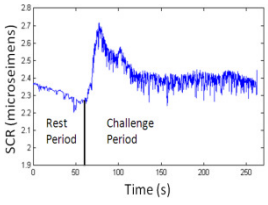
1. Which dataset (motor performance, physiological signals, a combination of both) as the prediction variable set returns the highest accuracy;
2. Which of three machine learning approaches – Neural Networks, k-Nearest Neighbor and Discriminant Analysis – predicts participants' desirable difficulty more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



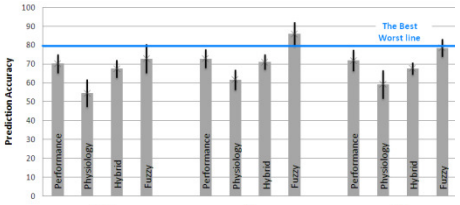
Hardware used for the study: A participant reaches for virtual targets using the robot.



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



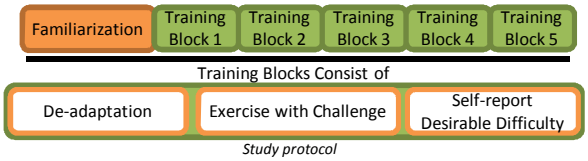
Physiological responses (SCR shown above) were used to determine users' affective states.



Comparison 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.

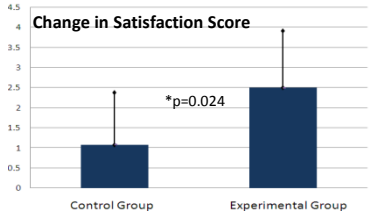
Results: Exercising under Adaptive Desirable Difficulty Condition

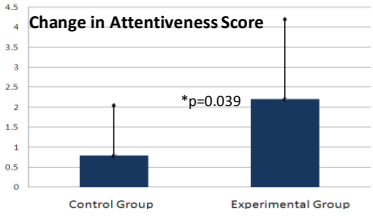
Able-bodied participants in a comparative study between a control and an experimental group [4].

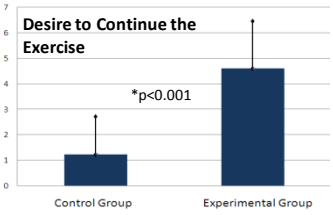


Study protocol

- 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.







[1] M.A. Guadagnoli, T.D. Lee, "Challenge point: a framework for conceptualizing the effects of various practice conditions in motor learning," Journal of Motor Behavior, 2004.
[2] N. Shirzad, M. Van der Loos, "Error amplification to promote motor learning and motivation in therapy robotics," in Proc. IEEE International Conference on Engineering in Medicine and Biology Society (EMBC), 2012.
[3] N. Shirzad, M. Van der Loos, "Adaptation of Task Difficulty in Rehabilitation Exercises Based on the User's Motor Performance and Physiological Responses," in Proc. IEEE International Conference on Rehabilitation Robotics (ICORR), 2013.
[4] N. Shirzad, "The Use of Physiological Signals and Motor Performance Metrics in Task Difficulty Adaptation: Improving Engagement in Robot-assisted Movement Therapy", M.A.Sc. Thesis, University of British Columbia, 2013.