The International Society for CNS Clinical Trials and Methodology (ISCTM)
Marina del Rey, CA USA 15–16 October 2018

Deep Learning-Based Human Activity Recognition for Continuous Activity and Gesture Monitoring for Schizophrenia Patients with Negative Symptoms

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Methodological Questions Being Addressed

Performing remote patient behaviour monitoring using wrist-worn sensors and Deep Learning for activity recognition to derive clinically relevant activity and gesture features of schizophrenia patients with negative symptoms in a clinical trial setting. Investigating the association with measures of motivated behaviour and symptom levels.

Introduction

Quantified evaluation and continuous monitoring of behaviour and symptoms associated with negative symptoms of schizophrenia has been a challenge in clinical trials. Wearable sensor technology provides new opportunities to tackle these problems. However, to connect the sensor data with clinical observations and measures of motivated behaviour still requires development of advanced analytics and real-world validations.

Methods

We conducted a 3-way cross-over proof of mechanism (POM) study (Roche study BP29904); 33 patients with moderate negative symptoms were recruited (30 males; 21 Black / African American, 9 White, 3 Asian; mean age 36.6±7 y; BNSS total score =36.0 ±3.6; PANSS NSFS = 22.8 ±1.4; PANSS PSFS = 19.4 ±1.8). Of these, 31 patients were provided with a GeneActiv© wrist-worn actigraphy device to record actigraphy data for 15 weeks. Negative symptoms were rated with the Brief Negative Symptom Scale (BNSS); Motivated behaviour was assessed with an effort choice task. To analyse the actigraphy data, we trained a 9-layer convolutional recurrent neural network using two public data sets containing wrist-worn acceleration data to infer the subjects' activities. The trained human activity recognition (HAR) model was tested with heldout validation data and achieved more than 95% of accuracy to separate the ambulatory (walking, stairs, cycling, jogging) activities from stationary activities (sitting, standing, lying down, hand work). We applied the HAR model on the collected actigraphy acceleration data of 31 schizophrenia patients from the BP29904 study and calculated active time ratio in patients' daily life. We also inferred the gesture events and gesture features based on the activities and acceleration signal using an empirically defined threshold on accelerometer signal from the wrist. Correlations between active time ratio, levels of negative symptoms and willingness to work for a high reward in the effort choice task during placebo treatment were calculated.

Results

The patient adherence rate was high: average monitoring time per patient was 1,859 hours, among which 25 patients have more than 1,000 hours of actigraphy data collected. The active time ratio of the schizophrenia patients was significantly associated with the % high effort choice during the placebo period (Spearman r = 0.58, P value = 0.002). The median daily gesture counts are also found to be negatively correlated with BNSS total score (Spearman r = -0.44, P value = 0.03), specifically with the diminished expression sub-score at the baseline (Spearman r = -0.42, P value = 0.03 in both cases).

Conclusions

These analyses demonstrate the feasibility to the use of wrist-worn actigraphy for continuously monitoring clinically-relevant behaviour in a clinical trial setting. Associations with key dimensions of negative symptoms support their validity. The activity and gesture features derived from human activity recognition model has shown promise for future clinical practice and drug development process.