Automatic assessment of tic expression

Yocheved Loewenstern[1], Noa Benaroya-Milshtein[2,3] Izhar Bar-Gad[1]

[1] Gonda Multidisciplinary Brain Research Center, Bar-Ilan University, Ramat Gan, Israel

[2] The Matta and Harry Freund Neuropsychiatric Tourette Clinic, Schneider Children's Medical Center of Israel, Petach Tikva, Israel

[3] Sackler Faculty of Medicine, Tel Aviv University, Tel Aviv, Israel

Background:
Tourette syndrome (TS) and other tic disorders are characterized by the expression of motor and vocal tics. Tics follow a complex waxing and waning pattern of severity, intensity, and frequency over multiple timeframes. Likewise, the large tic modulation by behavioral states and environmental factors complicates symptom assessment. The most prevalent measures used for assessing tic expression are subjective qualitative measures based on self-reports taken periodically during clinical visits, thus lacking objective quantitative assessments of tics over prolonged periods of time. The goal of the current study is to create an automatic measure for quantifying tic expression and modulation in natural behavioral settings.

Methods:
We used a custom-developed smartphone application to record data from children and adolescents with TS or other chronic tic disorders attending Schneider Children's Hospital. Each recording session included active (playing games, filling questionnaires) and passive (watching videos) tasks on the smartphone, while the patient's facial tics were simultaneously recorded by the frontal camera. Trained experts annotated the videos offline, marking the precise times of tic onset and tic completion, while specifying the subtypes of movement displayed. The recordings were stored on a secure server and 98-point facial landmarks were extracted from each frame. The landmarks representing the whole video were segmented to short clips, each labeled "tic"/"non-tic" based on the annotations. Finally, a tandem of custom deep neural networks for extracting the spatial (*grouped local feature network*) and temporal (*long short-term memory network*) were used for classifying the segments.

Results and Conclusions:
We recorded 45 sessions from 13 TS patients (7-18 years old, 1-4 sessions per patient). The session duration was 35.1±13.6 minutes including both active and passive tasks. All the patients expressed facial motor tics (177.2±116.7 tics per session, rate of 4.9±2.1 tics per minute). The tics were highly variable with different subtypes involving a combination eyes, nose, head, mouth and lip movements (5.3±3.0 repeating tic subtypes per session). Automatic tic detection was initially tested using binary classifications, i.e., determining whether a short video segment contains a tic or not. Preliminary results show that our model achieves over 97% precision recall within patients and 88% precision across patients. Applying the trained model on the whole video, by using a sliding window and then classifying each segment along the video, resulted in detecting roughly 90% of all the tics in the video. Finally, observing the different tic subtypes revealed large variability in the detection rates which were dependent on the representation of the tic subtypes in the training set. This novel objective measure of tic expression provides key insights to the modulation factors influencing motor tic

expression in TS patients during everyday activities. This work has the potential to provide clinicians a powerful tool for diagnosis and follow-up of their patients, and for evaluating the efficacy of different behavioral and pharmaceutical treatments. Finally, such a tool has the potential of revolutionizing the large-scale clinical studies and trials enabling faster development and testing of new measures.