A mobile app for managing and annotating symptoms of polytrauma involving traumatic brain injury, post-traumatic stress disorder, and complex pain

A. Smith[1,2] , A. Boyle[1,2] , R. Selzler[1] , F. Charih[1] , J. Holly[2] , C. Bridgewater[2] , M. Besemann[3] , D. Curran[2] , A. D. C. Chan[1] , J. R. Green[1]

[11] Carleton University, Ottawa, Canada [2] The Ottawa Hospital Research Institute, Ottawa, Canada,
[3] Canadian Forces, Health Services

Introduction

Among military service members, epidemiological studies report high coprevalence of pain, traumatic brain injury (TBI), and PTSD. Symptoms of this polytrauma-triad involve heightened sympathetic activation of the autonomic nervous system (SAANS) in reaction to external or internal stressors. Overlapping symptoms of triad diagnoses can synergistically amplify or obscure symptoms of polytrauma, complicating diagnostics and treatment. Therapy at The Ottawa Hospital Rehabilitation Centre (TOHRC) employs a Computer Assisted Rehabilitation Environment (CAREN). Immersed in a virtual environment (Fig 1), patient biological signals (movement and heart rate) can be acquired while their sensory environment is manipulated to probe for sensory processing deficits at an unconscious level. Once deficits are identified, patients can learn to mitigate SAANS responses with graded exposure to sensory triggers. During therapy, recognizing and promptly responding to SAANS is critical for clinicians. Failure to observe symptoms of autonomic dysfunction may result in an excessive SAANS response, and adversely affect treatment. Our study aims to create an app to facilitate the recognition and recording of polytrauma-triad symptoms, and the development of a real-time estimator of SAANS.

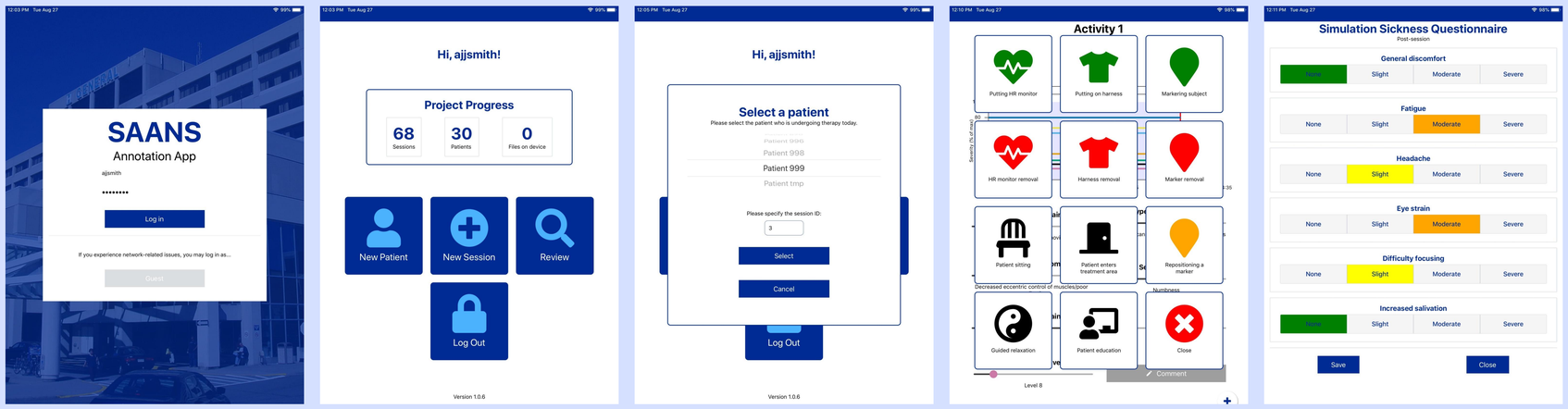
Fig 1 Computer Assisted Rehabilitation Environment (CAREN)

Methodology

In phase one, a requirements analysis workshop was conducted, including clinicians representing multiple disciplines within rehabilitation (psychology, chronic pain, and neurotrauma), app developers, and researchers (data science, engineering, and human factors). Workshop objectives were to determine: specific clinical indicators of SAANS, a method to collect and scale clinical estimates of SAANS, a method of transforming observational data into numerical representation of SAANS, and a basic concept for the application interface. A second workshop was held to fine-tune the beta version (Fig 2 and 3) of the app and to determine the feasibility of collecting data during active therapy sessions.

Results

An efficient and highly usable mobile app has been successfully user tested. The application annotates six symptom domains, clinician comments, and pain (Fig 3). To estimate and track SAANS, changes in autonomic nervous system (ANS) state are transformed into a numerical representation of SAANS using domain-specific signs and symptoms. The app enables annotation of changes in ANS state by clinicians in real-time and also for synchronization with biological signal data from CAREN.



A B C D E

Fig 2 SAANS application: **A)** log in screen; **B)** patient selection; **C)** patient session selection; **D)** Subject preparation; **E)** Simulator sickness question error, completed before and after a treatment session.

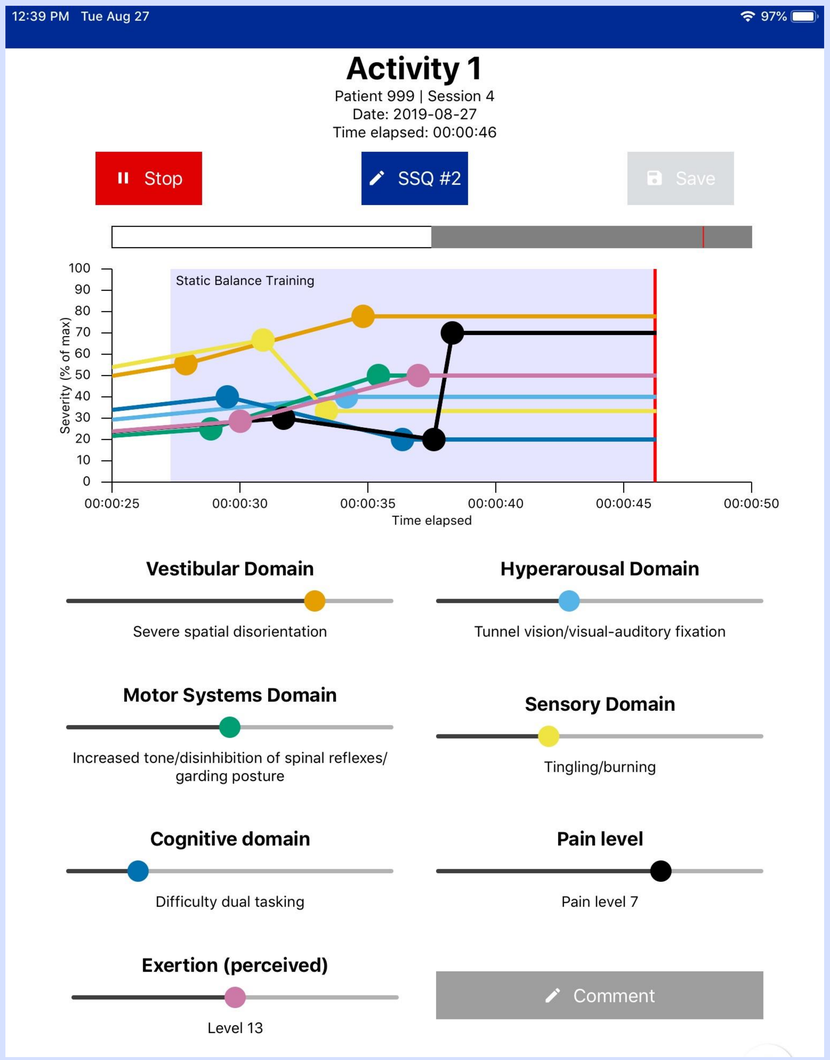


Fig 3 SAANS application symptom domains used to record patient reactions during VR therapy. Changes made to any domain are annotated in real time

Conclusion

This clinician recording tool will be used during data collection to capture clinical observations. These observations will form the gold standard estimator of SAANS and be synchronized with recorded biometric data. Tagged biometric data will be used to develop machine learning real-time estimator of SAANS.

Acknowledgements

The authors would like to acknowledge financial support through the Advance Analytics Initiative supported by CIMVHR and IBM Canada.

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For more information contact
Andrew Smith andrewsmith@toh.ca