Moving beyond current approaches to a broader view of epilepsy monitoring

Steven C. Schachter, M.D.

Chief Academic Officer and Director of NeuroTechnology

Center for Integration of Medicine and Innovative Technology (CIMIT), Boston

Professor of Neurology, Harvard Medical School

Outline

- Home monitoring with video-EEG
- Beyond current approaches: unmet needs and emerging technologies
- Opportunities and challenges for further development

Why monitor at home with video-EEG?

- Confirm clinical suspicion of epilepsy and seizure type(s) by recording events of interest in an environment where patient has the episodic behaviors
- Document and quantify seizures that patients may be unaware of

Schachter 2014

Example of available video-EEG home-based system

- Can record up to 96 hrs of EEG and 48 hrs of HD video on one memory card
- Low-light camera setting
- Uses Bluetooth to synchronize EEG and video
- Connects to PC via USB, can upload 24 hrs of EEG < 5 min

Schachter 2014

Moving beyond current approaches to a broader view of epilepsy monitoring:

Unmet needs and emerging technologies

Schachter 2014

Unmet needs in epilepsy monitoring

- Provide warning of an impending debilitating seizure
  - Serve as input for closed-loop system
  - Lessen risk of injuries, such as fractures, intracranial hematomas, burns; or death, for example from accidents, aspiration, drowning, or SUDEP
- Unpredictable nature of seizures is the worst aspect of epilepsy for patients

Schachter 2014

Unmet needs in epilepsy monitoring

- Monitor the long-term impact of treatments on seizure control and co-morbidities
- Replace patient diaries in clinical trials of anti-seizure therapies with more accurate physiologically-derived data
- Improve adherence to medication, lifestyle issues (e.g., sleep)

Schachter 2014

Unmet needs in epilepsy monitoring

- Assess patient safety during and after seizures
  - Summon help or emergency evaluation when needed
- Identify patients at greatest risk for developing epilepsy (e.g. from traumatic brain injury, stroke, Alzheimer's disease)
- Correlate specific symptoms with EEG or AED levels in real-time

Schachter 2014

Unmet needs in epilepsy monitoring

- Given these unmet needs, monitoring is evolving from EEG- and video-based devices for short-term use in establishing a diagnosis to long-term diagnostic and treatment systems incorporating a range of technologies to manage epilepsy
- Many such emerging technologies will enable this next stage of epilepsy monitoring

Schachter 2014

Emerging Technologies

- Hardware
  - EEG, non-EEG
- Software

Emerging Technologies

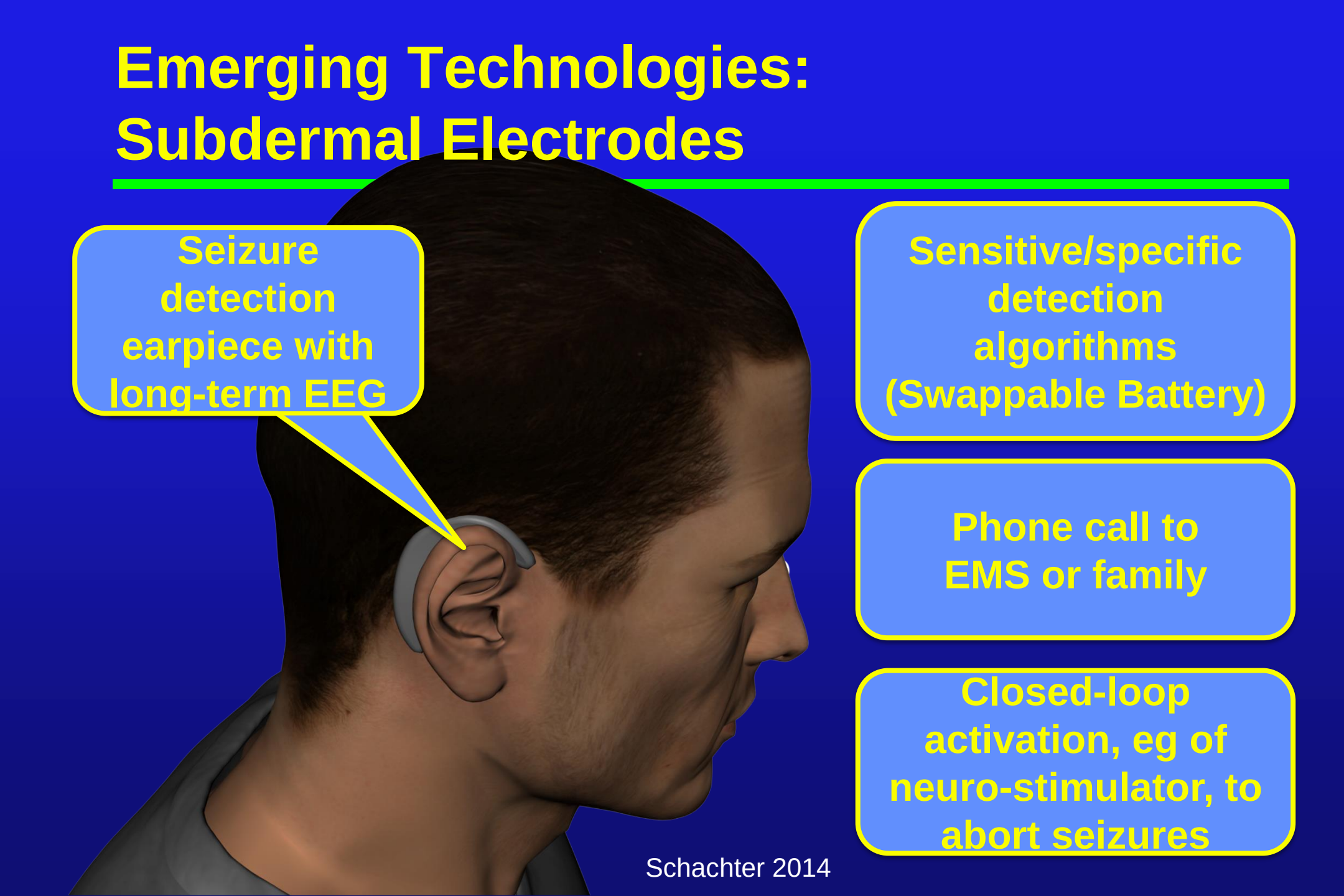
- Hardware
  - EEG based
    - Wearable EEG electrodes
      - Many designed for use in gaming or for brain-computer interfaces
    - Subdermal electrodes
    - Intracranial systems for seizure detection and prediction

Schachter 2014

Emerging Technologies

- Hardware
  - Wearable EEG electrodes

Emerging Technologies: Subdermal Electrodes



Schachter 2014

Sub-dermal Electrodes

Implantable EEG Recorder

Sub-dermal electrodes under the scalp (outside skull)

Few scalp-incisions, local anesthetic

Wirelessly powered by the earpiece

Transfers EEG signals wirelessly to earpiece

Schachter 2014

Emerging Technologies

- Hardware
  - EEG based
    - Intracranial system for seizure detection
      - Responsive Neurostimulation System™ (Neuropace)
    - Intracranial system for seizure prediction
      - Seizure Advisory System (NeuroVista)

Emerging Technologies

- Non-EEG based hardware
  - Accelerometers
    - Wristwatch (Beniczky et al. Epilepsia 2013;54:e58-61)
    - Wearable body sensor network (Dalton et al. IEEE Trans Biomed Eng 2012;59:3204-11)
  - Electrodermal activity sensor (Poh et al. Epilepsia 2012;53:e93-7)

Emerging Technologies

- Non-EEG based hardware, cont
  - Near-infrared (Nguyen et al. Epilepsy Res 2012;99:112-26)
  - Mattress movement monitor (Narechania et al. Epilepsy Behav 2013;28:172-6)
  - ECG (Nasehi et al. Comput Biol Med 2012;42:848-56; Jansen et al. Epilepsy Behav 2013;29:72-6)

Emerging Technologies

- Non-EEG based hardware, cont
  - Video-based analysis of movement detection

SAMi - Sleep Activity Monitor

Schachter 2014

Emerging Technologies

- Non-EEG based hardware
  - Accelerometers
    - SmartWatch consists of a GPS module and a proprietary accelerometer/gyroscopic sensor to detect the excessive and repeated motions of tonic-clonic seizures
  - Buttons allow users to cancel a false alert

Schachter 2014

Emerging Technologies

- Non-EEG based hardware
  - Electrodermal activity: EpiBand
    - Measures skin resistance (marker of sympathetic tone), motion, and skin temperature
    - Communicates wirelessly to smartphone
    - Tested as a method to detect GTCS and autonomic correlate to postictal EEG suppression after CPS and GTCS, which may be a risk factor for SUDEP (Poh et al. Neurology 2012;78:1868-76).

Schachter 2014

Opportunities and challenges for further development

Schachter 2014

Challenges for further development and clinical adoption

- Networking with IT and engineers from numerous disciplines
- Assembling development teams
  - Clinical expertise
  - Technology
  - Patient input
- Early financial support (for example, Epilepsy Therapy Project of the Epilepsy Foundation; see Shark Tank competition)

Schachter 2014

Challenges for further development and clinical adoption

- Strategies for demonstrating proof of principle
- Demonstrating favorable cost:benefit to payors
- Patient and physician acceptance and adoption
- Integration across technologies to customize and individualize systems for specific patients
  - No single sensor (EEG, accelerometer, etc) will be sufficient for all clinical situations
  - Interoperability therefore desirable

Schachter 2014

Summary

- Technologies are emerging that will broaden the capabilities and applications of seizure monitoring towards a comprehensive patient-specific epilepsy management system
- Challenges exist but can be solved by the engineering and medical communities working together

Schachter 2014

Thank you!

- Interested in collaboration? Contact me:
  - sschacht@bidmc.harvard.edu
- Learn more about CIMIT
  - Center for Integration of Medicine and Innovative Technology
  - http://www.cimit.org/neurotech.html