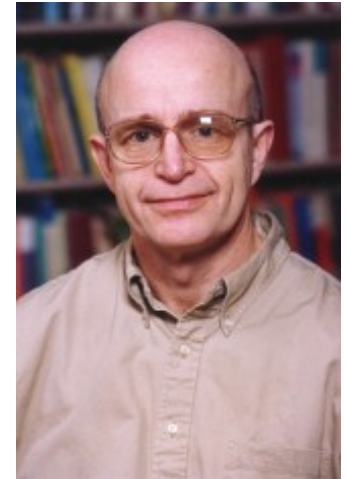


The Future of Education



Using EEG to Improve Massive Open Online Courses Feedback Interaction

Haohan Wang, Yiwei Li, Xiaobo Hu, Yucong Yang,
Zhu Meng, **Kai-min Chang**

Language Technologies Institute

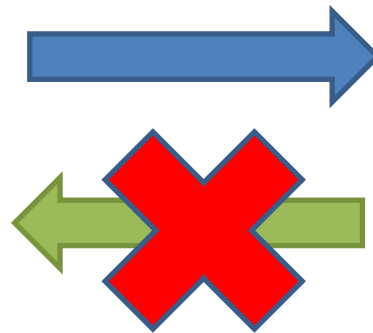
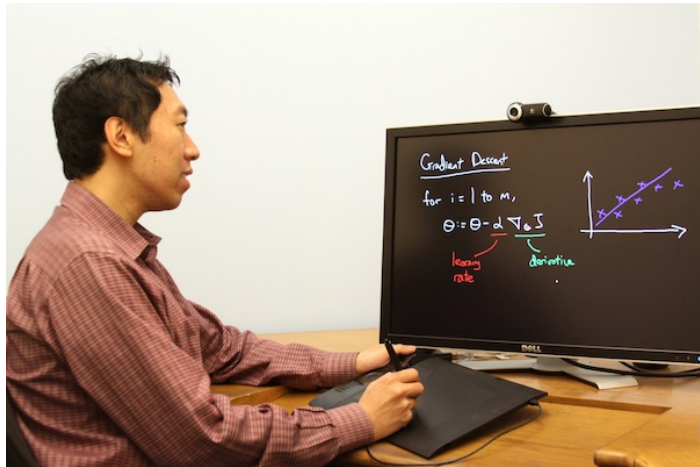
Carnegie Mellon University

This work was supported by the National Science Foundation under Cyberlearning Grant IIS1124240. The opinions expressed are those of the authors and do not necessarily represent the views of the Institute, or the National Science Foundation.



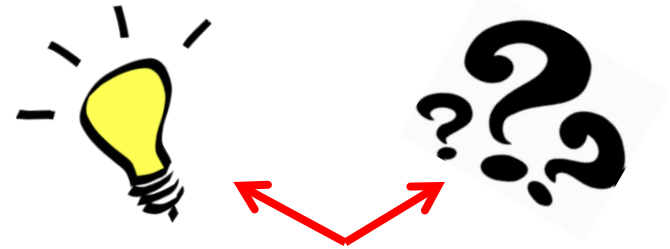
Challenge for MOOC

Instructor one-way push

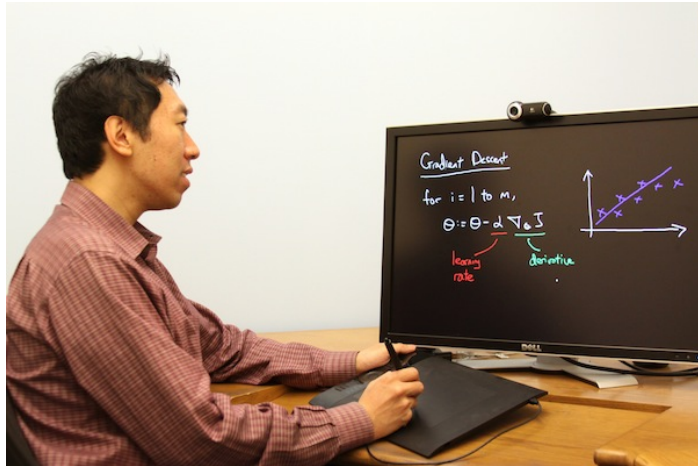


No real-time feedback
from the student

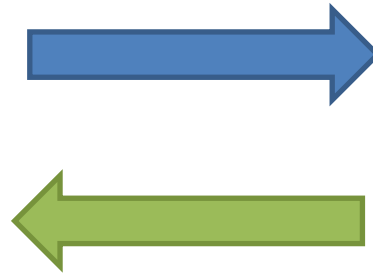
Improve learning experience in MOOC?



Instructor one-way push



Brain sensing



Real-time feedback from the student

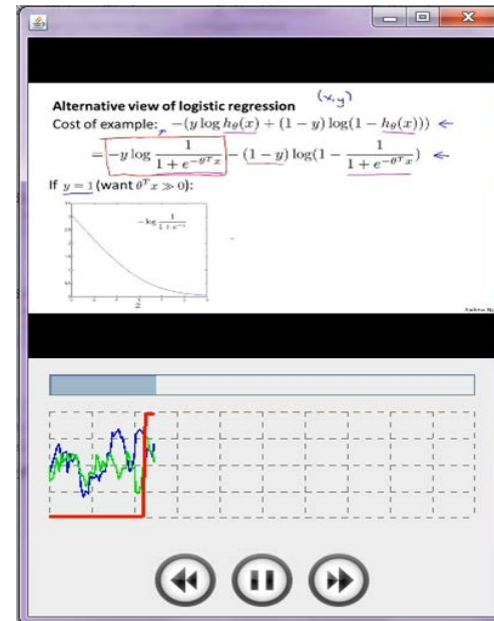
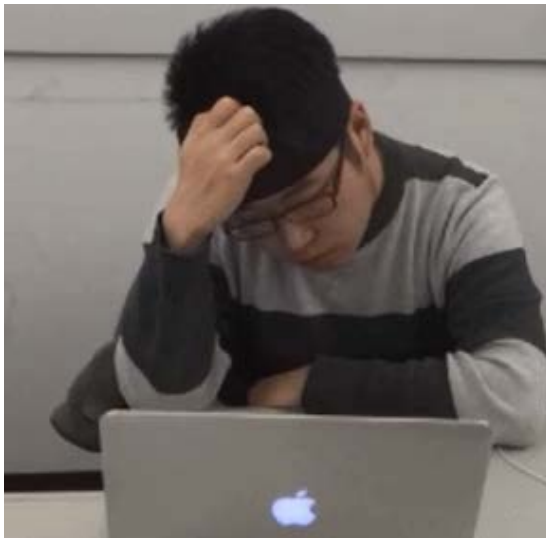
Our Approach: Brain Imaging

- **Electroencephalography (EEG)**
 - Voltage signal arised from large areas of coordinated neural activity
 - Rhythmic fluctuations in EEG has been associated with emotion (Marosi, E., et al., 2002), engagement (Berka et al., 2007), etc.
- **New consumer-friendly EEG device**
 - NeuroSky MindBand: Single-channel on forehead, dry electrode, \$100 USD
 - Detect human emotional responses (Heraz, & Frasson, 2009) and reading difficulty (Mostow et al., 2011) in ITS



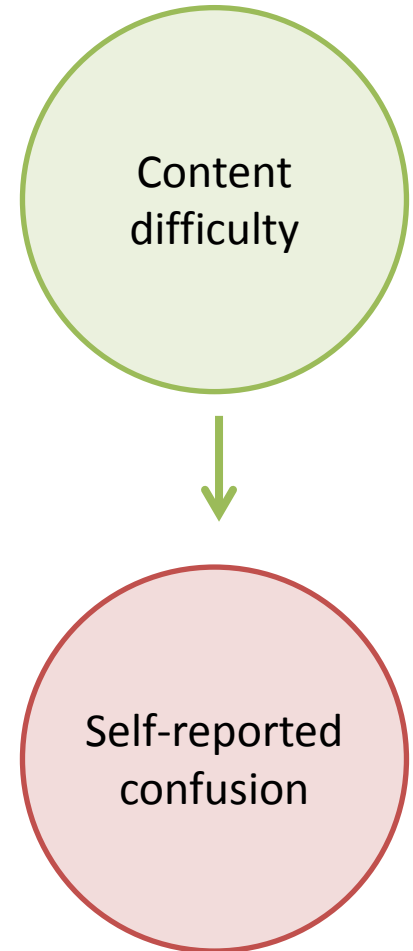
Research Questions

- Can EEG detect **confusion**?
- How does it compare to human?

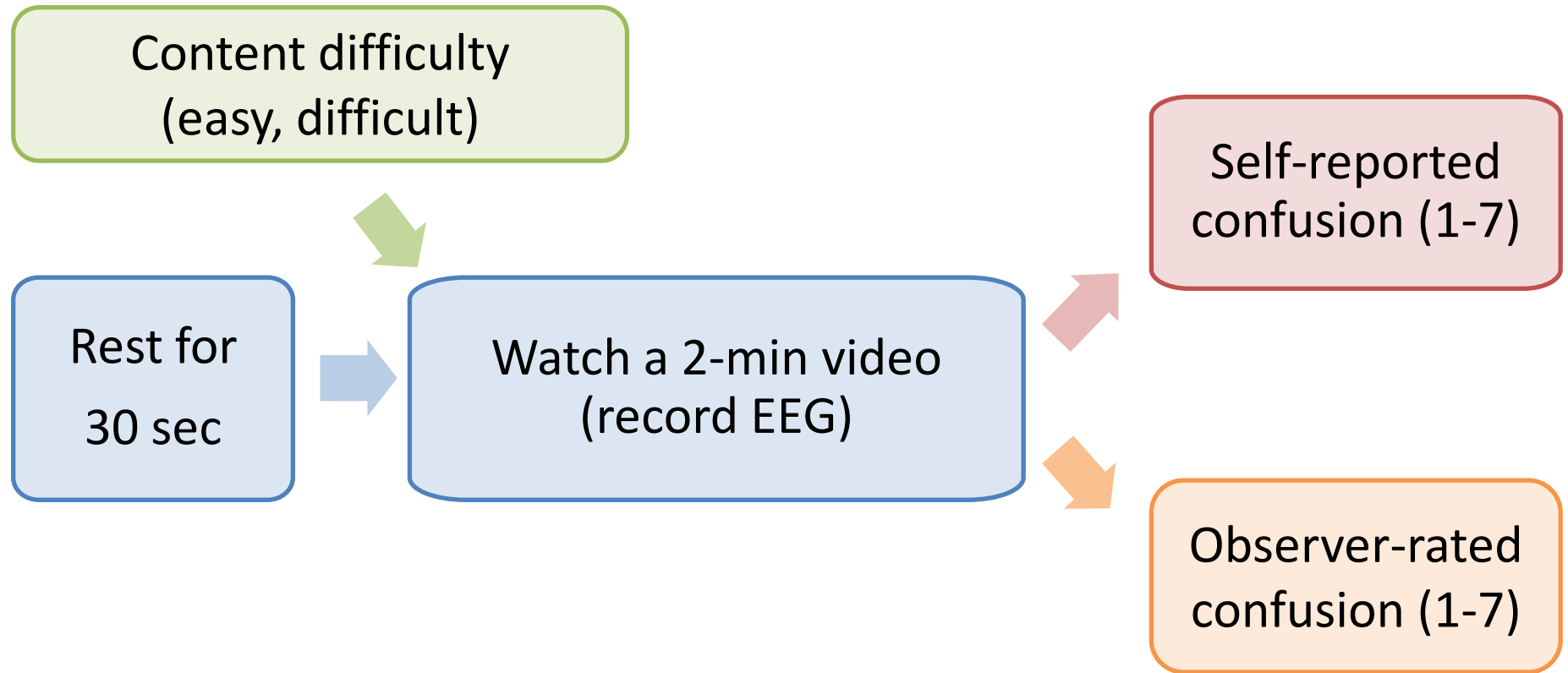


A Pilot Study

- 10 college students
- Each watched 10 two-minutes video clips extracted from MOOC (<http://open.163.com>)
 - 5 easy videos (e.g. elementary algebra, geometry, etc.)
 - 5 difficult videos (e.g. quantum mechanics, stem cell, etc.)

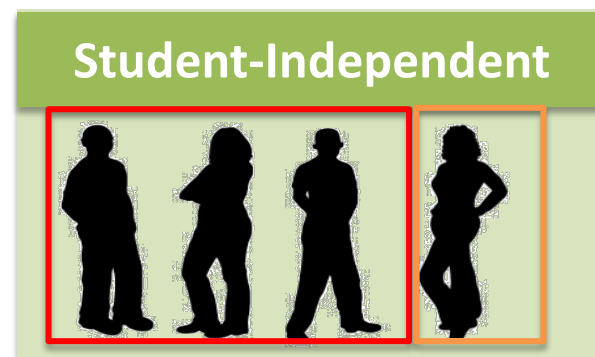
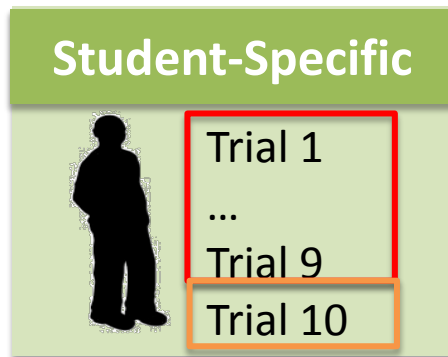


Experiment Process

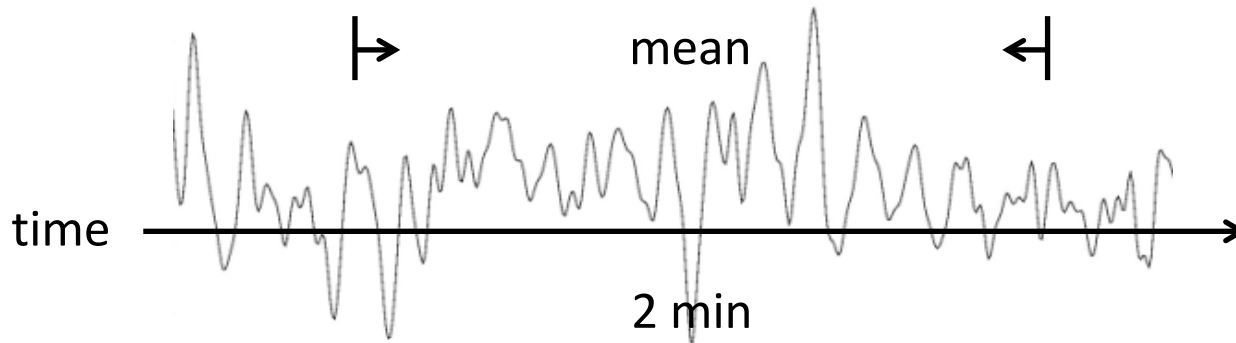


Can EEG Detect Confusion?

- **Classifier:** Gaussian Naïve Bayes
- **Features:** EEG signals (averaged over time)
- **Labels:**
 - Content difficulty (binary)
 - Self-reported confusion (map to binary by median split)
- **Cross-validation:** Across trials and students



EEG Features



Given



Measure	Purpose
Raw waveform	Raw EEG sampled at 512 Hz
Attention / Meditation	Proprietary measures, sampled at 1 Hz
Gamma (30-100 Hz)	History of idea, attentive focus
Beta (12-29 Hz)	Fully-awake, alert, excitement
Alpha (8-11 Hz)	Deeply-relaxed, passive-awareness
Theta (4-7 Hz)	Drowsiness, unconscious
Delta (1-3 Hz)	Sleep, unaware

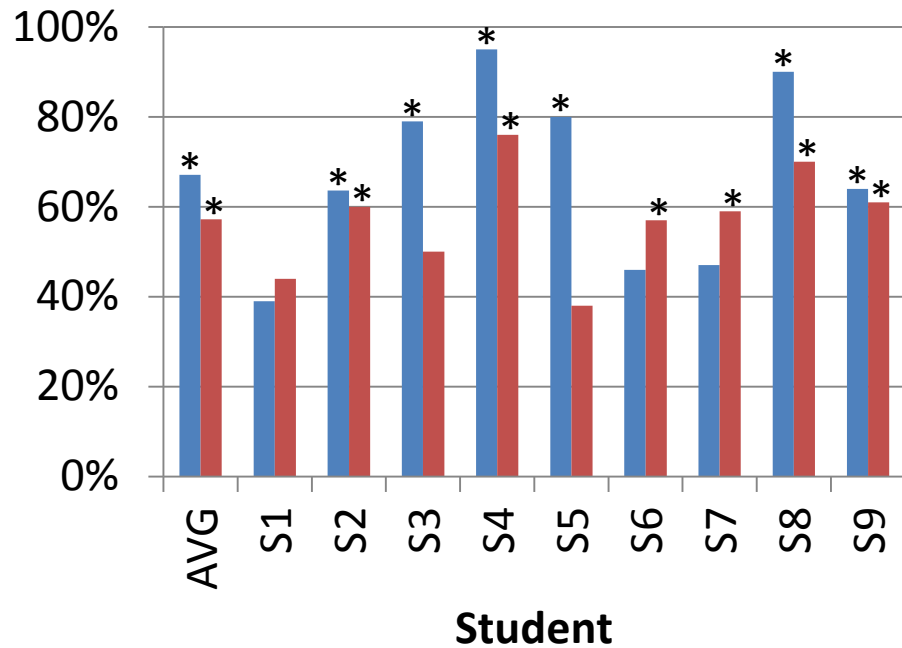


FFT

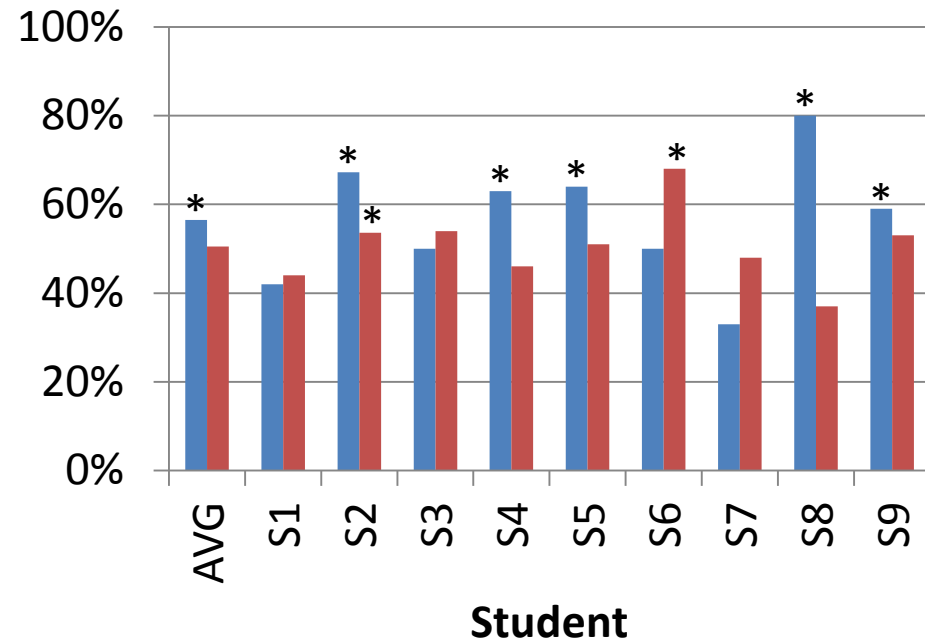


Can EEG Detect Confusion?

Content difficulty
(ACC = 67%* and 57%*)

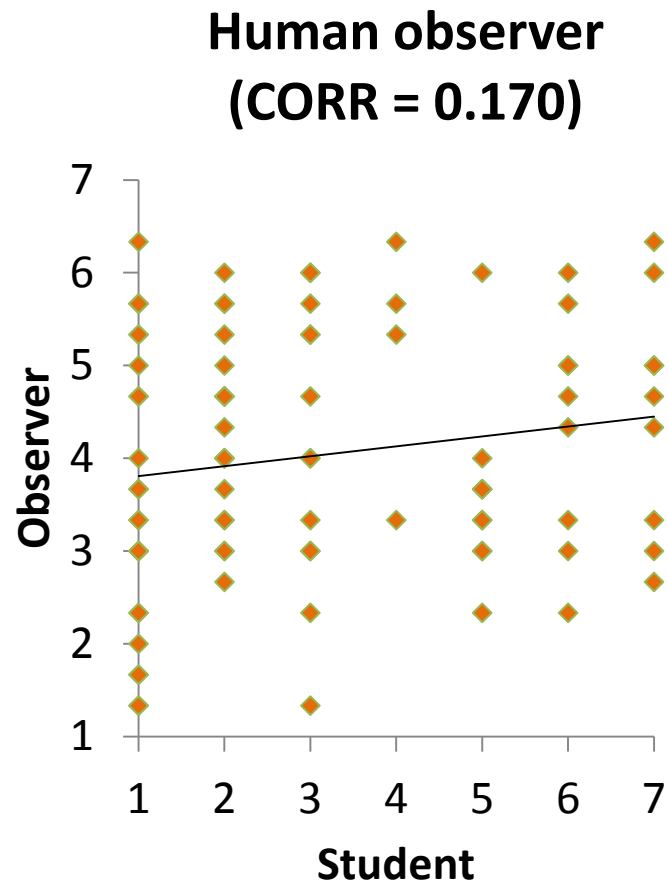
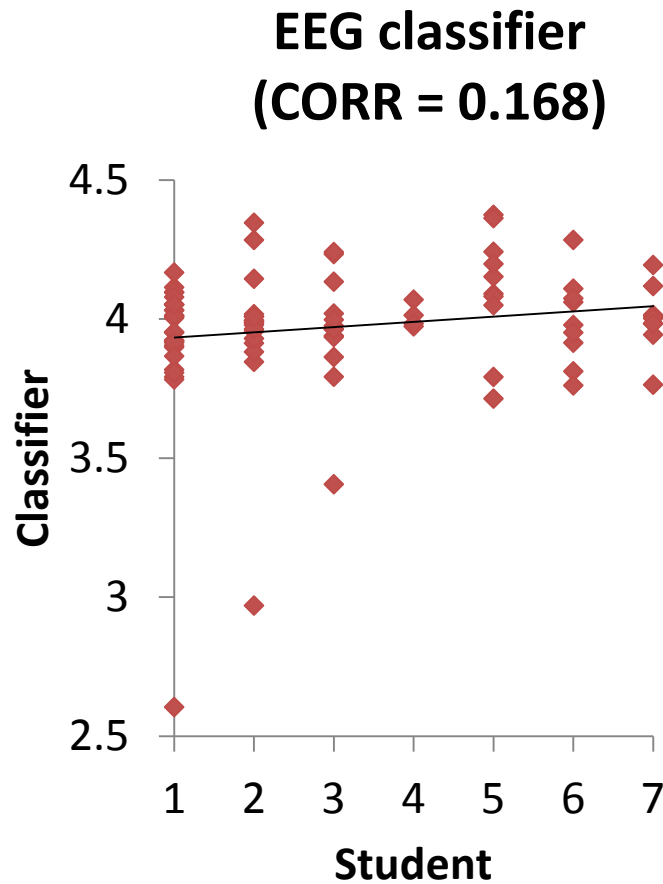


Self-reported confusion
(ACC = 57%* and 51%)



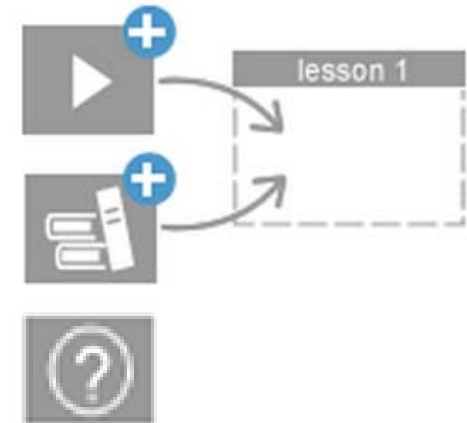
■ Student-specific ■ Student-independent

How does it compare to human?



Applications for MOOC

- 7% completion rate (Jordan, 2013)
 - Help instructors compose MOOC lessons that optimize engagement
- Students don't know when to ask for help (Aleven, et al., in press)
 - Personalize learning experience



Congratulations you have finished the course

Course ID: 11695
Course Name: Competitive Engineering
User Name: Yiwei Li

Your Mindwave:

The mindwave graph displays a fluctuating line representing cognitive activity. The line is primarily blue and green, with several sharp red vertical spikes indicating periods of high activity or confusion. A red rectangular box highlights a specific segment of the graph, corresponding to the 'Confusion Time sequence' table below.

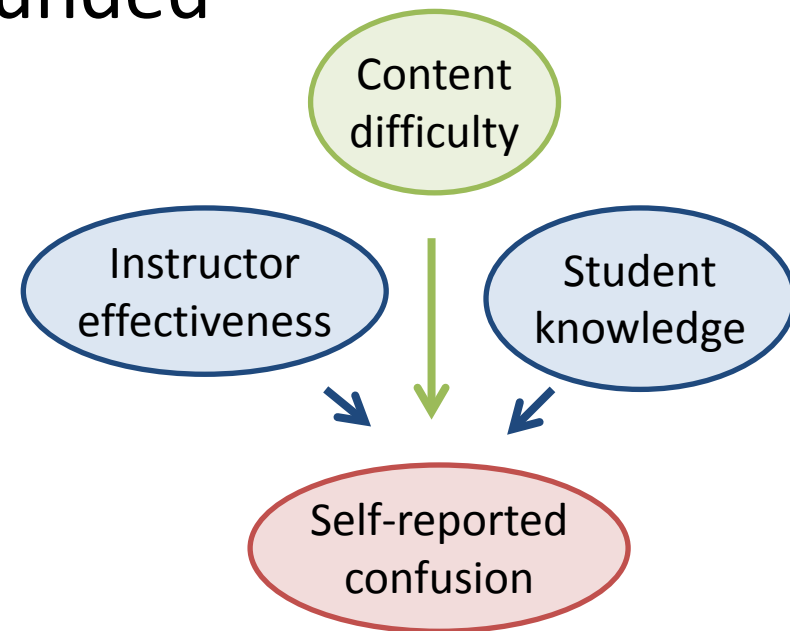
Confusion Time sequence:

From	To	Interval	Tips
0h1m05s	0h1m34s	29s	Click here
0h1m37s	0h1m47s	10s	Click here
0h1m49s	0h2m03s	14s	Click here
0h2m15s	0h2m17s	2s	Click here
0h4m40s	0h4m49s	9s	Click here
		54s	

The percentage of confusion time is 5.1113%
You can understand this lecture well!!!

Limitations

- Class project for a group of Biotechnology Innovation and Computation students
- “Confusion” may be confounded
- Not real MOOC data
- No comparison with other detectors



Discussion

- MOOC provides huge amount of data
 - One more source of data that directly measures brain!
- Signals are noisy...
 - Brain imaging technology will continue to get better and more available
- Not scalable...
 - Portable EEG devices may become house-hold accessories like microphone and webcam
- Not what MOOCs need...
 - Tell us what you think is useful!

Take Home Message

1. **Weak but above-chance** performance for using EEG to detect when a student is confused
2. Availability of **consumer-friendly** EEG devices

NeuroSky
Brain Wave Sensors for Every Body

emotivo
you think, therefore, you can



Questions

- Haohan Wang
 - Biotechnology Innovation and Computation, Carnegie Mellon University
 - E-mail: haohanw@andrew.cmu.edu

- Kai-min Kevin Chang
 - Language Technologies Institute, Carnegie Mellon University
 - E-mail: kkchang@cs.cmu.edu

