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Adaptive Review for Mobile MOOC Learning via Implicit Physiological Signal Sensing

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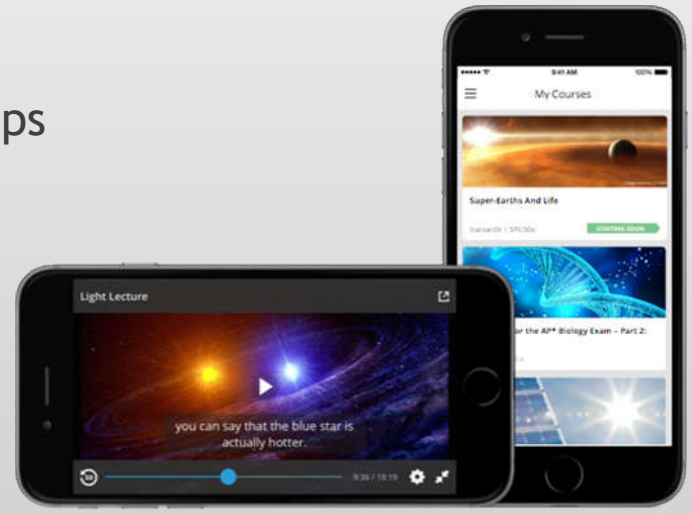
Mobile MOOCs

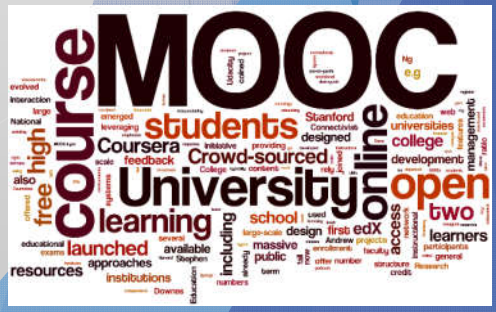
- Primary learning resources → Videos
  - 3-15 min.
  - Ideal to watch on mobile devices
- Coursera, edX, Udacity have mobile apps



edX mobile app (https://www.edx.org/mobile)

Challenges of MOOCs

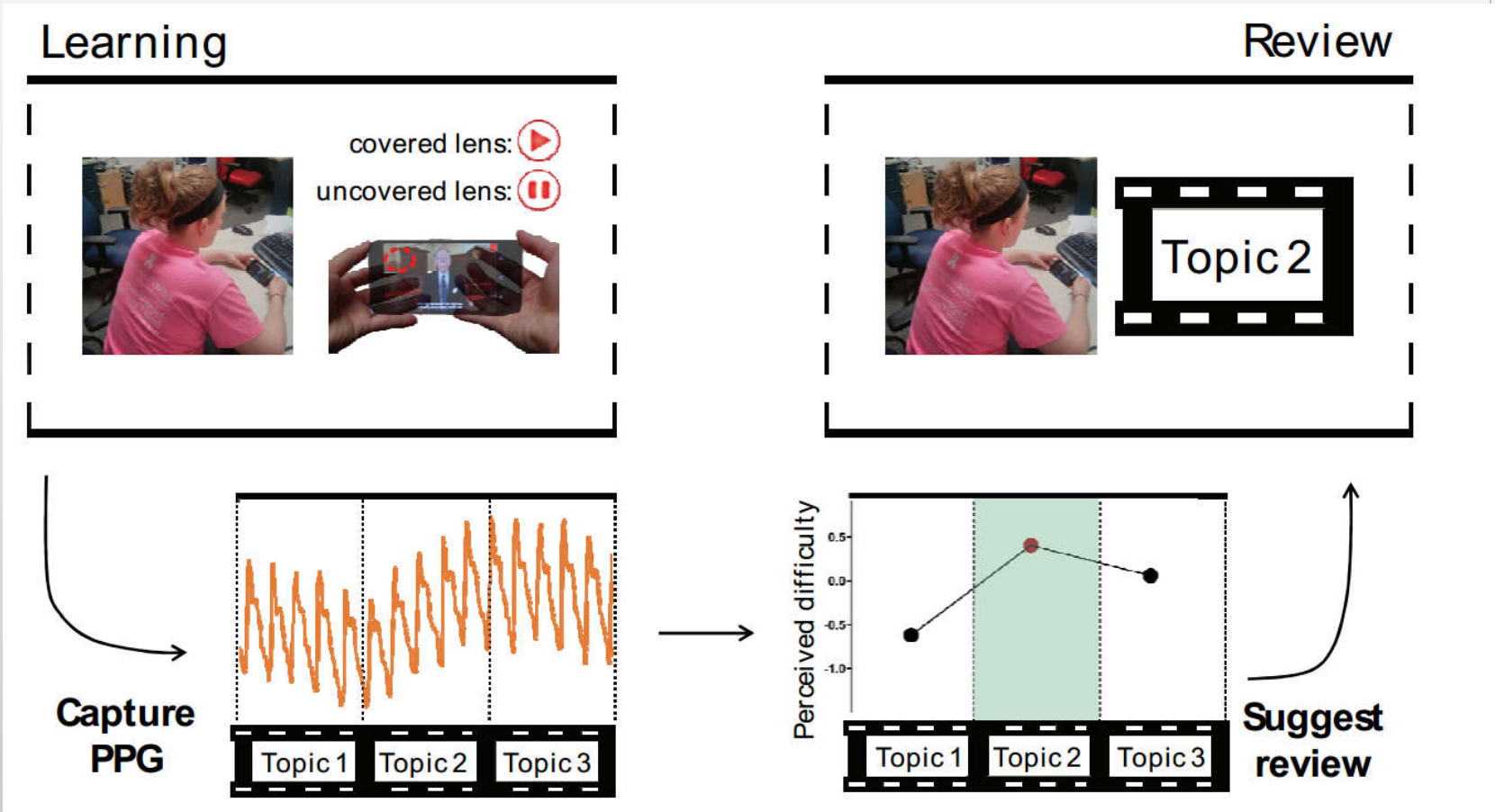
- Because of ‘one-size-fits-all’ concept;
  - Low engagement and retention
  - Uni-directional information flow
  - Lack of personalization
    - Static and asynchronous nature of pre-recorded videos
    - Insufficient monitoring and modeling of the learning process
      - Limited information for analysis: Self-reports and Clickstream analysis
      - Aggregated learning analysis
    - Cost of fine-grained in-lecture assessment



AttentiveReview

- Intelligent intervention technology for mobile MOOC learning, without hardware modification
- One solution to the lack of personalization in mobile MOOCs
- Infers learners' ***perceived difficulty*** levels while watching videos and recommends 'review materials' by analyzing the photoplethysmography (**PPG**) **waveforms** captured *implicitly* from **fingertip transparency changes** via back camera of mobile phones.
- Structure:
  1. Back camera → a tangible video controller & heart rate tracker
  2. Heart rate uncovers the difficult sections of videos
  3. System recommends those sections for reviewing
- Link for detailed view: https://www.youtube.com/watch?time_continue=176&v=rocYVTdOXzE

AttentiveReview

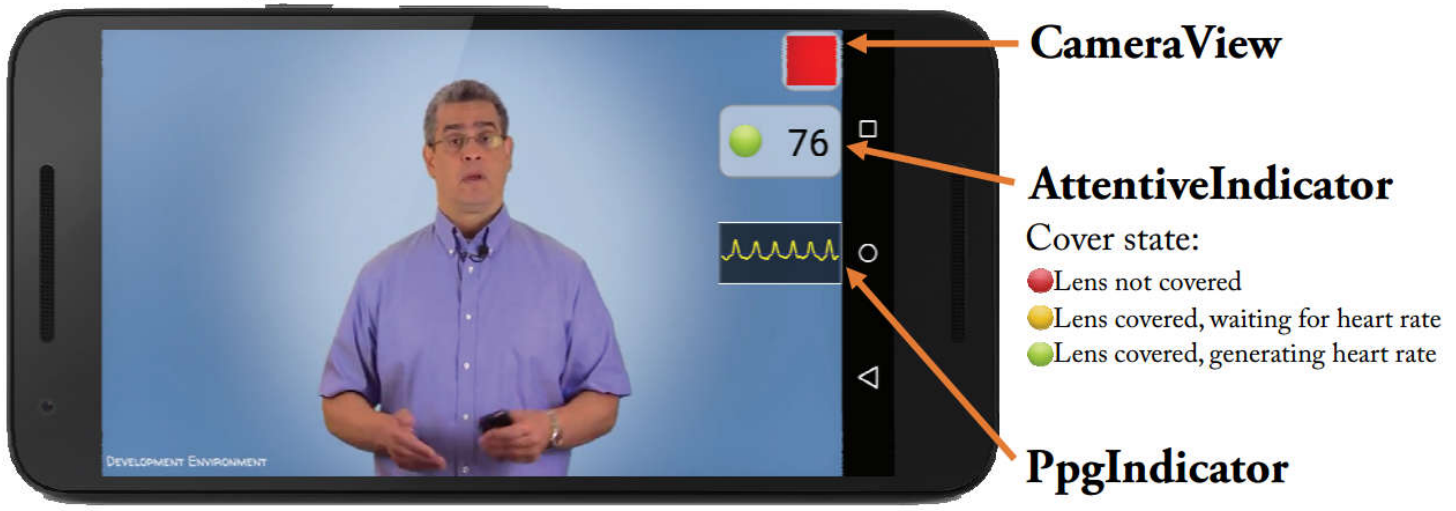


Related Studies

- On Physiological Signals for educational purpsoes:
  - Skin conductance (Woolf et al., 2009), eye gaze (D'Mello, 2012), facial expressions (Woolf et al., 2009), electroencephalogram (EEG) (Szafir, & Mutlu,2013), functional near-infrared spectroscopy (fNIRS) (Afergan et al., 2014), and **heart rate/PPG** (Hjortskov et al., 2004; Lyu et al., 2015; Xiao, & Wang, 2015).
    - → In order to infer learners' cognitive and affective states
- On AttentiveReview:
  - Used PPG signals for detecting *mind wandering* (Pham, & Wang, 2015), *boredom* and *confusion* (Xiao & Wang, 2015)

Design of AttentiveReview

3.1 Tangible Video Control



The video watching interface of AttentiveReview, showing the camera preview window, the attention indicator, and the PPG preview window.

Design of AttentiveReview

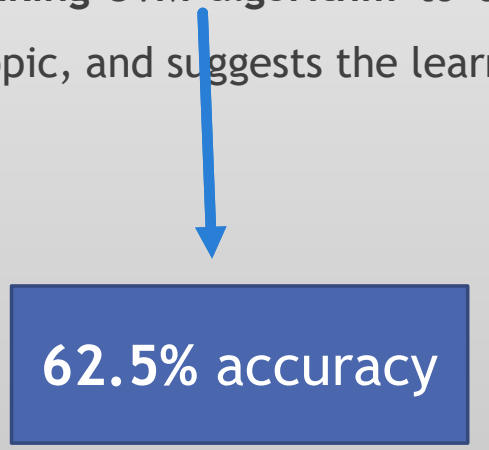
3.2 Implicit PPG Sensing

- In every cardiac cycle, the heart pumps blood to capillary vessels and **changes** the **transparency** of the corresponding human body parts, including the **fingertips**. These **transparency changes correlate directly with heart beats** and **can be detected by the covered back camera.**

Design of AttentiveReview

3.3. Adaptive Review Algorithm

- Extracts both temporal domain and frequency domain features from a learner' PPG waveforms collected from the learning process.
- Uses a **ranking SVM algorithm** to determine learners' perceived difficulty in each learning topic, and suggests the learner to review the most difficult topic.



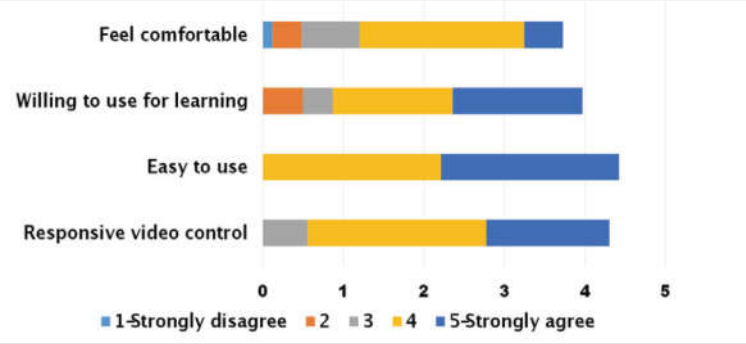
User Study:

- **Experimental Design:**
- background survey and pre-test; 2) MOOC learning; 3) MOOC reviewing; 4) posttest and closing survey
- Four different interventions:

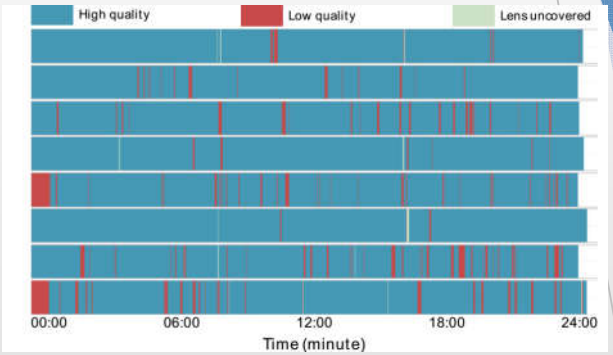
  1: No-review 2: Full review 3: Adaptive review 4: Counter-adaptive review

- **Learning Material:**
- Law (unfamiliar topic to avoid the effect of learners' prior knowledge)
- 3 topics/ each topic 8 min-lasted videos /24 min overall
- **Participants:**
- 32 learners. 8 learners for each group.

Results

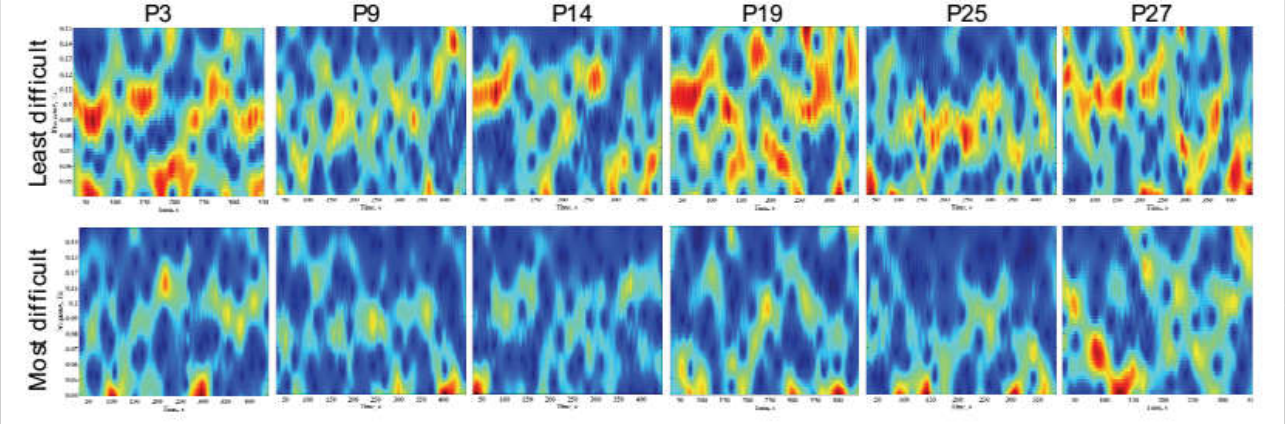


Usability of AttentiveReview: 3.72- 3.82 – 4.30 – 4.42



Average of **Signal Quality:** 93.7%

Heart rate variability spectrogram (LF and HF) of six participants



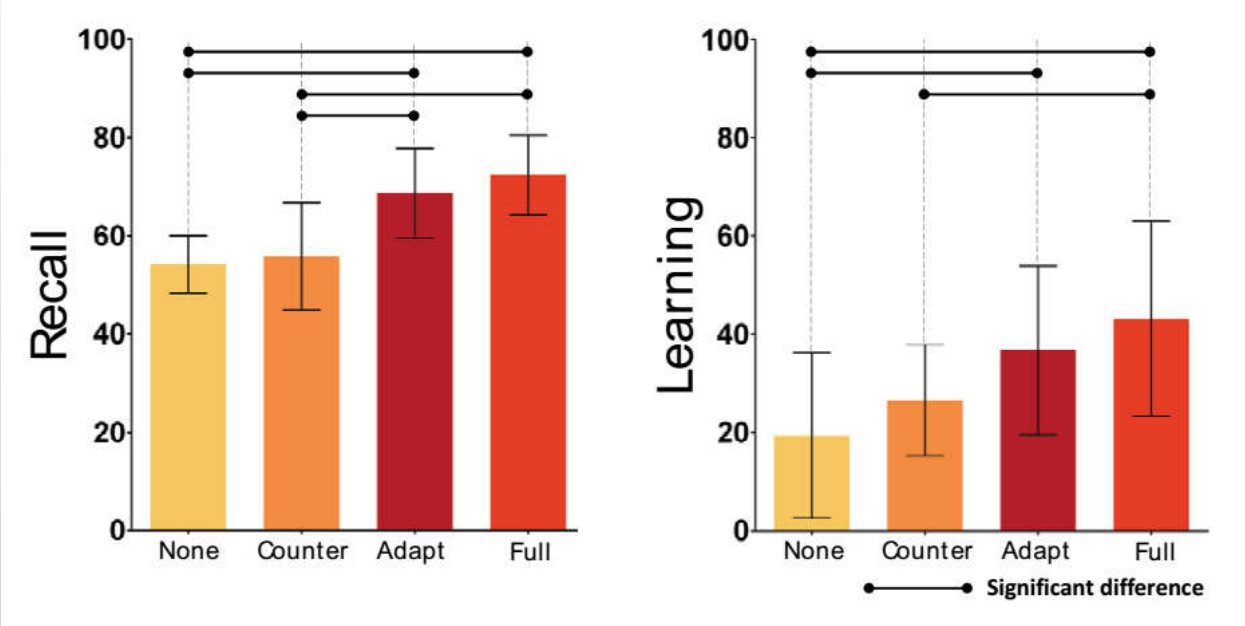
High frequency power reduced under stressful condition

Similar observations in learning difficult topics

Results

- **Learning Outcomes** of 4 groups:
- Adaptive review **significantly better** performances in both *Recall* and *Learning* than no review.
- Adaptive review **more efficient** in time than full review under comparable performance.

→ Adaptive review achieves equivalent cognitive learning performance as a full review, with 66.7% less review time

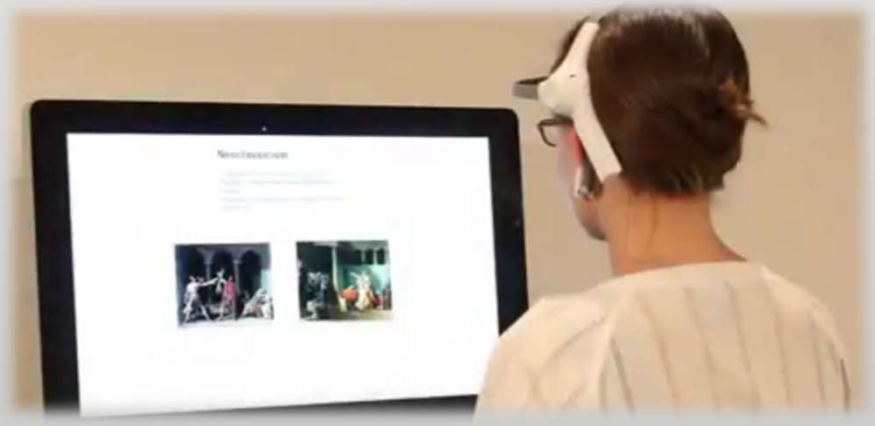


Discussion

- Supervised machine learning algorithm

  → accounted for **84.9%** of the variability in perceived difficulty levels.

- Using *deterministic metrics* such as *attention* index feature from EEG signals (e.g., ARTFul) to derive review recommendation ?
- How about intervention during learning process, instead of after learning ?



ARTFul Adaptive Review Tech(Szafir, & Mutlu, 2013)
(https://www.youtube.com/watch?v=MlU76hw-DCA)

Conclusion

AttentiveReview is;

- Intuitive and responsive to use
- Capture learners' PPG signals with high quality,
- Effectively recommend review materials improving learners' information recall and learning outcome
- Significantly improved **information recall** (+14.6%) and **learning gain** (+17.4%) when compared with the no review condition

For more information,

Please visit http://www.attentivelearner.com

Q/A

References

Afergan, D., Peck, E. M., Solovey, E. T., Jenkins, A., Hincks, S. W., Brown, E. T. & Jacob, R. J. (2014, April). Dynamic difficulty using brain metrics of workload. In *Proceedings of the 32nd annual ACM conference on Human factors in computing systems* (pp. 3797-3806). ACM.

D'Mello, S., Olney, A., Williams, C., & Hays, P. (2012). Gaze tutor: A gaze-reactive intelligent tutoring system. *International Journal of human-computer studies*, *70*(5), 377-398.

Hjortskov, N., Rissén, D., Blangsted, A. K., Fallentin, N., Lundberg, U., & Søgaard, K. (2004). The effect of mental stress on heart rate variability and blood pressure during computer work. *European journal of applied physiology*, *92*(1-2), 84-89.

Lyu, Y., Luo, X., Zhou, J., Yu, C., Miao, C., Wang, T., ... & Kameyama, K. I. (2015, April). Measuring photoplethysmogram-based stress-induced vascular response index to assess cognitive load and stress. In *Proceedings of the 33rd Annual ACM Conference on Human Factors in Computing Systems* (pp. 857-866). ACM.

Pham, P., & Wang, J. (2015). AttentiveLearner: improving mobile MOOC learning via implicit heart rate tracking. In *International Conference on Artificial Intelligence in Education* (pp. 367-376). Springer International Publishing.

Szafir, D., & Mutlu, B. (2013, April). ARTFul: adaptive review technology for flipped learning. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1001-1010). ACM.

Woolf, B., Burleson, W., Arroyo, I., Dragon, T., Cooper, D., & Picard, R. (2009). Affect-aware tutors: recognising and responding to student affect. *International Journal of Learning Technology*, *4*(3-4), 129-164.

Xiao, X., & Wang, J. (2015, November). Towards attentive, bi-directional mooc learning on mobile devices. In *Proceedings of the 2015 ACM on International Conference on Multimodal Interaction* (pp. 163-170). ACM.