Summary: Education is moving online. During the global pandemic this ongoing process accelerated and educators leveraged existing online video content to supplement synchronous remote instruction. However, passive viewing of video often fails to engage students. We hypothesized that the level of attention to online video is predictive of the information student manage to retain. To test this, we measured eye gaze position in remote experiments, and electroencephalography (EEG) in the laboratory. We use inter subject correlation of these signals as a validated metric of attentional engagement with the video. We used dynamic and well-produced content that is widely available online for STEM disciplines. Results demonstrate that attention is not equally engaged across students, and that this is predictive of individual learning performance. Additionally, we prospectively tested interventions that aim to promote active viewing on an online platform. We find that interleaving questions, allowing rewind, and providing feedback all improve performance. However, these interventions came at a cost of additional time investment of the learner, which only helped low performing individuals. Future experiments will test additional interventions that promote active viewing, and will test the hypothesis that performance gains are mediated by enhanced attentional engagement with the videos.

Experimental design: Attention (ISC) Performance (test score)

A first video is presented while assessing attention (using ISC of eye movements or EEG). This is followed by a corresponding test. This baseline is used to identify participants with high and low baseline attention (or performance). All participants are then randomized into a control condition (passive viewing) or an intervention condition (active viewing).

Possible outcomes:

(A) Here low attending students benefit from the intervention more than attentive students in terms of test score (an interaction in the 2x2 design). The ISC metric replicates this pattern suggesting that effect is mediated by attention (B). Here all students benefit from the intervention equally, but ISC does not increase, suggesting the effect is not mediated by attention.

Interleaving questions in video playback improves performance, but more time only helps participants with low baseline performance.

Performance is higher for attentive students, but it is hard to improve attention to video.

Attentional engagement can be measured remotely with eye tracking

A first video is presented while assessing attention (using ISC of eye movements or EEG). This is followed by a corresponding test. This baseline is used to identify participants with high and low baseline attention (or performance). All participants are then randomized into a control condition (passive viewing) or an intervention condition (active viewing).

Attentional engagement with video is predictive of test taking performance

Subject 3 (green) does not. (C) The same experiment was performed online recruiting subjects on Prolific using conventional web cameras to measure eye movements. ISC-eye is measured for each of N=203 subjects by correlating with the median eye/pupil traces recorded in the lab (i.e. traces from the remote subjects do not need to be transmitted). (D) After viewing the video attentively (A - distraction) ISC-EEG varies significantly across participants. Here we test three interventions remotely in three different RCTs (N=200 participants in total, recruited on Prolific). Low and high baseline performance groups (blue and red) are determined by a median split across participants.

Attentional state and individual traits correlate with test scores.

Correlation coefficient (r) across students indicated as light blue arrows (* p<0.05). Attentional engagement is measured as ISC-EEG during passive viewing of the video. Performance is measured as a test score with multiple choice questions about material presented in those videos. Individual student traits here were limited to working memory capacity (WMC; measured with the DigitSpan task) and grade point average (GPA in their UG major).