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The use of eye tracking for analyzing students' attention, emotional, and cognitive load

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Eye tracking feedback on student learning

- Long fixations and regressions may signal **difficult lexical access**. Lecturer may decide how much time should be allocated to users for looking at certain AOIs.

- Learners with **stronger visual memory** but weaker verbal processing capabilities are likely to spend **more time looking at pictures** rather than at text.

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Eye tracking feedback on student learning

- **Body temperature decreases during calculations** and **increases at the end** of the task. **Pupil size increases at the beginning** of a task and **goes back** to its initial dimension **at the end**.

- **Pupil size** is directly correlated with the **cognitive effort**. It is **significantly larger** after **highly arousing** positive and negative **stimuli** than after neutral stimuli with medium arousal.

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Eye tracking feedback on student learning

- Cognitive load evaluation considers **blink rate**, **pupil size** and **fixation** data.

- During **searching**, the cognitive load is **higher**: saccades and blinks almost disappear, and pupil size is very large.

- **Saccadic rate decreases** from **preparation**, to **viewing**, to **searching**.

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Eye tracking feedback on student learning

- Towards **the end** of the task, the **number of pupil dilations decreases**, but the **average pupil diameter increases**. **Smaller pupil dilations** towards the end of the task are known to be a sign of **tiredness**.

- The average **length of fixations** is **lower in visual tasks** compared to textual tasks.

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Eye tracking feedback on student learning

- Most **peaks in pupil size match** relevant user "**behaviors**": when a solution is discarded because recognized as wrong, or when the user recognizes the right choice, just before saying it out loud.

- Graphs for "**impossible problems**" have **many fluctuations**, although meaningful peaks in pupil size can be still identified. Numerous **peaks in pupil size without** the right **answer** indicate **user difficulties**.

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Better learning from educational video

(1) The onscreen instructor draws graphics on the board while lecturing (*dynamic drawing principle*).

(2) The onscreen instructor shifts eye gaze between the audience and the board while lecturing (*gaze guidance principle*).

Mayer, R.E., Fiorella, L. & Stull, A. Five ways to increase the effectiveness of instructional video. *Education Tech Research Dev* 68, 837–852 (2020).

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Better learning from educational video

(3) The lesson contains prompts to engage in summarizing or explaining the material (*generative activity principle*).

(4) A demonstration is filmed from a first-person perspective (*perspective principle*).

(5) Subtitles are added to a narrated video that contains speech in the learner's second language (*subtitle principle*).

Mayer et al. (2020)

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Instructor presence in video

"There are many open questions regarding the role of **instructor presence** in the design of video lectures, including the extent to which the instructor should be **visible to the audience**, the level of instructor **realism** (i.e., a human, robot, or animated agent), and which aspects of the instructor's **body** should be **visible** (i.e., full body, head, or hands)." (p. 264)

Stull, A.T., Fiorella, L., Mayer, R. E. An eye-tracking analysis of instructor presence in video lectures, *Computers in Human Behavior,* 88 (2018), pp. 263-272.

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Instructor presence in video

"For example, the presence of the instructor rather than the voice-only narration, contributes to **positive perceptions** of learning and **satisfaction** while **lowering mental effort** although other research has shown **no learning difference** with the presence or absence of an instructor and yet others show the presence of the instructor to be **distracting**." (Stull et al., 2018, p. 264)

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Instructor presence in video

"Regarding the level of realism of the instructor, studies have suggested that students prefer **real human instructors** over animated humans although others have found that **animated robots** are preferred over real robots which suggests that realism may not be the most relevant characteristic to investigate." (Stull et al., 2018, p. 264)

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Instructor presence in video

"As an exogenous cue, the **instructor's eye-gaze automatically draws and directs attention**. When performed too frequently, a student's attention may be drawn away from important information without suitable time for that information to be organized and integrated for long-term learning. For these reasons, effective instruction should **minimize access to the instructor's face in video** lectures, and **when** the instructor is **visible**, should **implement eye gaze cues in a strategic manner**." (Stull et al., 2018, p. 264)

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Instructor presence in video

"We found that **eye movements** during watching of instructional videos are **similar between students**, in particular if they are **paying attention**. The effect of attention is strong, allowing one to detect with a few minutes of gaze-position data whether the student is distracted." (p. 4)

J. Madsen, S.U. Júlio, P.J. Gucik, R. Steinberg, L.C. Parra, Synchronized eye movements predict test scores in online video education *Proceedings of the National Academy of Sciences*, 118 (2021).

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Instructor presence in video

"Students **performed well** in subsequent quizzes if their **eyes followed the material** presented during the video in a **stereotypical pattern**. We replicated this finding in two subsequent laboratory experiments, where we confirmed that the effect persists when students do not expect to be quizzed and that the effect of **attention does not depend on the specific type of video or the type of questions asked**." (Madsen et al., 2021, p. 4)

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Instructor presence in video

"Thus, we conclude that one can detect students' attentional engagement during online education with readily available technology. In fact, we can **predict how well students will perform** on a test related to an instructional video, by **looking at their eye movements** while maintaining online privacy. (Madsen et al., 2021, pp. 4-5)

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Eye tracking: action plan

1. Literature analysis
2. Design of valid experiments, pre- and post quizzes, interviews
3. Creation of sample video materials by lecturers and students
4. Testing sample videos on lecturers and students
5. Simple post-video quizzes or interviews to assess learning and knowledge retention
6. Analysis of eye-tracking data and quizzes
7. Recommendations to lecturers

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Eye tracking: testing and analysing videos

Creation of sample video materials by lecturers and students

- with/without lecturer/combination of these;
- dynamic writing/prepared slides/combination of these;
- writing on a board/tablet/pc/ combination of these.

1. Testing sample videos on lecturers and students
2. Simple post-video quizzes or interviews to assess learning and knowledge retention
3. Analysis of own experience and recommendations to lecturers

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Coming next: sample video

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