Metrics of Meaning in Eye-Tracking Research

How Hyper-Personalized Feedback Changes the Face of Chemistry Education

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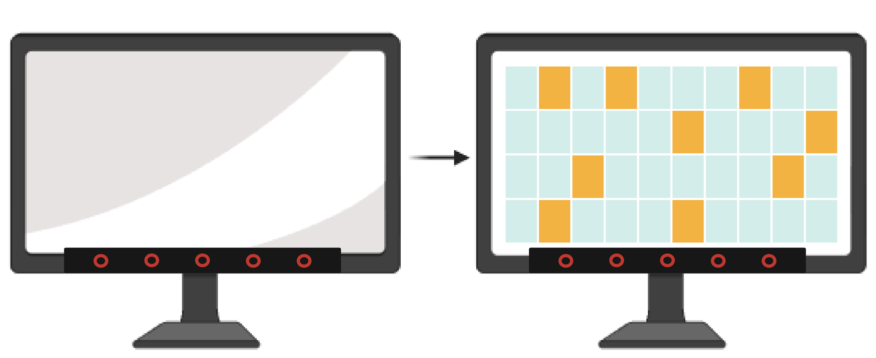
INTRODUCTION

When approaching a challenging chemistry problem with diagrams, text, graphs, and equations, an individual's **gaze often skips** over critical information. It is unlikely for a learner to answer a problem correctly if they have not viewed the necessary elements. (Even now, your eyes darted to the bold text before reading the first line.)

The RevChem Collaborative Research project employs eye-tracking technology to **inform artificially intelligent cues** and **improve problem-solving performance**. An eye-tracking system has the unique ability to uncover a participant's viewing strategies. Analyzing where learners look at a chemistry problem illuminates how individuals effectively or ineffectively observe, approach, and persevere through challenging content.

METHODS



• In the third and final phase of the project, RevChem is investigating how a **Google Sheets "decider"** can interpret eye-tracking data to identify the greatest gaps between the time a participant focuses on an important element and the average fixation time required by successful problem-solvers.

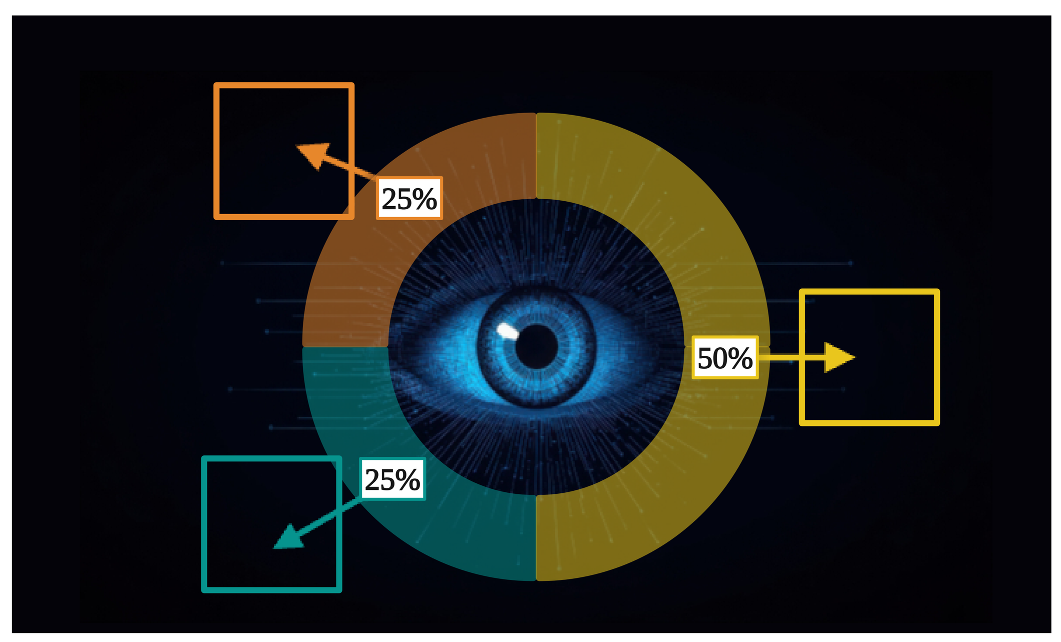
• After solving three chemistry questions, participants are presented with a set of new questions where the formatting has been preserved.

• Critical elements that received insufficient attention in the original problems are now boxed in yellow, allowing the decider to provide rapid feedback based on the individual's visual problem-solving strategies.

NEW METHODS

R Studio was also assessed for its ability to expedite data analysis for former and future phases using new metrics:

(1) Percentage of Fixation Duration



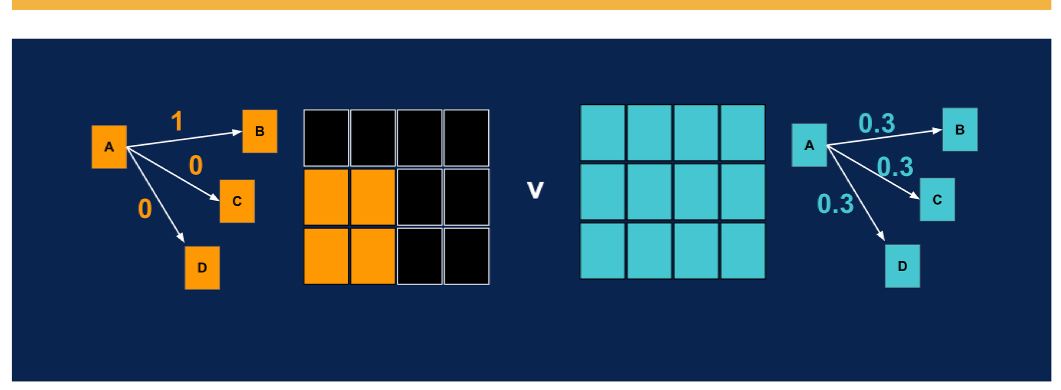
Contextualizes the portion of the time a participant focuses their gaze on one particular Area of Interest in a chemistry problem.

(2) Transition Probability Matrix

	A	B	bottom	C	D	E	equation	top
A	0.000	0.000	0.333	0.444	0.000	0.000	0.222	0.000
B	0.182	0.000	0.364	0.182	0.000	0.182	0.091	0.000
bottom	0.040	0.160	0.000	0.080	0.000	0.040	0.560	0.120
C	0.083	0.167	0.250	0.000	0.167	0.083	0.167	0.083
D	0.000	0.000	0.000	0.000	0.000	0.500	0.500	0.000
E	0.286	0.143	0.143	0.286	0.000	0.000	0.143	0.000
equation	0.120	0.120	0.400	0.080	0.000	0.080	0.000	0.200
top	0.000	0.111	0.444	0.000	0.000	0.000	0.444	0.000

Analyzes the likelihood of making a transition to each Area of Interest that exists from a given starting point.

(3) Entropy

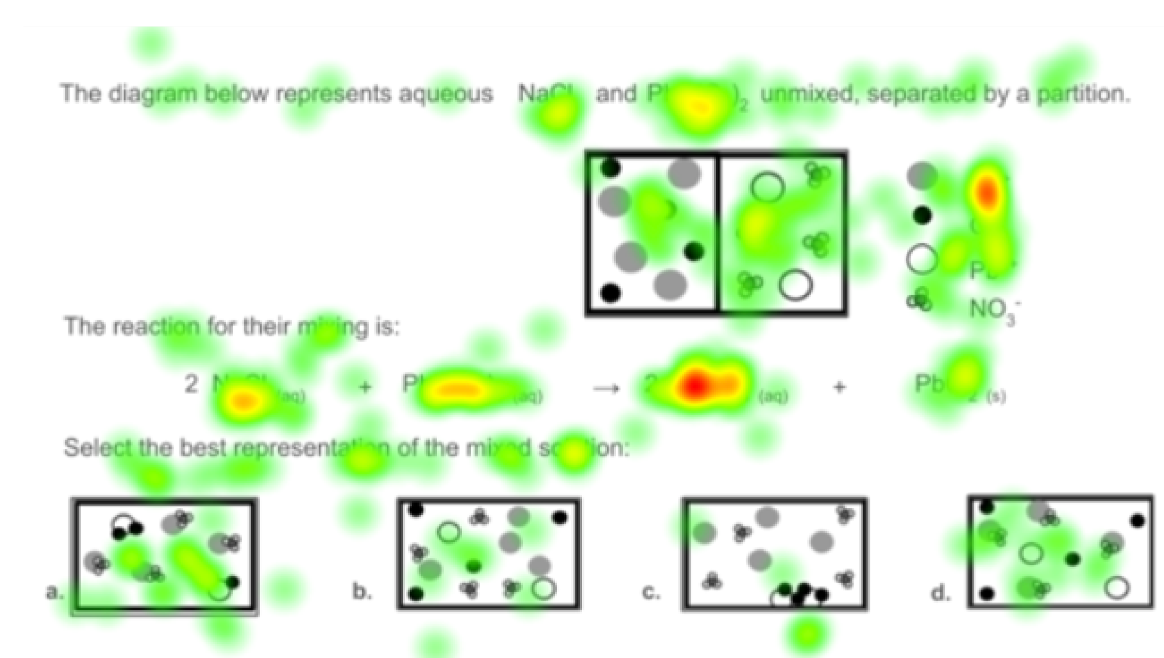


Measures the uncertainty associated with visual fixations or transitions between Areas of Interest.

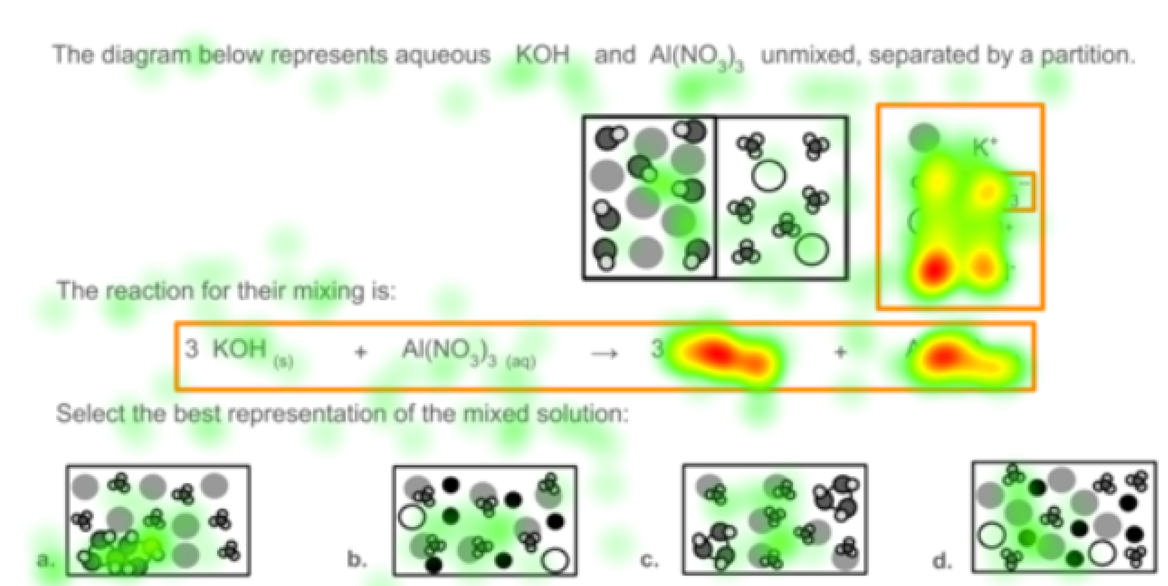
Low entropy: more concentrated and informed viewing strategies
High entropy: indicates higher "search" behavior and cognitive load

PRELIMINARY RESULTS

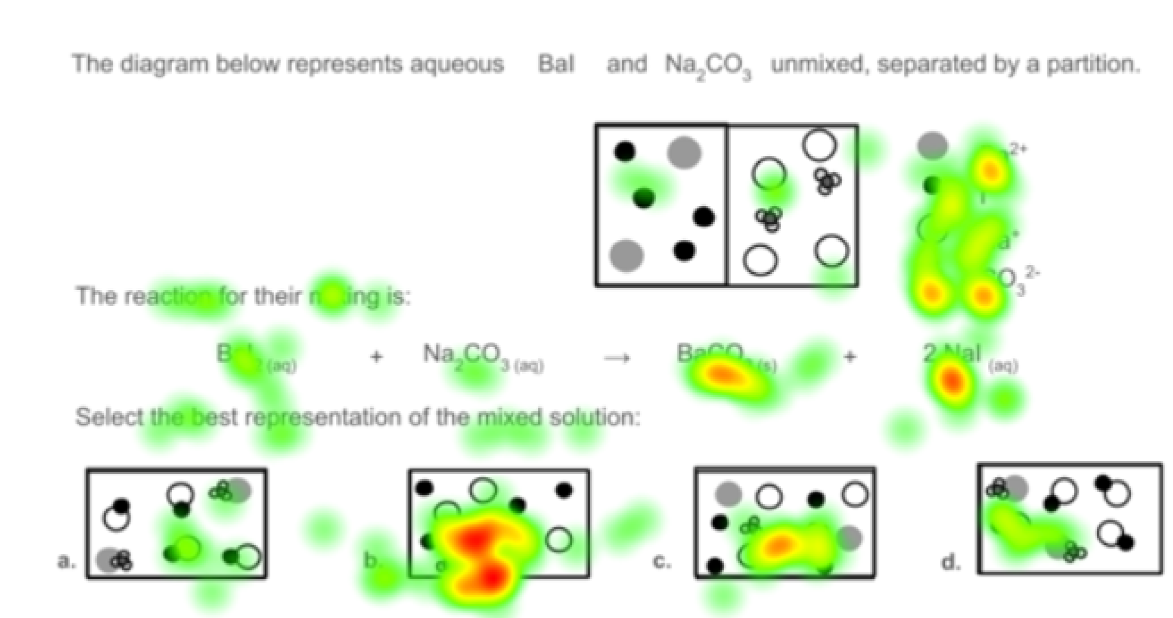
1. Heat map showing participant focus upon first exposure to a chemistry problem: **No guided viewing**



2. Participant focus upon exposure to a similar chemistry problem: **Google Sheets "decider" crafts** yellow cue boxes where fixation was lacking in the original problem



3. Participant focus upon exposure to a second similar chemistry problem: **No guided viewing**



Viewing behavior appears to have changed; Improvement in critical Area of Interest focus

CONCLUSION

WHERE LEARNERS LOOK MATTERS

It is a common misconception when a student answers a question incorrectly that they do not know *how* to solve the problem, yet the student may have all the tools they need, have studied the question intently, and produce an incorrect answer simply because they **skipped over** a single element in the prompt.

Preliminary findings have already indicated the viewing behavioral changes participants may make when encouraged to take on a new point of view. Even reiterating to students the need to **read carefully and scan the subtext** can make a monumental difference in problem-solving performance.

SELECTED REFERENCES

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A complete source list can be found in the attached project report.