Studying Problem-Solving in a Dynamic Game Environment Using Eye-Tracking

Educational Psychology
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Background

The Problem-Solving Environment

The problem-solving environment under investigation is the commercially available game Baba is You. Baba is You has a unique blend of well-defined and complex problem elements, such as having a limited number of solutions and the player being initially unaware of the dynamic interaction between game rules and components. The dynamic, visible rule structure in Baba is You is an auspicious environment for eye tracking that is different from the static, well-defined problem spaces typically studied in the past.

Benefits of Eye Tracking in This Context

Eye tracking is a semi-continuous indicator of cognitive processing that allows players to play Baba is You without any additional processing demands [8]. Eye tracking also is informative about what the participants are perceiving to be task relevant (e.g., what rules) and where attention is being allocated. Finally, eye tracking taps into unconsciousness processes that can not be access through other methods (e.g., talk-aloud protocols), and it provides a high level of detail for deep analysis [5].

Limitations of Eye Tracking in This Context

The primary assumption accompanying eye tracking is the eye-mind hypothesis [6], meaning what is being fixated on is what is being processed. In other words, if I am looking at the rule "KEY IS PULL" in Figure 1, I am actively processing that rule. For this context, it is helpful that the visual environment is conducive to the task at hand [2]. A second limitation is fixation does not equal comprehension—that is, long periods of looking at a rule does not mean understanding of that rule has been attained. This second limitation is why it is important to incorporate other measures with eye tracking that tap into the end product of learning [2].

Method/Design

Participants/Procedure

Approximately 12-15 undergraduate students from the University of Minnesota will be asked to play the video game Baba is You for two one-hour problem-solving play sessions while their eye-movements are tracked with the Eye Link II (SR Research) headband-mounted eye tracker. Play sessions include a 10-minute setup period and two 20-minute play periods with a 5 min break after the first 20 minutes. Video and audio data of the participants talking out loud will be collected concurrently with the eye gaze data.

Three Methodological Features

Defining Areas of Interest (AOIs)

Although the methods for defining AOIs have been diverse [1], there have been two dominant ways used in prior research : (a) through algorithms and (b) manually using software (e.g., [7] and [3]). The novel approach used in the current study is to convert the log data of player's actions to a readable file imported to the eye tracking software.

```
ID,Global timestamp,Timestamp,Event type,Event,Level,Details
ZackTesting,0:0:9.76667:76,0:0:0:0,event,start,177level,
ZackTesting,0:0:9.76667:76,0:0:0:0,event,init_object,177level:1. the lake,algae:1:1
ZackTesting,0:0:9.76667:76,0:0:0:0,event,init_object,177level:1. the lake,algae:1:2
ZackTesting,0:0:9.76667:76,0:0:0:0,event,init_object,177level:1. the lake,hedge:1:3
ZackTesting,0:0:9.76667:76,0:0:0:0,event,init_object,177level:1. the lake,hedge:1:10
ZackTesting,0:0:9.76667:76,0:0:0:0,event,init_object,177level:1. the lake,hedge:1:14
ZackTesting,0:0:9.76667:76,0:0:0:0,event,init_object,177level:1. the lake,algae:2:1
ZackTesting,0:0:9.76667:76,0:0:0:0,event,init_object,177level:1. the lake,algae:2:2
```

Figure 1. An example of log system data (top) and a defined AOI in Baba is You (bottom).

Combining Measures

Based on the recommendation of [2], the study will include eye tracking with verbal protocols. Combining these two measures can inform different aspects of the problem-solving process. For example, if someone says, "I am trying to think about what to do.", the eye tracking data will clearly show the rules under consideration.

Time-locked Analyses

Many eye tracking studies use quantitative analyses [4], and [2] further suggested that analyzing specific time intervals across a trial is informative about the changes in processing at different points in time (i.e., time-locked analyses). Eye gaze data will be analyzed using both quantitative and qualitative methods. Qualitatively, a novel problem-solving framework will be used to investigate eye movements at specific points in time in the problem-solving process. For example, if the player notices a deviation in their approach (a move that is coded in our transcripts), the point in time that this move occurred will be used as a point of departure for further eye movement analyses.

The Problem-Solving Framework

Action Revision

What goals are the player pursuing? What rules are they focusing on using? What prediction are they making?

Noticing Deviation

Does the player notice anything deviating from their approach that warrants addressing? How do they describe the deviation?

Causal Explanation

What from the game's rules does the player position as responsible for the observed deviation?

1:29	BH.01: {I wonder if I could try rock is win {((starts moving ROCK into place at FLAG IS WIN))
1:34	BH.01: See if that's (2.0)
1:37	BH.01: { (.) } {ROCK(FLAG/)-IS-WIN)}
1:38	BH.01: {(5.0) {((walks baba to rock icons))
1:44	BH.01: {(.) {((baba positioned on rock))
1:45	BH.01: I just keep going right through it
1:48	Basel: Why do you think uhm you're going through stuff
1:54	BH.01: (Well::) I am floating (.) but I {don't } know if that's the ca:se {FLAG(ROCK/)-IS-WIN)}

Expected Outcomes

Data collection will be conducted in the spring of 2022. By gathering eye movement, log, and talk-aloud data, we are anticipating a rich dataset. The strength and weaknesses of these measures will work together to paint a more complete picture of the complexities of the problem-solving process.

References

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