AECT 2014

Using Eye-Tracking for Serious Game Analytics

Citation:

Byun, J. H., Loh, C. S., & Zhou, T. (Nov 2014). *Assessing play-learners' performance in serious game environments by using* in situ *data: Using eye tracking for Serious Game Analytics.* Paper presented at the Annual Conference of the Association for Educational Communications and Technology (AECT), Jacksonville, FL. (http://www.csloh.com/research/publications/)

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- Purpose of the Study
- Research Question
- Game Environment
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- Conclusion

Virtual Environment Lab (V-Lab)

- http://www.csloh.com/research/v-lab/
- Established 2009
- Research in performance assessment with virtual training environment
- *Information Trail* © - *in situ* assessment framework
- Data visualization
- Serious Games Analytics

BACKGROUND OF THE STUDY

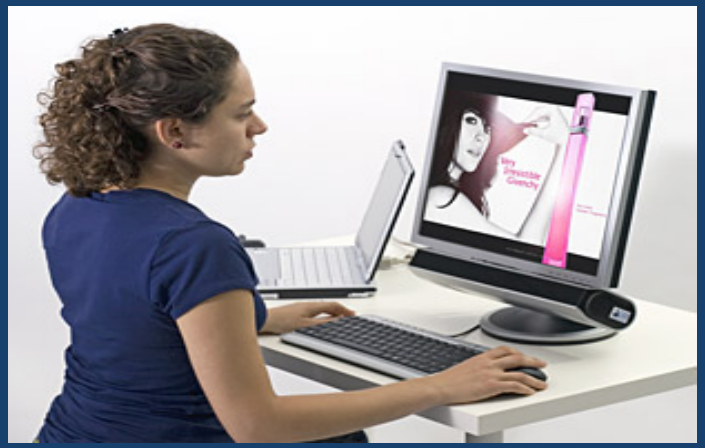
- Types of Game Assessment

Game Scoring	• Target acquired (Baker, Niemi, & Chung, 2008) • Obstacles overcome • Time for completion (Reese & Tabachnick, 2011)
External (*ex situ*) Assessment	• Formative Summative Assessment • (De-)briefing (Chin et al., 2009; Ifenthaler, 2009), After Action Review (AAR) • MC-Test, Essay, Test Scores (Schrader & McCreey, 2008) • Knowledge maps, Casual diagrams (O'Neil & Lang, 2008, Spector & Koszalka, 2004)
Embedded (*in situ*) Assessment	• Not interrupting the game • Click-streams, log-files (Chung & Baker, 2003; Dummer & Ifenthaler, 2005) • Information Trails© (Loh, 2007, 2012; Loh, Anantachai, Byun, Lenox, 2007; Loh & Li, 2010)

(Ifenthaler, Eseryel, & Ge, 2012)

BACKGROUND OF THE STUDY

- Eye Tracking
  - the process of recording gaze/eye movement, (micro saccade, fixation, scan path etc.) i.e., the way in which a person observes a scene, using a video-based device, eye-tracker

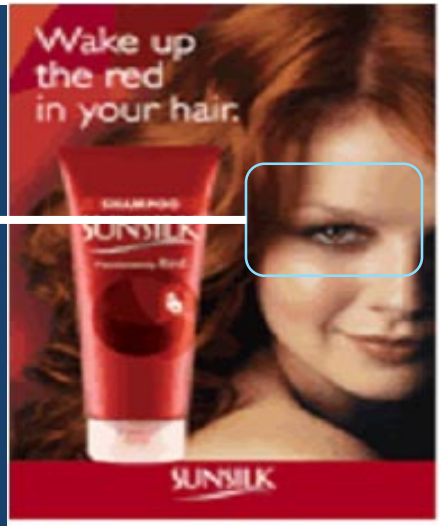


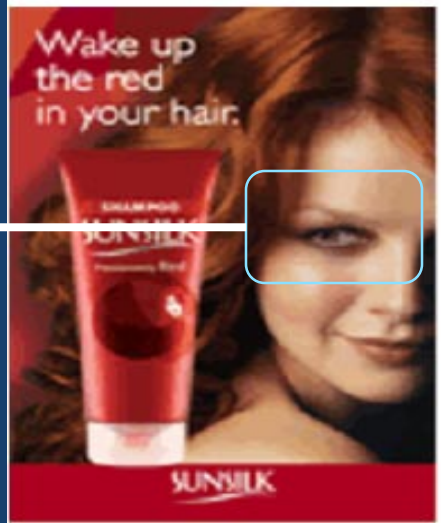
(Ristovski, Hunter, Olk, & Limsen, 2013).

BACKGROUND OF THE STUDY

- Eye Tracking
  - In Marketing

Eyes can guide your eyes





BACKGROUND OF THE STUDY

- Eye Tracking
  - In Human Computer Interaction (HCI)

The F-shape reading pattern of Website users

BACKGROUND OF THE STUDY

USE OF EYE TRACKING IN GAME STUDY

Jennet, et al. (2008)

- Investigated players' immersion in First-person Shooting game
- Findings: Decrease of fixations per second in the immersive condition as compared to the increase seen in a non-immersive control condition

Kickmeier-Rust, Hillemann, and Albert (2011)

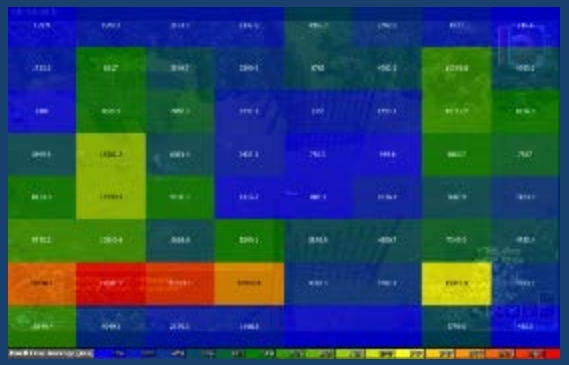
- Studied the usability of a game, learner satisfaction and learning efficacy by using eye-tracking
- Findings: High and low performers exhibit different visual patterns; Eye tracking could be successfully applied to measure critical aspects with regard to the quality of serious games

BACKGROUND OF THE STUDY

- Gap in the previous studies
  - Most existing studies focused on using eye tracking to understand *gameplay* (i.e., players' behavior) in relation to game design
  - Little investigation has been focused on how eye-tracking data can help us understand play-learners' behavior and (and possible assess) performance in Game-Based Learning environments

PURPOSE OF THE STUDY

- To investigate the use of eye-tracker for assessment in role-playing type serious games



RESEARCH QUESTION

- Can we use eye-tracker for performance assessment in role-playing type serious games?
  1. What kind of information can we obtain from eye-tracker?
  2. Is there any difference on eye-tracking data between expert and novice players? If so, is it possible to differentiate players' performance by analyzing the eye-tracking data?
  3. What are the benefits/pitfalls on using eye-tracking for assessment with role-playing type serious games?

GAME ENVIRONMENT

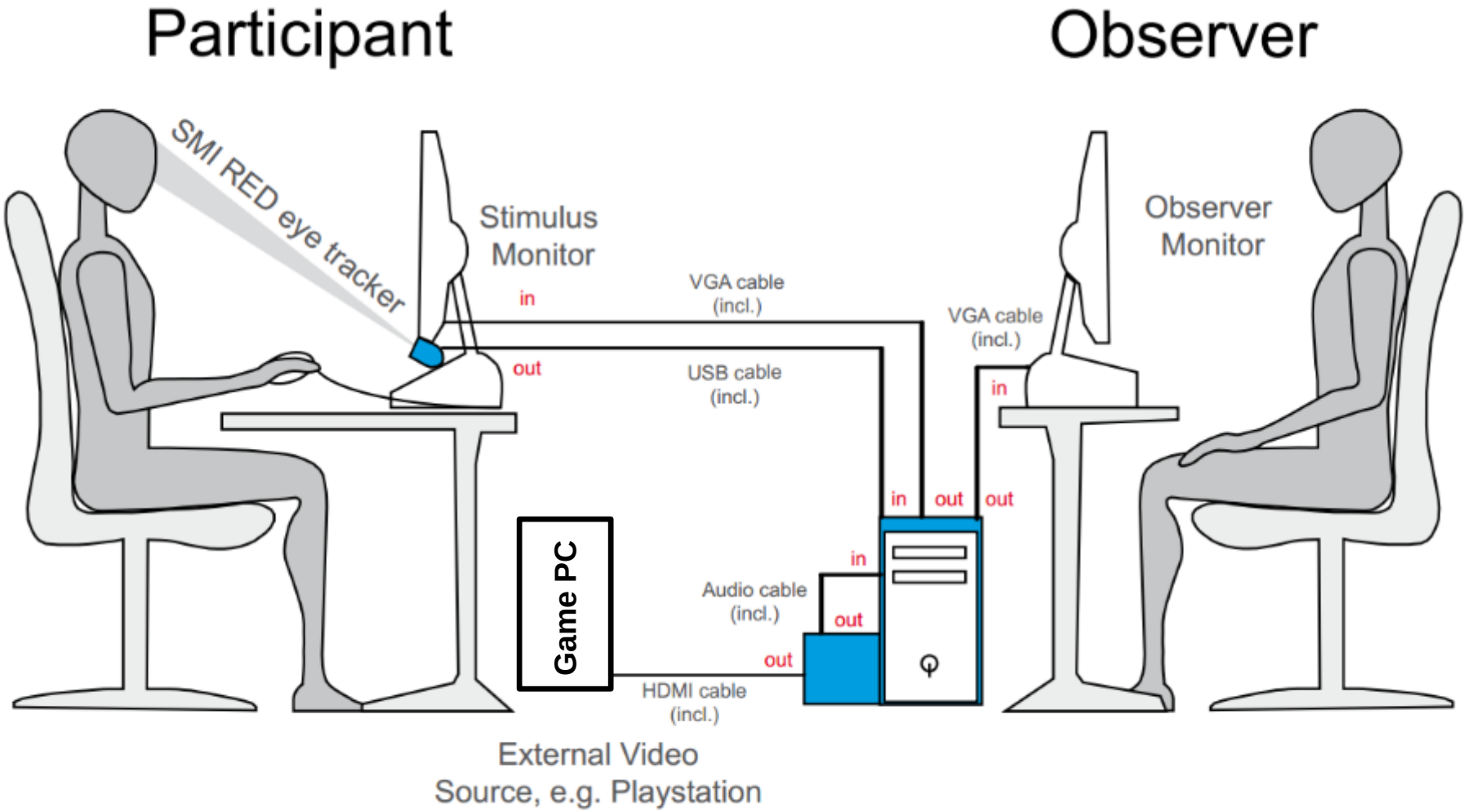
- Backstory:
  - It's time for you to join the rank of the village's Guardians. All you need to do is to pass the qualifying test. But wait, since your old man held the record to the Guardian challenge, you are also given the chance of your life to break his record. It sure is tough to be the Champion's kid… Do you have what it takes to be the new Champion?
- Goal of Game
  - Military-style Search and Rescue Mission:
  - Find 5 villagers and 1 blacksmith » Report to Mission Giver

GAME ENVIRONMENT

Found 1 villager.

Screenshot: "The Guardian" – by Christian S. Loh

EXPERIMENTAL SETTING



DATA COLLECTION

- Number of participants:
  - 3 Expert players (2 male, 1 female)
  - 3 Novice players: 1 male, 2 female
- Data collection process

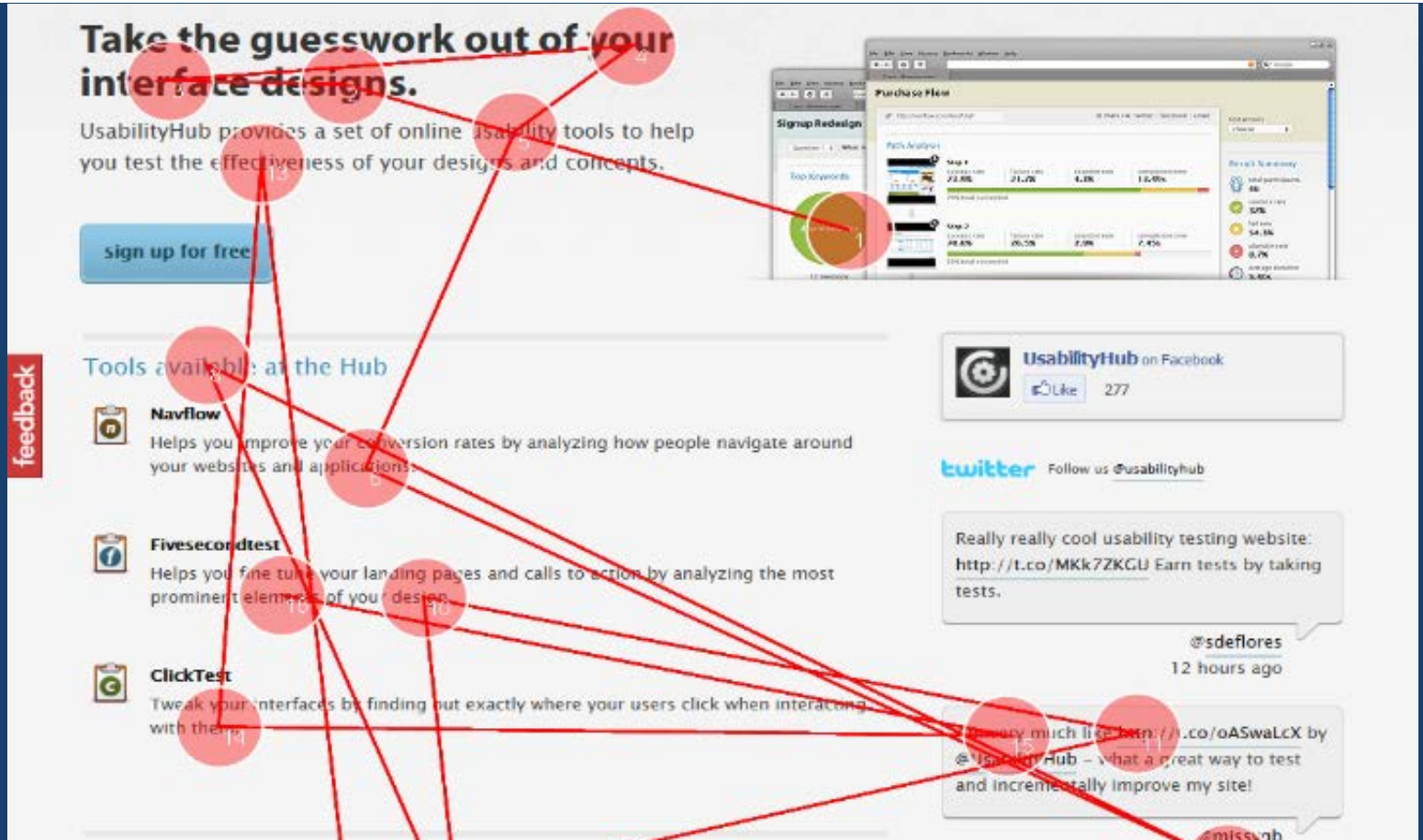
Enter	Consent	Instruction	Tutorial	Calibration	Play	Exit
V-Lab	Complete consent form	How to navigate the game area, control the avatar, communicate with NPCs, equip and use items, etc.	Play training module until familiar with gaming environment and input control	Eye-Tracker calibration when ready to begin data collection	the game until the game over message appears	V-lab

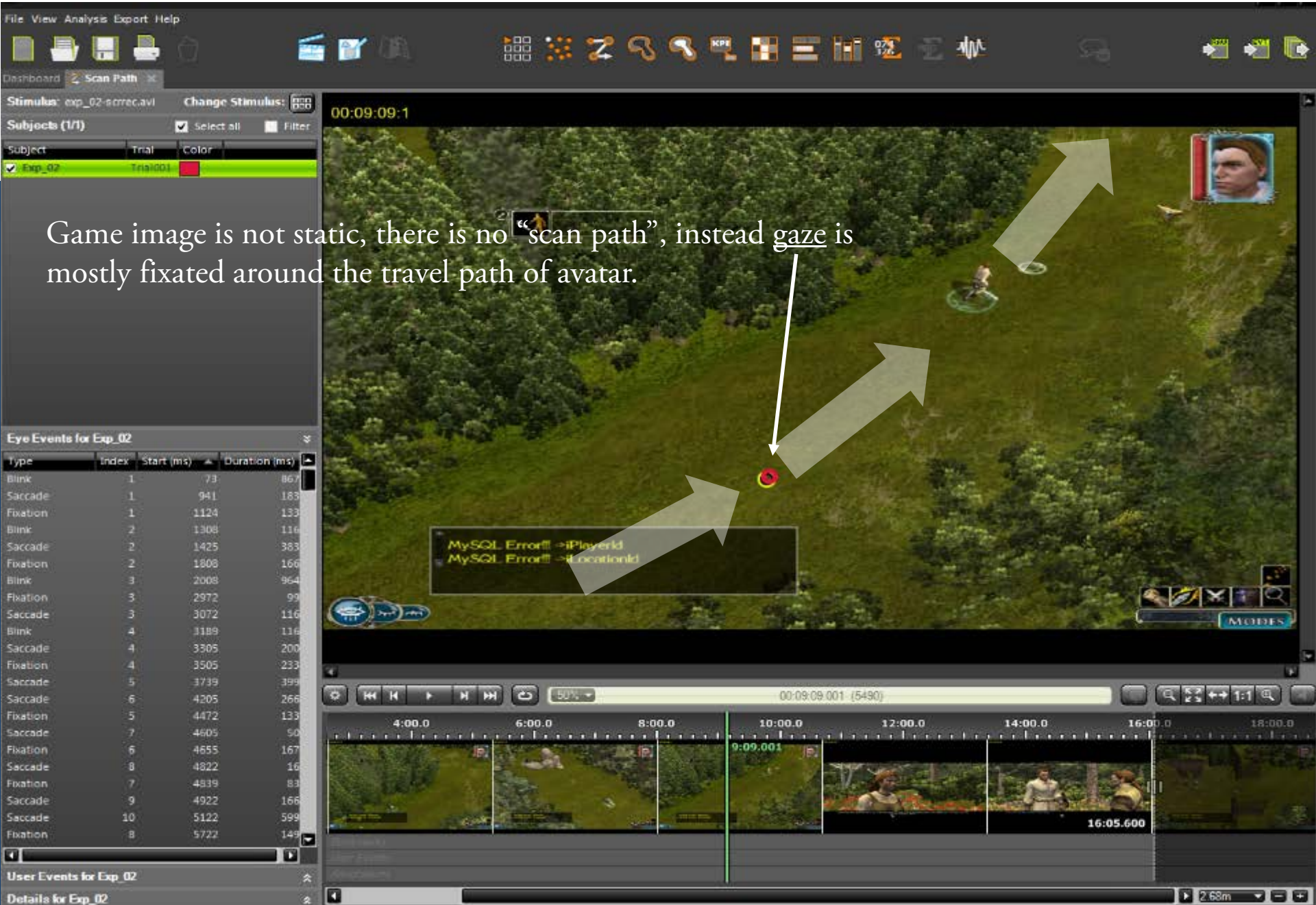
FINDINGS

- Research Question #1.
  - What kind of information can we obtain from eye-tracker?
    - *Scan Path*
    - *Attention Map*
    - *Key Performance Indicators*
    - *Gridded Area Of Interest (AOI)*
    - *AOI Sequence Chart*
    - *Binning Chart*
    - *Event Statistics (ES)*
    - *Line Graph*

INFORMATION #1

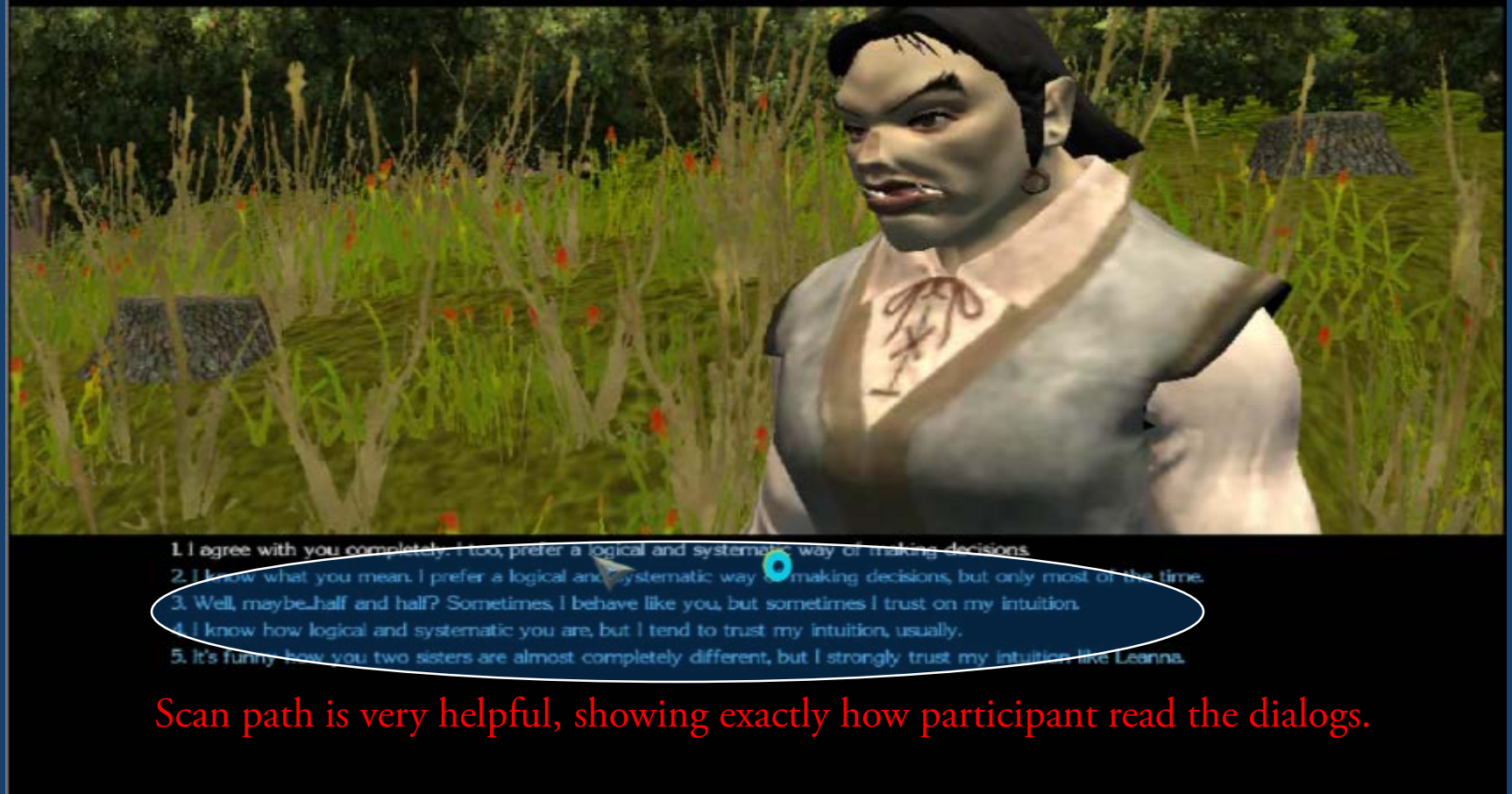
- Scan path
  - The visualized gaze data overlaid over the stimuli: image/video.




File View Analysis Export Help
Dashboard
Scan Path
Stimulus: exp_02-scrrec.avi
Change Stimulus:
Subjects (1/1)
Select all
Filter
Subject
Trial
Color
Exp_02
Trial001
00:09:09:1
Game image is not static, there is no "scan path", instead gaze is mostly fixated around the travel path of avatar.
Eye Events for Exp_02
Type
Index
Start (ms)
Duration (ms)
Blink 1 73 867
Saccade 1 941 183
Fixation 1 1124 133
Blink 2 1308 116
Saccade 2 1425 383
Fixation 2 1808 166
Blink 3 2008 964
Fixation 3 2972 99
Saccade 3 3072 116
Blink 4 3189 116
Saccade 4 3305 200
Fixation 4 3505 233
Saccade 5 3739 399
Saccade 6 4205 266
Fixation 5 4472 133
Saccade 7 4605 50
Fixation 6 4655 167
Saccade 8 4822 16
Fixation 7 4839 83
Saccade 9 4922 166
Saccade 10 5122 599
Fixation 8 5722 149
MySQL Error!! ->iPlayerId
MySQL Error!! ->iLocationId
MODES
00:09:09.001 (5490)
4:00.0
6:00.0
8:00.0
10:00.0
12:00.0
14:00.0
16:00.0
9:09.001
16:05.600
User Events for Exp_02
Details for Exp_02

id	player_name	conv_recipient	conv_member	conv_text	action_description	time
8	Alene Swift	NPC	Elder Meyer	Talk to NPC	Start Conversation	14:35:08:358
9	Alene Swift	NULL	NULL	NULL	Acquire Item	14:35:47:3547
10	Alene Swift	NULL	NULL	NULL	Acquire Item	14:35:50:3550
11	Alene Swift	NULL	NULL	NULL	Acquire Item	14:35:50:3550
12	Alene Swift	NULL	NULL	NULL	End Conversation	14:35:56:3556

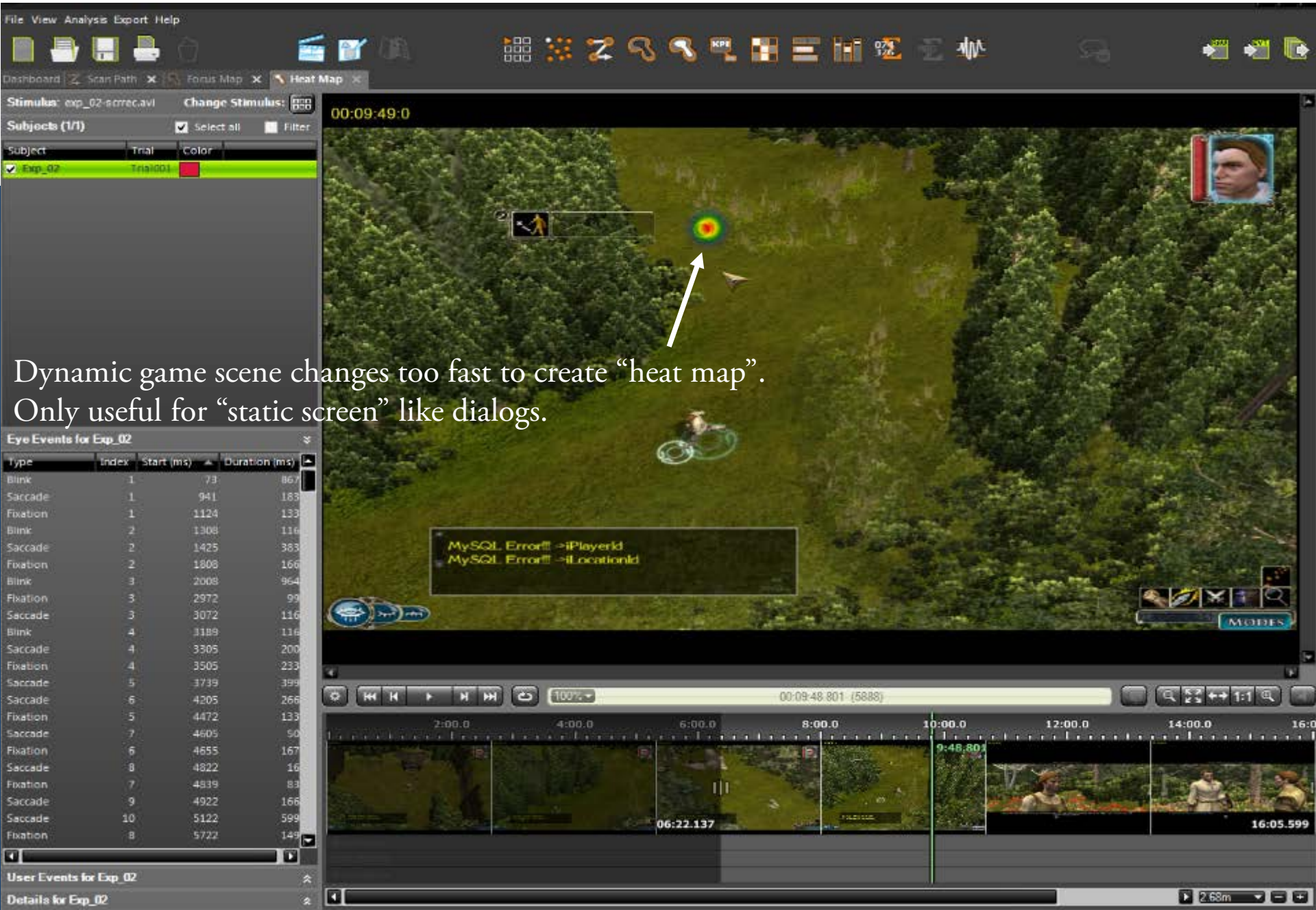
Game log is not very helpful, no way to tell how participant interact/read the dialogs.



Scan path is very helpful, showing exactly how participant read the dialogs.

INFORMATION #2

- Attention Map
  - The information showing gaze patterns over the stimulus image visualized as Heat map or Focus map

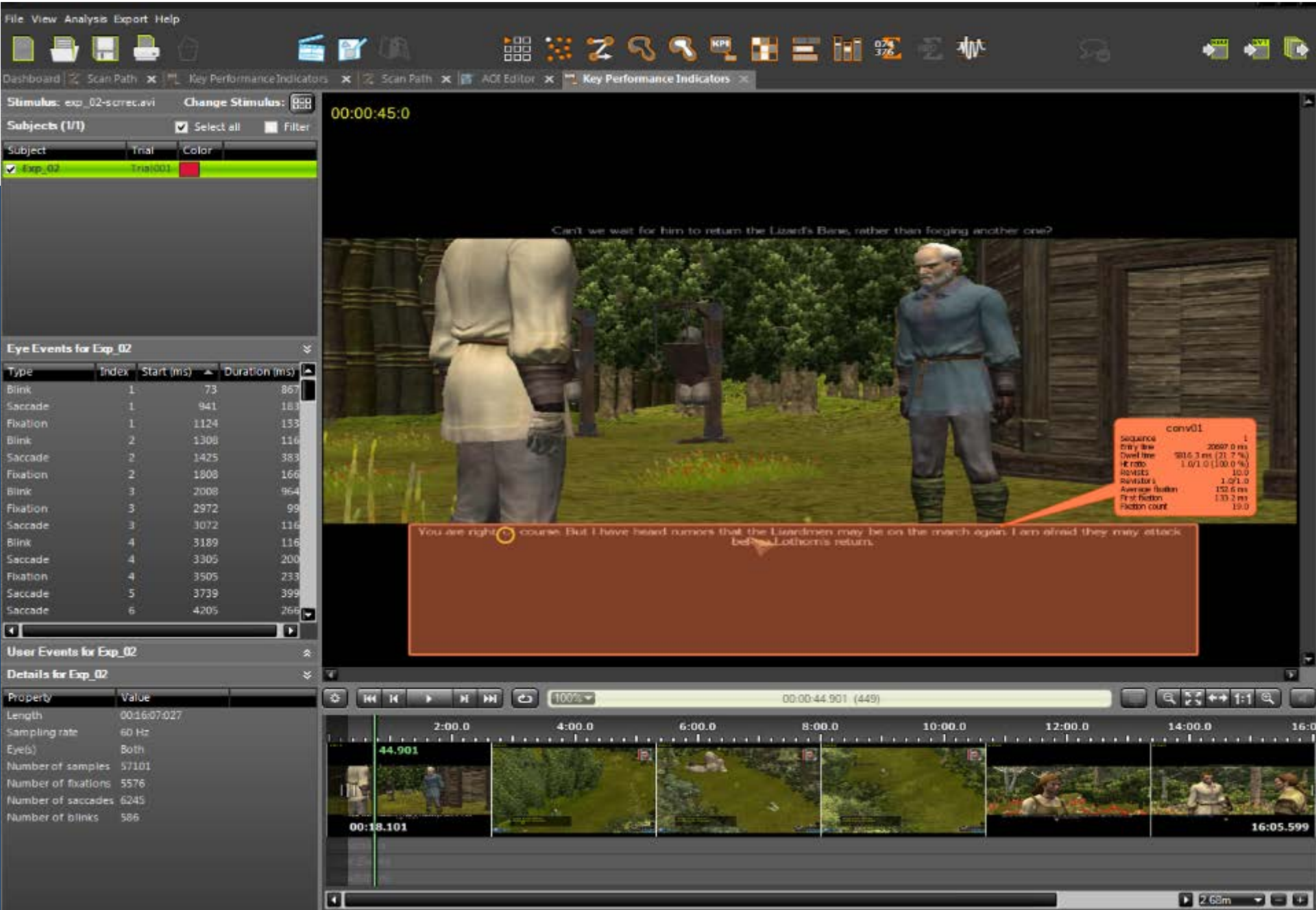


Dynamic game scene changes too fast to create “heat map”.
Only useful for “static screen” like dialogs.

INFORMATION #3

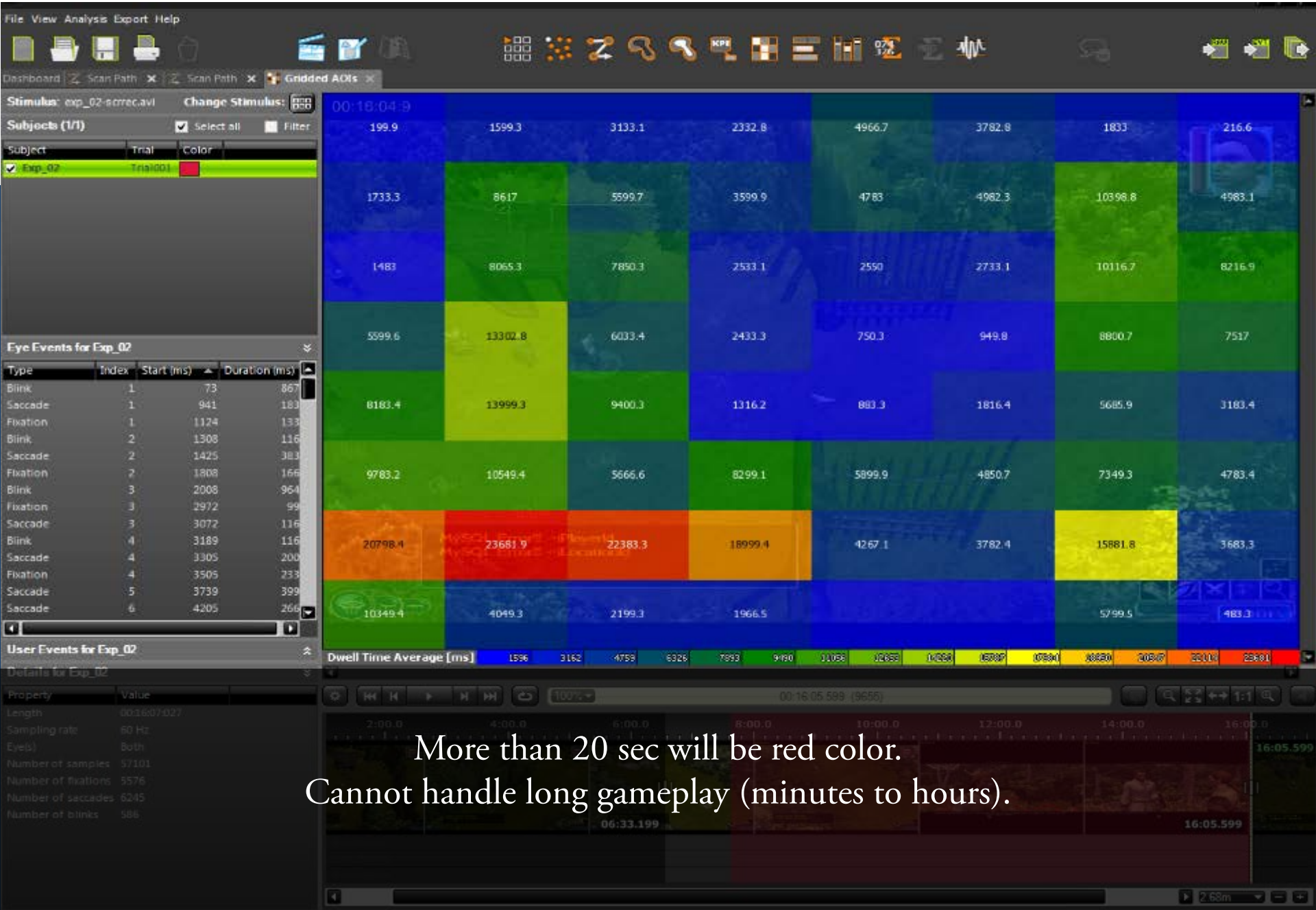
- Key Performance Indicators (KPI)
  - The data presenting relevant statistical data for each defined Area Of Interest (AOI) over the stimuli
    - Quantitative Data Type

- Entry time
- Dwell time
- Hit ratio
- Revisits
- Revisitors
- Average fixation
- First fixation
- Fixation count


File View Analysis Export Help
Dashboard
Scan Path
Key Performance Indicators
Scan Path
AOI Editor
Key Performance Indicators
Stimulus: exp_02-scrrec.avi
Change Stimulus:
Subjects (1/1)
Select all
Filter
Subject
Trial
Color
Exp_02
Trial001
00:00:45:0
Can't we wait for him to return the Lizard's Bane, rather than forging another one?
conv01
You are right, of course. But I have heard rumors that the Lizardmen may be on the march again. I am afraid they may attack
Eye Events for Exp_02
Type
Index
Start (ms)
Duration (ms)
Blink 1 73 867
Saccade 1 941 183
Fixation 1 1124 133
Blink 2 1308 116
Saccade 2 1425 383
Fixation 2 1808 166
Blink 3 2008 964
Fixation 3 2972 99
Saccade 3 3072 116
Blink 4 3189 116
Saccade 4 3305 200
Fixation 4 3505 233
Saccade 5 3739 399
Saccade 6 4205 266
User Events for Exp_02
Details for Exp_02
Property
Value
Length 00:16:07:027
Sampling rate 60 Hz
Eye(s) Both
Number of samples 57101
Number of fixations 5576
Number of saccades 6245
Number of blinks 586
00:00:44.901 (449)
2:00.0
4:00.0
6:00.0
8:00.0
10:00.0
12:00.0
14:00.0
44.901
00:18.101
16:05.599

INFORMATION #4

- Gridded AOI
  - Visualizing participants' gaze patterns and statistics parameters by altering the color of a grid of AOIs over the stimuli based on the amount of attention received

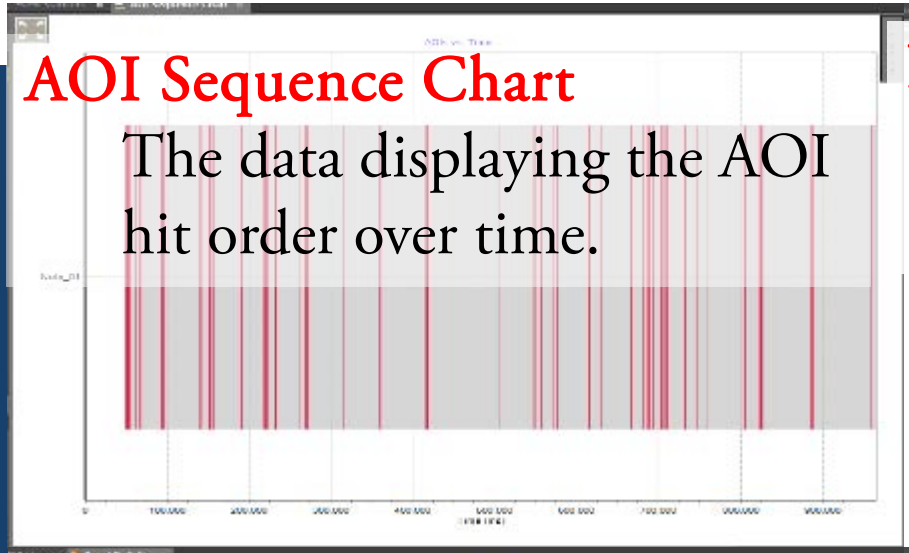


More than 20 sec will be red color.
Cannot handle long gameplay (minutes to hours).

OTHER INFORMATIONS

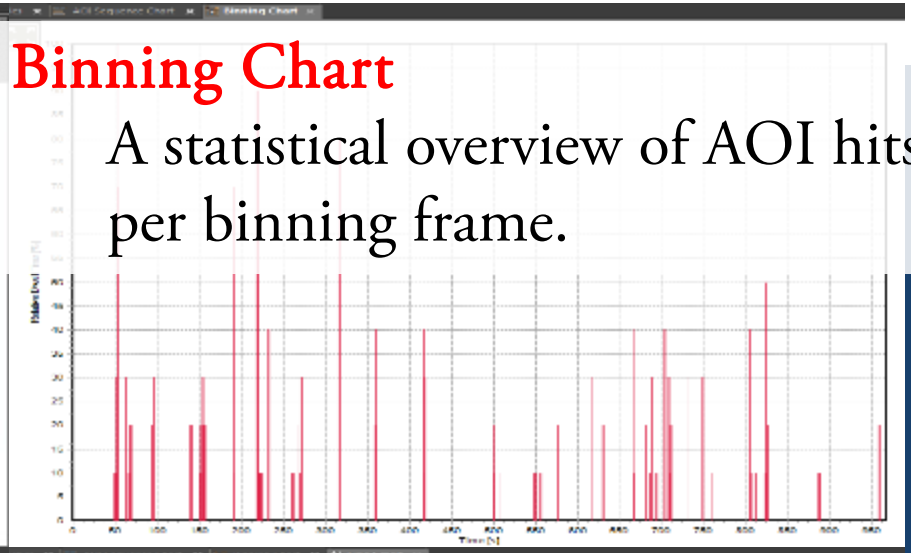
AOI Sequence Chart

The data displaying the AOI hit order over time.



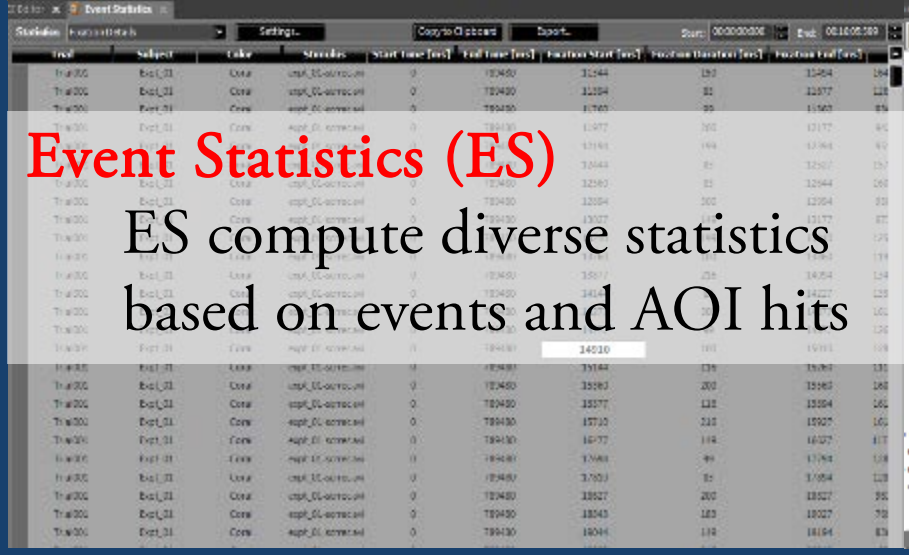
Binning Chart

A statistical overview of AOI hits per binning frame.



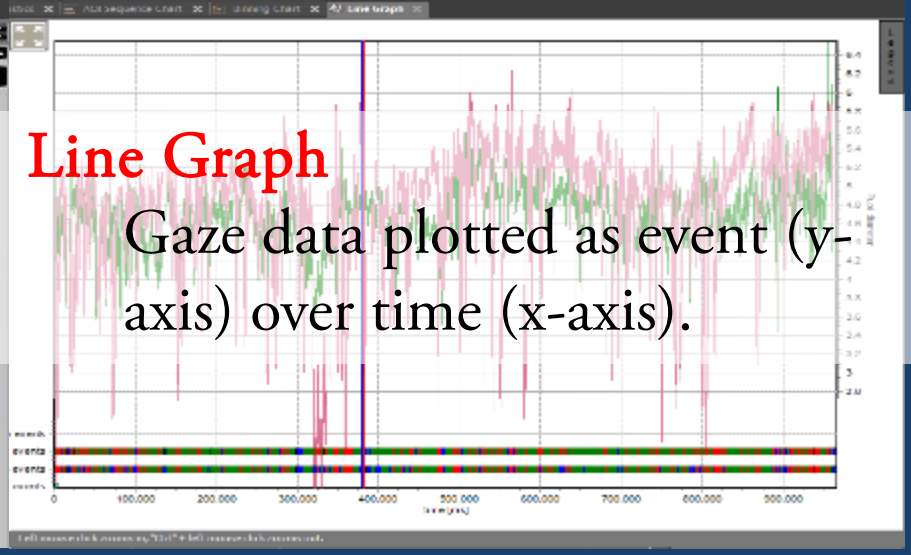
Event Statistics (ES)

ES compute diverse statistics based on events and AOI hits



Line Graph

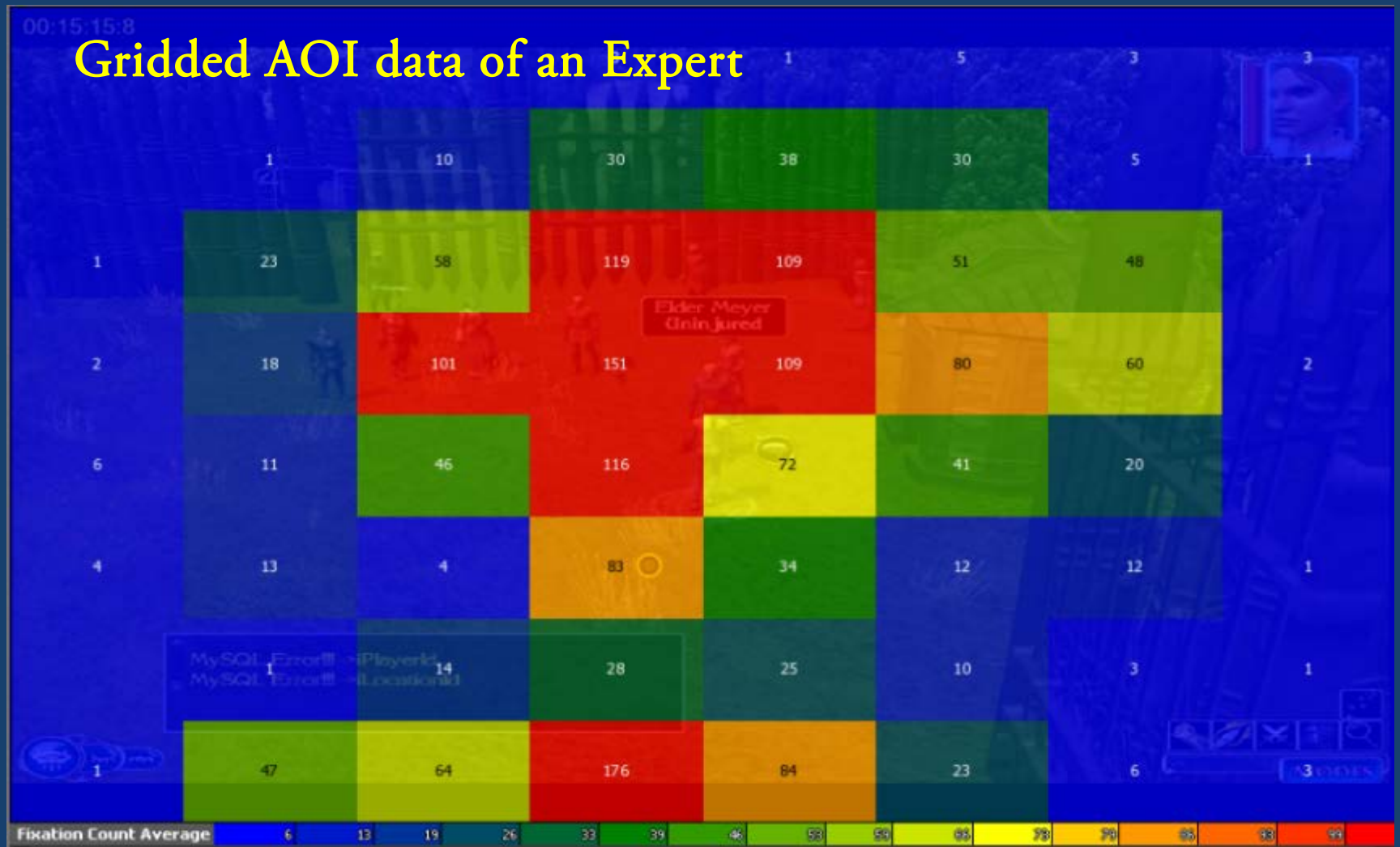
Gaze data plotted as event (y-axis) over time (x-axis).



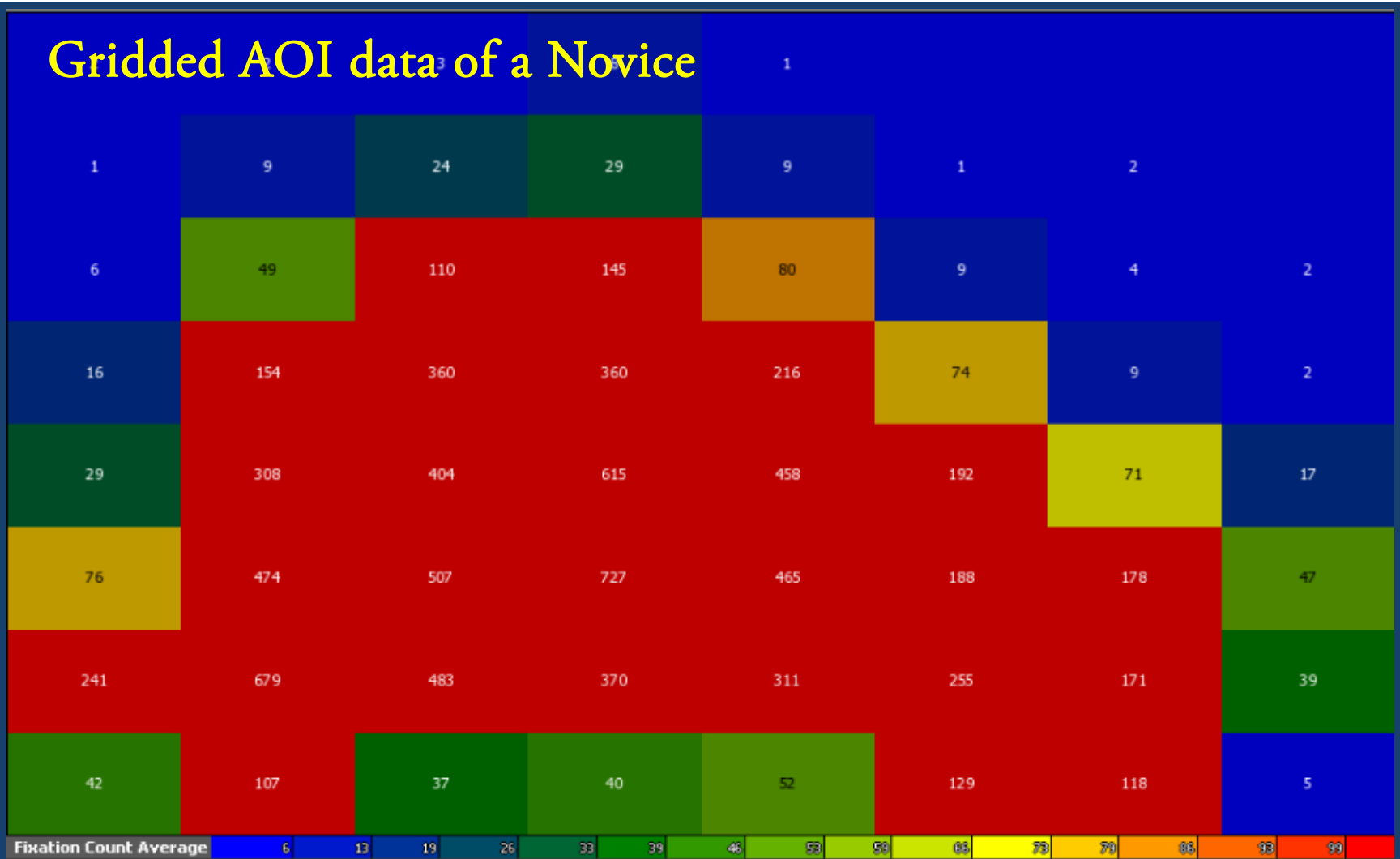
FINDINGS

- **Research Question #2:**
  - Is there any difference on eye-tracking data between experienced and novice players? If so, is it possible to differentiate players' performance by analyzing the eye-tracking information?
- We found differences between expert and novice players.
  - Scan path data analysis showed that
    - Experienced players tend to skip unimportant texts, but novices tend to read all the text very thoroughly (DUH!)
    - Experts look ahead systematically to 'emerging' events and paths (to anticipate what is coming), novices don't know where to look (randomly looking around).
  - Gridded AOI information may have some use
    - Novice players (tend to spend too much time in the game). Experts have more focused red areas, novices have 'diffused' area.

FINDINGS



FINDINGS


Gridded AOI data of a Novice
1
1 9 24 29 9 1 2
6 49 110 145 80 9 4 2
16 154 360 360 216 74 9 2
29 308 404 615 458 192 71 17
76 474 507 727 465 188 178 47
241 679 483 370 311 255 171 39
42 107 37 40 52 129 118 5
Fixation Count Average
6 13 19 26 33 39 46 53 59 66 73 79 86 93 99

FINDINGS

- **Research Question #3:**
  - What are the benefits/pitfalls on using eye-tracking with role-playing type serious games?
- Benefits
  - mixed data for qualitative and quantitative analyses
  - *ex situ* assessment to understand players' behavior
- Issues
  - continuously moving game scenes
  - difficulty on keeping still the participants' head position

FINDINGS

- **Benefits of Eye Tracker in Game-based Assessment**
  - Mixed data for qualitative and quantitative analyses
  - Qualitative data:
    - Scan path data containing video clip recorded players' behavior in game environment
  - Quantitative data
    - KPI, Gridded AOI
  - More detail information to understand actual players' behavior, which cannot be collected/analyzed by using game log data only
    - e.g., whether or not players actually read the conversation texts

FINDINGS

- Pitfalls to watch for:
  - The continuously moving game scenes made hard to
    - Capture consistent gaze point of the participants in the game environment
    - Set custom AOI for analyzing specific parts of the game environment
    - Get the attention map data (i.e., heat map and focus map)
  - The difficulty on keeping still the participants' head position
    - Participant change posture based on dynamic emotional status
    - Eye-tracker may "loose" participants' eye movement
  - Current eye tracking software cannot fully accommodate "gameplay"
    - Gameplay study can take a long time (hour-hours) -- compared with media/ advertisement research (minutes, or seconds)

CONCLUSION

- **Eye-tracking method can**
  - Be used for role-playing type Serious Games in spite of several issues to be resolved
  - Complement players' *in situ* behavioral gameplay data: to explain what players actually do in real world (triangulation of data)
  - Useful for performance analysis in game environments in the future (if issues are resolved)
  - Maybe used in conjunction with other analytics to create new *insights*
- More research is needed

SERIOUS GAMES ANALYTICS

- **Purpose:**
  - Analyzing play-learners' behaviors during game-based learning/training environments, through:
    - *ex situ* method – e.g., Eye Tracking, psychophysiological devices (but NOT pretest/posttest, or self-reported data), and
    - *in situ* method – e.g., telemetry, or *Information Trail*

    to create *actionable insights* to raise skills and improve performance.

NEW BOOK!

- "Serious Games Analytics: Methodologies for Performance Measurement, Assessment, and Improvement"
  - Edited by Loh, C.S., Sheng, Y. and Ifenthaler, D.
  - 2015, forthcoming – to be published by Springer

Q&A

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