

User Study Design and Description

This document contains additional information about the conducted user study to investigate analytic behavior and trust building in visual analytics. This document covers the following sections:

1. Study Design
2. Tasks/Hypotheses
3. Questionnaire

1 Study Design

Goal and Scope The goal of the study was to evaluate the NTE integrated with a real VA system. In addition, the aim was to create an initial dataset for different users to investigate analytic processes further, especially with focus on interaction phases (exploration and verification) and human trust building.

Setting: The user study took place in a quiet room to minimize environmental disturbances. The participant used two monitors, one showing the note taking environment the other one showing the soccer analysis tool. The person, who was responsible for the study, observed the participant, took notes about comments and answered questions.

Participants : The participants were between 23 and 29 years old. Four of them were female, the others male. Though the soccer analysis tool is used to provide a data analysis basis for the study, the domain knowledge of participants was not important for the study as trust and interaction data were investigated and not the quality of the analysis results. Participants with a similar experience about computers were chosen. They were spending an average of 6 to 9 hours per day at the computer and they have enough experience with computers in general to understand the system in a short time. Furthermore, they never worked with the system before and had small to medium knowledge about soccer. In addition to those 9 participants a soccer expert who already worked with the soccer analysis tool took part in the study.

Procedure: Each participant was instructed to perform the following steps:

1. First, we welcomed the participant and handed out a questionnaire (to capture participant information)
2. We introduced the tool and its functionality with an example.
3. Then we gave a general instruction about the study (6 tasks) and about the procedure to complete a task and continuing with the next task. After each task the participants had to assign a trust rating to each finding and a general trust value (for the complete system).

4. We explained them how the used soccer visualizations work.
5. Furthermore, we reported our intention/understanding of trust. “Please estimate how confident you are with the finding/system”. “E.g., imagine you would be a soccer coach that has to judge and report about the performance of his players.” “How strong do you trust in the visual findings and your derived conclusions?”
6. The NTE was prepared for our study. It generated a hypothesis for each task. Further, it was only possible to continue the study once a task has been completed.
7. Then we handed out a tutorial document containing explanations and some training tasks. The participants had to complete the tutorial.
8. Then, the participants solved the six main tasks by adding widgets (findings, notes) to the prepared hypotheses. Additionally, they had to mark the widgets as verifying, falsifying, or neutral and they had to assign trust ratings. During the study we observed how the participants are using VA system and NTE. They were allowed to ask questions.
9. After the study, the participants had to complete their questionnaire. They had to answer trust related questions and provide feedback about the NTE.

2 Tasks/Hypotheses

The study was composed of 6 analysis tasks using the soccer analysis tool and the NTE. During the study (after task 4), we raised the participants awareness of system caused uncertainties to investigate if it impacts the trust building process. We explained them that the used techniques are simplifying and aggregating information (i.e., a degree of uncertainty is introduced by changing the level of detail). In the following, the six analysis tasks are described in more detail:

1. **Hypothesis:** Player number 5 of the blue team caused the foul, **Type:** Elementary, Direct Lookup, **Remarks:** A simple question for the beginning, participants can build trust in the system.
2. **Hypothesis:** In the first half of the game, passes of the red team mostly end at the halfway line, **Type:** Synoptic, **Remarks:** Different interpretations depending on the zoom level are possible.
3. **Hypothesis:** Player number 16 of the red team was involved in all three goals of his team, **Type:** Elementary, **Remarks:** Simple question but more interaction necessary than for question 1.
4. **Hypothesis:** In the second half the blue team does not play often over the right side, **Type:** Synoptic, **Remarks:** Conflicting information can be found, probably a decrease of trust.
5. **Hypothesis:** The red goal keeper has prevented exactly one goal, the others were not scored for other reasons, **Type:** Elementary, **Remarks:** Requires a high number of interaction, as there are a lot of scoring chances. One chance is not clearly represented.
6. **Hypothesis:** The majority of the passes of the blue team is played over the whole width of the field, **Type:** Synoptic, **Remarks:** Positive and negative evidences can be found. A high number of interactions is necessary.

3 Questionnaire

9 participants and an additional soccer coach used our system and answered the questionnaire. The detailed questions of the questionnaire can be found as another supplemental material. The results are as follows:

Aggregated Results:

- **Age:** min: 23, max: 29, average: 23.6, median: 23
- **Job:** All of the participants were students. (8 Computer Science, 1 materials engineering)
- **Exp Data:** Experience with data analysis systems: min: 1, max: 5, average: 2.6, median: 2
- **Exp Computers:** Experience with computer systems: min: 4, max: 7, average: 6.3, median: 7
- **Time:** Average time per day working with computers: 3-6h: 2, 6-9h: 6, 9-12h: 1
- **Exp Soccer:** Expertise in soccer: min: 1, max: 5, average: 2.6, median: 2
- **Emotion:** How did you feel while working with the system? “certain”: 5, “uncertain”: 3, “confused”: 2, “NA”: 1

The users were asked to rate the following statements on a scale between 1 and 7. Result is shown in figure 1.

- **Trust Statement (TS) 1:** I trust more in automation than in humans.
- **TS 2:** While working with a data analysis system I think that it has bugs.
- **TS 3:** While working with computers I think that they do not work faultless.
- **TS 4:** I trust in what other people tell me.
- **TS 5:** I suspect hidden motives in people.
- **TS 6:** I was annoyed of adjusting the trust value.

Participants	TS1	TS2	TS3	TS4	TS5	TS6	
P1	5	4	5	5	5	4	
P2	5	3	4	4	4	4	
P3	5	4	4	4	4	3	
P4	4	4	4	4	4	4	
P5	5	3	4	4	4	4	
P6	4	4	4	4	3	4	
P7	5	4	4	4	4	4	
P8	5	4	4	4	4	4	
P9	5	3	4	4	4	4	
Average	5,56	5,11	4,56	4,89	4,11	5,00	
Median	6	5	5	5	5	5	
	1	2	3	4	5	6	7

Figure 1: This graphic represents the answers of the 9 participants. Light blue are the smaller values, the darker the color gets, the higher the value.

Per Participant:

- **P1:** Age: 23 , Job: Student, Exp Data: 1, Exp Computers: 7, Time: 6-9, Exp Soccer: 2, TS1: 4, TS2: 2, TS3: 2, TS4: 5, TS5: 6, TS6: 3, Emotion:“certain”.
- **P2:** Age: 25 , Job: Student, Exp Data: 3, Exp Computers: 6, Time: 3-6, Exp Soccer: 2, TS1: 6, TS2: 7, TS3: 3, TS4: 4, TS5: 5, TS6: 5, Emotion:“uncertain”.
- **P3:** Age: 23 , Job: Computer Science, Exp Data: 2, Exp Computers: 6, Time: 6-9, Exp Soccer: 2, TS1: 6, TS2: 6, TS3: 3, TS4: 5, TS5: 2, TS6: 7, Emotion:“certain”.
- **P4:** Age: 23 , Job: Student, Exp Data: 5, Exp Computers: 6, Time: 6-9, Exp Soccer: 4, TS1: 5, TS2: 2, TS3: 5, TS4: 6, TS5: 4, TS6: 6, Emotion:“confused”.
- **P5:** Age: 24 , Job: Student, Exp Data: 2, Exp Computers: 7, Time: 6-9, Exp Soccer: 3, TS1: 6, TS2: 7, TS3: 2, TS4: 6, TS5: 1, TS6: 5, Emotion:“certain”.
- **P6:** Age: 24 , Job: Student, Exp Data: 3, Exp Computers: 7, Time: 9-12, Exp Soccer: 6, TS1: 5, TS2: 5, TS3: 6, TS4: 6, TS5: 7, TS6: 6, Emotion:“certain”.
- **P7:** Age: 23 , Job: Student, Exp Data: 5, Exp Computers: 7, Time: 3-6, Exp Soccer: 1, TS1: 6, TS2: 5, TS3: 4, TS4: 2, TS5: 2, TS6: 5, Emotion:“uncertain”.
- **P8:** Age: 23 , Job: Student, Exp Data: 2, Exp Computers: 7, Time: 6-9, Exp Soccer: 3, TS1: 6, TS2: 5, TS3: 3, TS4: 6, TS5: 6, TS6: 4, Emotion:“uncertain”.
- **P9:** Age: 29 , Job: Student (Materials Engineering), Exp Data: 1, Exp Computers: 4, Time: 6-9, Exp Soccer: 1, TS1: 6, TS2: 7, TS3: 3, TS4: 4, TS5: 5, TS6: 4, Emotion:“certain”.
- **Soccer Expert:** Age: 29 , Job: Soccer Coach, Exp Data: 4, Exp Computers: 6, Time: 0-3, Exp Soccer: 5, TS1: 6, TS2: 1, TS3: 7, TS4: 3, TS5: 1, TS6: 7, Emotion:“uncertain”.

Free text user feedback was captured in German language and is not included in this document.