Analysis of saccadic movements of students solving problems with graphs in physics

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Abstract. 23 high school students were eyetracked when solving physics problems with graphs. We analyzed their saccades (length, direction). We did not observe differences between correct and incorrect solvers. Some pupils (correct or incorrect solvers) showed a high similarity of saccade directions for the beginning and for the total viewing time, some not.

1 Introduction

The paper focuses on the students graphing in physics. Several typical problems of students graphing, e.g. graph as picture, were identified [1], [2]. The use of the eyetracking method is proving to be beneficial, where we use it to estimate students' cognitive processes when solving problems. Most studies in PER has focused on differences in fixations distribution between correct and incorrect solvers. Klein et al. also focused on students saccades when viewing the vector field diagrams [3].

A graph is a complex abstract representation, but one that at first glance looks like a picture. The eye movements of students who exhibit low prior graphing knowledge might show tracking of the graph curve, aimless graph viewing, etc. Our research questions were: are there differences in the saccades of correctly and incorrectly answering students when solving physics problems with graphs? Particularly, in the length of saccades and in the saccades directions (during the overall time and during the very beginning)?

2 Methods

23 high school students solved 7 problems with realistic graphs from mechanics with a more complex curve shape. Students were eyetracked (TobiiTX300) while viewing the graphs. We then recorded their verbal response and the students proceeded to solve the next task. After the experiment, we reviewed the record with them and they completed an additional questionnaire about their attitudes towards science.

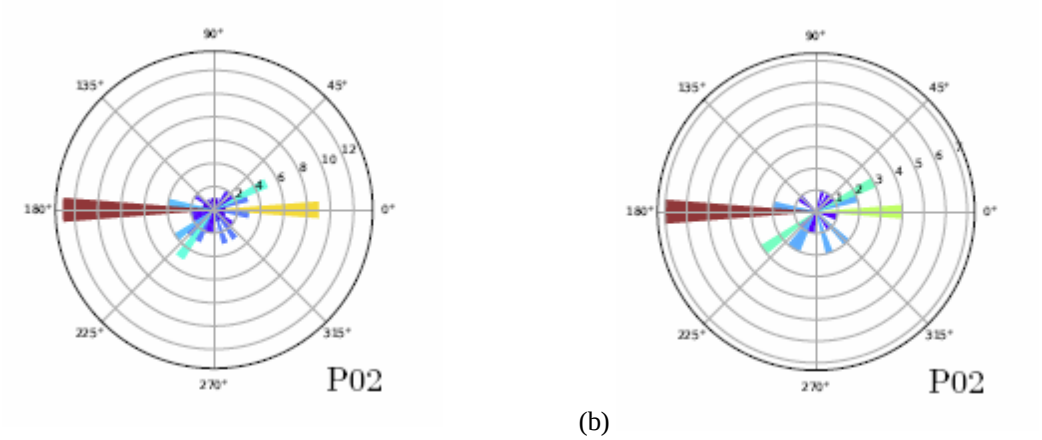
3 Results

Tab. 1 shows the number of correctly and incorrectly answering students. The seventh problem was very difficult; we did not analyse this task. Further, Tab. 1 shows the average length of the saccades. The data suggest that there are no differences between the two groups.

Task No.	Correctly answering students		Incorrectly answering students		Task No.	Correctly answering students		Incorrectly answering students	
	number	av. length of saccades	number	av. length of saccades		number	av. length of saccades	number	av. length of saccades
1	17	146,2	6	155,3	5	18	191,3	5	187,7
2	3	138,1	20	132,6	6	3	136,4	20	146,4
3	11	221,4	12	217,9	7	1	-	22	-
4	15	203,3	8	223,0					

Tab. 1 Average length of saccades of correctly and incorrectly answering students.

We plotted the direction of saccades for each participant and each task on a polar graph (Fig. 1). We displayed the data for the total viewing time and for the first 40 saccades (approx.10s). We performed a qualitative comparison of the graphs between correct and incorrect solvers. No differences were identified. Some pupils showed a high similarity of saccade directions for the beginning and for the total viewing time (Fig. 1), some not. Both of these groups of students were present among both correct and incorrect solvers.



(a) (b)

Fig. 1 Direction of saccades – a participant and one task.
(a) For the total viewing time, (b) for the first 40 saccades.

4 Conclusion

Differences in the distribution of fixations between correct and incorrect solvers have been identified in many previous studies. We did not observe differences in the case of saccades (length, direction). Some pupils (correct or incorrect solvers) showed a high similarity of saccade directions for the beginning of viewing and during the total time, some not.

References

[1] R. Beichner, Testing students' interpretation of kinematic graphs, *Am J.Phys*. **62** (1994) 750-762.
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[3] P. Klein et al., Instruction-based clinical eye-tracking study on the visual interpretation of divergence: How do students look at vector field plots?, *Phys Rev P.E.R.* **14** (2018) 010116.