Difficulty rating in mountain biking

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Abstract
The aim of this study was to investigate the gaze behavior of mountain bike riders while analyzing and rating the technical difficulty of mountain bike trails. Differences in the visual attention to the trail itself and its surrounding risk parameters were expected between skilled mountain bike riders and beginners. Gaze behavior of 12 beginners and 17 experts was measured using a portable eye-tracking system. As predicted, visual attention to certain areas of interest differed in many cases. While experts predominantly focus the trail itself to analyze its grade of difficulty, beginners give significantly more attention to the surrounding risk parameters. In some cases the beginners gaze these risk parameters more intensively than the trail. Furthermore, experts observe single key sections on the trail while beginners just get an overview of the trail. The findings suggest that difficulty rating systems in mountain biking should provide both, information on the technichal challenge of the trail and also information on its potential risk parameters.

Key words
eye-tracking, gaze behavior, visual attention, mountain biking, risk, difficulty rating, sports

Introduction

In many outdoor sports, like kayaking or rock climbing, difficulty rating systems are obligatory by now. These difficulty rating systems allow athletes to match their own skill level to the challange of a river or a climb. In kayaking for example, the international scale of river difficulty is a worldwide spread and generally accepted tool to describe the difficulty of rivers in six grades (Nies et al. 2005, DKV, 2012). It merges the technical challenge of a section and its potential risk in a single number. In climbing there are some different difficulty rating systems, but they are all composed in the Table of Difficulties of the International Mountaineering and Climbing Federation (Union International des Associations d'Alpinisme - UIAA, 2012), what makes each rating system comparable to another.

In mountain biking numerous types of different scales have spread locally. Most of these scales in mountain bike destinations or bikeparks just reflect the technical difficulty of the trail itself, but give no information about risk parameters like exposure or obstacles surrounding the trail that could hurt the rider in case of an accident. The Trail rating Guidelines published by the International Mountain Bicycling Association for example (IMBA) give the advice to rate the technical challange of a trail only (IMBA, 2012). However, these guidelines admitt in point six that a wide variety of additional features could contribute to the difficulty of a trail. They mention exposure as an example that could provide an added psychological challenge beyond the technical challenge of the trail. But there is no further information how to handle with these additional features when rating a trail.

In german speaking mountain bike communities another rating system called singletrail-skala (STS, Schymik et al. 2008) is spreading since the last years. It describes the trail difficulty in six grades from S0 (easy) to S5 (severe). Allthough there is known no tourist destination that uses this rating system, the mountain bike guide education curricula of the German and the Austrian Alpine Clubs (www.alpenverein.de, www.alpenverein.com) support this difficulty rating system. It exclusivly describes the technical challenge of a trail and excludes strictly the use of other criteria like exposure or obstacles surrounding the trail (Schymik et al., 2008).

Both examples show that there seems to be lack of knowledge about how much mountain bike riders are influenced by these risk parameters when rating a trail. Apart from that, there is no evidence whether riders of different skill levels are affected differently. The aim of this study was to quantify the visual attention towards these surrounding risk parameters when mountain bike riders of different skill levels are rating the difficulty of a mountain bike trail.

Methods

Participants, task and procedure

29 Subjects (12 mountain bike beginners, mean age 31 ± 9 years; 17 Experts, 34 ± 9 years) volunteered

to participate in this study. The participants' task was to analyze and rate 18 trail situations of different difficulty levels. Three situations of each grade according to STS were chosen. These were shown as pictures by a data projector on a projection screen and randomly presented to each subject separately. The participants were allowed to analyse the pictures for 15 seconds. Afterwards the rating sheet appeared automatically on the projection screen with following question: "How would you rate the technical difficulty of this mountain bike trail section?". Subjects were able to click their vote on a six-point bi-polar Likert scale below the question. Time for rating was also limited to 15 seconds while the last three seconds were visualized by a countdown to get sure that the voting was finished before the next trail situation appeared. As the rating of the difficulty of different trail situations was the purpose of a previus study, the main focus in this study was on analysing the subjects' gaze behavior while watching the pictures of the trails.

Apparatus and data analysis

While analyzing the pictures gaze behavior of the subjects was recorded by a Tobii Eyetracking System (Tobii Glasses, www.tobii.com). Eye gaze has been used as a proxy for visual attention in many investigations in sports (for a review, see Williams et al., 2004). The system used in this study works with a sampling rate of 30 Hz. The eye-tracking system allows analyzing the participants view on different areas of interest (AOIs).

Fig. 1: example of a trail situation (left) and its AOIs (right).

Figure 1 shows an example of one riding situation and its AOIs. Similar to this example following AOIs were defined for all the pictures in case they appeared:

Trail: as the subjects' task was, to rate the technical challenge of the trail section, this is the area which gives the main information on this topic.

Risk of Obstacles (RO): this area was defined as the corridor in the direct surrounding of the trail which contains obstacles that could hurt the rider in case of an accident (e.g. rocks, trees, rough surface, etc.).

Risk of Exposure (RE): this area gives the observer visual information on the height and steepness of the abyss next to the trail tread. In some of the chosen pictures a fall would be certainly fatal.

Key Sections (KS): some trails featured additional challenges on the trail that impede travelling (e.g. roots, rocks, ledges, etc.), those were defined as an extra AOI.

R*ider:* All pictures used in this study showed a mountain bike rider. The rider gives the observer realistic information on the proportions of the trail (width, length, etc.).

Danger Area (DA): both risk parameters (RO and RE) were added and defined as the Danger Area.

Consider that not all pictures show all of these AOIs. For example some of the riding situations featured no KS while others have no DA because of inexistent exposure or obstacles in the surrounding of the trail. This mixture was selected to get information on how the different AOIs influence the subjects gaze behavior.

Data was analyzed by using the Tobii Studio Eye Tracking Software Version 3.1 (Tobii Glasses, www.tobii.com). The total fixation duration on each AOI was calculated for each subject and laterly summed for both groups, the beginners and expert group. As in other studies (Heinen, 2011), fixations were defined as a gaze of at least 100ms duration to the same position. Gazes shorter than 100ms were filtered out.

Dependent variables were compared using an independent samples t-test. Significance criterion was defined as α=5%.

Results

Mean values of all trail situations

Figure 2 and Table 1 present an overview of fixation durations of experts and beginners towards the definded AIOs (Rider, DA, KS, Trail) as mean values of all trail situations. As can be seen, beginners gaze significantly longer towards DA (p<0.001) while experts gaze significantly longer towards the trail (p<0.001). Furthermore, experts give significantly more visual attention to KS (p=0.044). There is no difference in gazing the rider (as this was not expected).

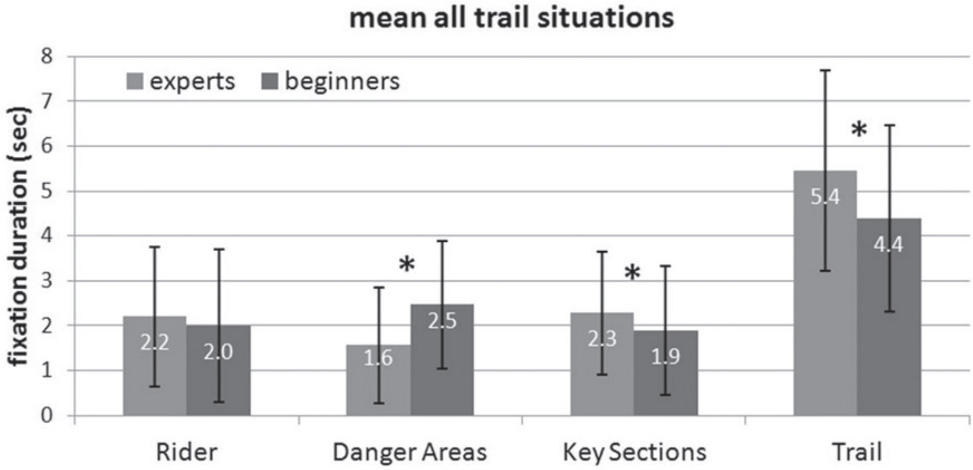

Fig. 2: differences in fixation durations between experts (light grey) and beginners (dark grey). Mean values of all analysed trail situations. (* p<0.05)

Tab. 1: Mean values (M) and standard deviations (SD) of fixation durations (sec) of experts and beginners on different AOIs. Mean of all trail situations.

	Rider		**Danger Areas (DA)**		**Key Sections (KS)**		**Trail**	
	experts	**beginners**	**experts**	**beginners**	**experts**	**beginners**	**experts**	**beginners**
M	2.2	2.0	1.6	2.5	2.3	1.9	5.5	4.4
SD	(±1.6)	(±1.7)	(±1.3)	(±1.4)	(±1.4)	(±1.4)	(±2.2)	(±2.1)
	p=0.216		p<0.001*		p=0.044*		p<0.001*	

Selected case studies of trail situations

Figure 3 shows an S1 graded trail according to STS. While there is no difference between experts and beginners concerning gazing the trail, beginners gaze significantly longer to DA (p=0.007).

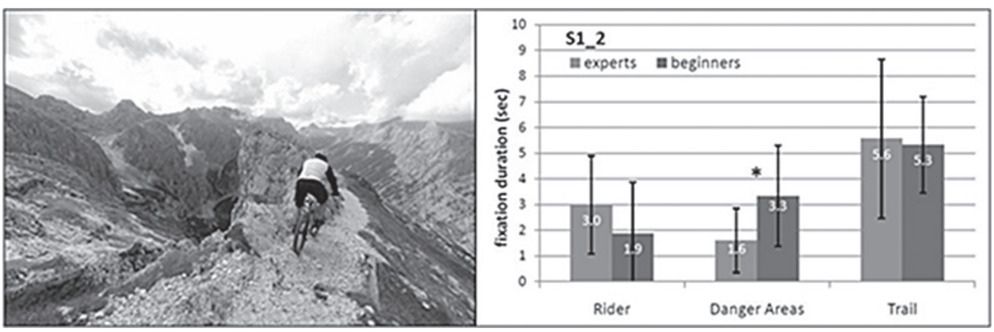

Fig. 3: S1 graded trail (left) and differences in fixation durations (right) between experts (light grey) and beginners (dark grey). (* p<0.05)

Figure 4 shows an S2 graded trail according to STS. Statistical analasys reveals significant differences in gazing DA (p=0.030) and KS (p=0.047). Again, beginners are gazing longer towards DA, while experts'

visual attention towards KS is higher.
Describtiv analysis of this trail situation shows, that beginners even gaze longer towards DA (4.6 sec ± 2.3 sec) than to the trail (4.1 sec ± 2.6 sec). In contrast, experts are gazing more than twice as long towards the trail (5.9 sec ± 2.2) than to DA (2.8 sec ± 1.8 sec).

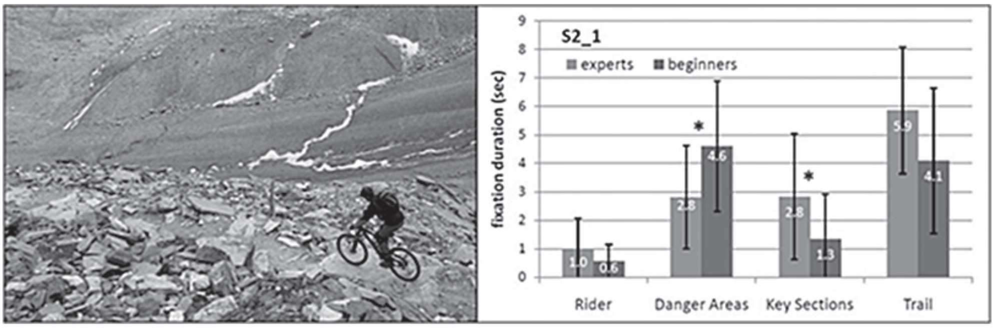

Fig. 4: S2 graded trail (left) and differences in fixation durations (right) between experts (light grey) and beginners (dark grey). (* p<0.05)

Figure 5 shows an S3 graded trail according to STS. In this case, the beginners gaze significantly less towards the trail than the experts (p=0.018). Instead, beginners pay more visual attention towards DA compared to the experts (p<0.001).

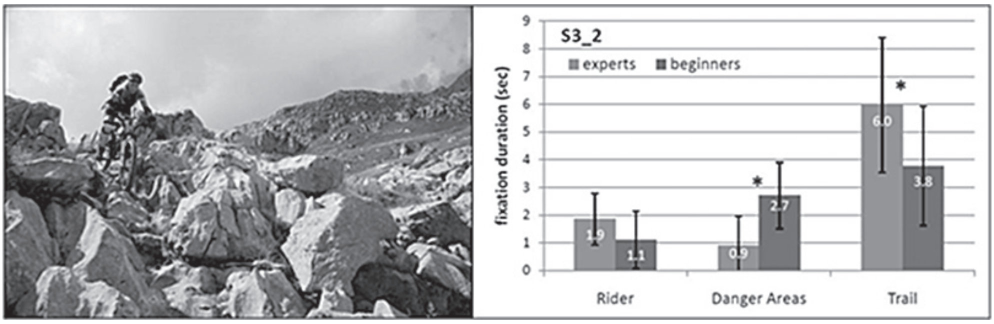

Fig. 5: S3 graded trail (left) and differences in fixation durations (right) between experts (light grey) and beginners (dark grey). (* p<0.05)

Figure 6 shows an S3 graded trail according to STS. Although we defined a KS in this trail situation (the ledge beyond the front wheel of the rider), significant differences were just figured out in gazing DA (p=0.009) with longer fixation durations of the beginners.

Again, describtiv analysis of this trail situation shows, that beginners gaze longer towards DA (4.0 sec ± 1.7 sec) than to the trail (3,7 sec ± 2.4 sec) while experts are gazing predominantly the trail (4.7 sec ± 2.4 vs. DA=2.2 sec ± 1.8 sec).

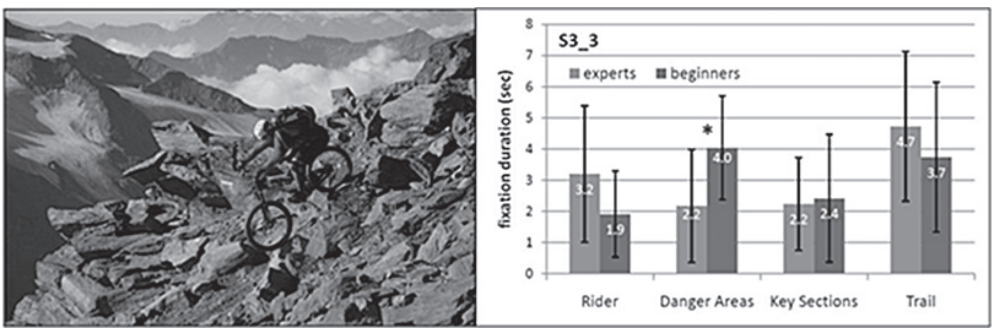

Fig. 6: S3 graded trail (left) and differences in fixation durations (right) between experts (light grey) and beginners (dark grey). (* p<0.05)

Figure 7 shows an S3 graded trail according to STS. This trail situation features no DA. As a result, statistical analasys identified no differences in visual attention between experts and beginners.

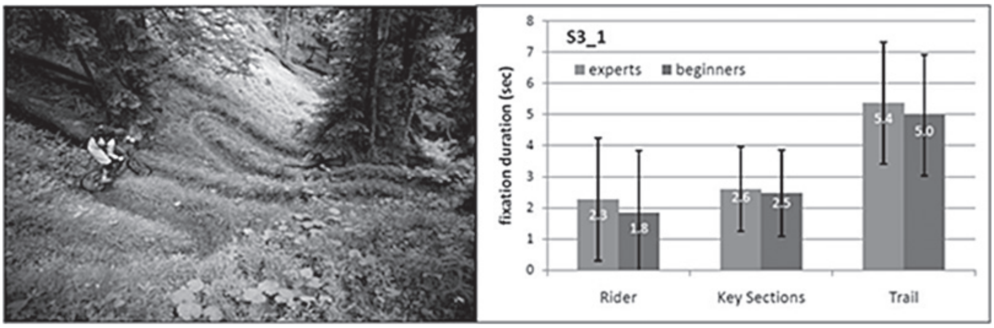

Fig. 7: S3 graded trail (left) and differences in fixation durations (right) between experts (light grey) and beginners (dark grey). (* p<0.05)

Discussion

Visual attention can provide important insights to the information used in desicion situations (Raab, Johnson, 2007). The main aim of this study was to quantify the visual attention towards different areas of interest while analyzing the technical challange of a mountain bike trail. The technical challange is commonly described by objective criteria such as trail width, tread surface (e.g. hardened or loose), steepness, turn radius or obstacles that impede riding (e.g. roots, rocks, ledges, etc.) (Schymik et al., 2008, IMBA, 2012). So as the participants task in this study was to rate the technical challange of a mountain bike trail, their visual attention should be expected exclusively on these criteria. Against this assumption, we predicted that mountain bike riders do not solely focus on that objectiv trail creteria but also attend to risk parameters that surround the trail. Furthermore, differences in the visual attention towards these AOIs were expected between skilled mountain bike riders and beginners.

Analyzing the visual attention of athletes of different skill levels has been purpose of many research projects in sport (for a review, see Williams et al. 2004). A common finding is that highly skilled athletes show longer fixation durations to more important areas, compared to less skilled athletes (Raab, Johnson, 2007). These findings are consistant with those in our study as the skilled mountain bike riders gaze the trail in all situations longer than the surrounding danger areas. In contrast, the beginners in some cases even focus the danger areas longer than the trail. Furthermore, in most cases the skilled riders visual attention is focused significantly longer to the key sections as these are an important predictor of the technical challange of the trail. The explanation for this phenomenon is that expert athletes use their rich knowledge base to pick out the most important aspects of the displayed scene (Moran et al. 2002).

Another finding of this study is that if the trail is not surrounded by danger areas, there are no differences in visual attention between both experimental groups. This leeds to the conclusion that (in case of the beginners) risk parameters are responsible for the deflection from the main task, analysing the objectiv trail criteria. Maybe the presence of risk parameters leads to a kind of arousal or even to a state of anxiety even though participants are just analysing pictures and are not in a realistic setting. This assumption is supported by the results of Moran et al. (2002). They investigated the influence of risk parameters on anxiety and visual attention in gymnastics (back flip on a beam) in a similar experimental setup than in our study. Moran et al. report that an increase of risk parameters (low beam with safety mats, low beam without safety mats, high beam without safety mats) involves an increase of anxiety level. Furthermore, this increase of anxiety level evoked more and longer gaze fixations on unimportant peripheral areas than on central locations.

Due to the fact that the study of Moran et al. (2002) as well as ours is based on an laboratory experimental setup using picture slide shows, the transfer to realistic situations seems to be limited at first glance. In both cases a realistic setup certainly would not withstand the ethical review committees scrutiny. Nevertheless there is some research correlating visual attention with anxiety or arousal in realistic setups. Causer et al. (2011) examined visual attention of elite shotgun shooters under low (practice) and high (competition) anxiety conditions with the result of reduced duration towards the center of target in high anxiety conditions. In a more comparable action to mountain biking Janelle et. al (1999) investigated the influence of anxiety on visual attention in simulated auto racing. The results indicate that as anxiety increased, drivers increasingly fixated peripheral areas of the display with a corresponding decrease in visual attention towards the racetrack. Wilson et al. (2006) report similar findings in a similar experimental setup with an additional decrease of driving performance (driving time) and driving control (variability of wheel and accelerator pedal). These findings confirm attentional control theory (ACT, Eysenck et al. 2007). ACT maintains that an increase of anxiety reduces attentional control at the cost of goal directed control. Reduction of attentional control is discribed as a distraction from task-relevant stimuli to task irrelevant ones (see also Wilson, 2008). Allthough we did not meassure anxiety levels of participants when analysing the trail situations in our study, evidence is made that mountain bike beginners are diverted from objective trail criteria (task-relevant stimuli) to danger areas (task--irrelevant stimuli) more than experts. In consideration of ACT, this could lead to reduced performance and riding control and in consequence to accidents especially if mountain bike beginners ride trails in deceiving awareness of there are no risky danger areas surrounding the trail. That leads to the conclusion that describing the difficulty of mountain bike trails requires both, information on the technical challenge of a trail and its potential risk parameters. And furthermore - due to the fact that skilled riders and beginners are affected differently by risk parameters - the technical challenge and the risk parameters should be described separately in a difficulty rating system for mountain bikers.

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