Workload assessment for motorcycle riders

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ABSTRACT:

Both German and European studies have shown that compared to other modes of transport accident rates and injury risk for Powered Two Wheelers (PTW) are particularly high. Efforts are taken to enhance safety and comfort for motorcycle riders e.g. through Advanced Rider Assistance Systems (ARAS) and On-Bike Information Systems (OBIS). Consequently, questions about distraction and rider workload arise and need to be addressed. A riding simulator study (n=14) was conducted in order to test the sensitivity of performance measures, subjective ratings as well as physiological measures to controlled variations in rider workload, while in a second study (n=15) these parameters were used in order to assess the effects of different secondary tasks. The secondary task of operating an OBIS led to the highest workload e.g. indicated by deteriorated lane keeping and increased subjective ratings compared to a simple visual, an auditory and no secondary task at all.

1 INTRODUCTION

The relative trend between the numbers of fatalities of motorcyclists compared to that of other road users within Europe is alarming. Whilst the percentage of fatally injured car drivers, moped riders or pedestrians declined over the years, there is a relative tendency for motorcycle riders to be even more involved in fatalities [1]. At the same time the riding patterns of motorcyclists within the EU changes towards high-mileage riding (more than 5,000 km per year) [1] and bigger touring bikes [2]. These kinds of motorcycles are more often equipped with Advanced Rider Assistance Systems (ARAS) like e.g. speed alert warning or blind spot monitoring and On-Bike Information Systems (OBIS) like e.g. navigation systems that should support riders and prevent accidents or mitigate injuries. Nevertheless, those systems might also bear potential for distraction if attention is attracted by flashing lights or audio signals. This holds especially for OBIS as ARAS like e.g. Traction Control work unobtrusively most of the time. This paper describes a first empirical approach towards specification of the sensitivity of different workload measures to be applied for the assessment of rider information systems. The complete project report will be published soon [3]. Hereby, workload "…represents the cost incurred by a human operator to achieve a particular level of performance." [4]. Therefore an approach towards workload description is proposed and the effects of different secondary tasks on workload were examined.

2 METHOD

2.1 Riding simulator

The simulator that was used for the study is equipped with a full-size motorcycle mockup type BMW R100S including all relevant devices and physical controls (Fig. 1).

Fig. 1 Riding simulator (left) and an exemplary track section (right)

The bike is rotatable fixed at its longitudinal axis. Shifting his weight the rider has the possibility to roll the motorcycle passively but there is no active motion of the mockup. The riding simulator includes simulation of longitudinal and lateral dynamics, sound simulation and image generation for urban, highway and rural scenarios (60 degrees field of view). The riding scenario control includes the definition of road geometry, influence on the appearance of the surrounding landscape and detailed control of other traffic participants. All components are based on WIVW driving simulation software SILAB. Furthermore, all parameters of the simulation as well as all accumulated data can be recorded. This includes e.g. inputs of the rider, physical quantities of the vehicle dynamics simulation, characteristics of the road geometry or information about other traffic participants. Data from real motorcycle rides was used to validate the motorcycle simulator, especially focussing on the relationship of acceleration, brake pressure and pitch angle.

2.2 Test procedure

2.2.1 Study 1: workload description

The first study aimed to describe changes in workload induced by the following variations in strain:

- track difficulty (easy: track width 3.50 m, curve radii > 1000 m, little oncoming traffic, smooth slope vs. difficult: track width 2.75 m, curve radii between 150 and 800 m, dense oncoming traffic, obstacles, steep slope)
- riding instruction ("as safe as possible" vs. "as fast as possible without endangering anybody")
- length of ride (short: 10 minutes vs. long: 60 minutes)

All participants completed four short rides on rural roads with all possible combinations of track difficulty and riding instruction. In addition they performed one long ride on the difficult track and the instruction to ride as fast as possible without endangering anybody on a separate day. Pulse rate was recorded while riding. After each ride participants were asked to fill in the NASA Task Load Index as a subjective measure of rider workload [4].

2.2.2 Study 2: effects of different secondary tasks

The second study analysed the effects of different types of secondary tasks. This is of high relevance as different OEMs and suppliers already offer a variety of ARAS or OBIS using e.g. a visual or acoustic human machine interface (HMI). A total of 15 riders rode on courses of varying difficulty (easy vs. difficult) under four different secondary task conditions: baseline without any secondary task, counting certain target words in an audio-book (acoustic), Peripheral Detection Task (visual, [5]) and operation of a user interface (navigating through system levels in a menu) via touchscreen simulating an on-board computer. The order of conditions was randomly assigned to each rider. After each ride participants were asked to fill in the

NASA Task Load Index.

2.3 Participants

All participants were recruited from the WIVW test driver panel. 14 riders participated in the first study, five to them were women. Mean age was 33 (sd= 11) years. The participants rode 3094 (sd= 3056) km on average the year before. 15 participants were recruited for the second study, two of them were women. Mean age was 36 (sd= 14) years. The participants rode 4045 (sd= 4274) km on average the year before. In both studies, two participants were experienced in using an on-bike navigation system.

3 RESULTS

3.1 Study 1: workload description

All three varied components of strain (track difficulty, riding instruction, length or ride) clearly influence the riders' performance. Riding data, subjective ratings and pulse rate were investigated to register workload. In this paper only the effects of varying track difficulty and riding instruction are reported. Experimental data were analysed with a repeated measures ANOVA using the four combinations of track difficulty and riding instruction as within factor. The significance level was set at .05.

As manipulation check one can see that different instructions lead to different mean velocities ($F_{3,11}$= 83.67, p< .001; Fig. 2 left). Riding "as safe as possible" leads to a lower mean velocity than the instruction to ride "as fast as possible without endangering anybody". This seems to be related to the lateral behaviour as the standard deviation of lateral position (SDLP) increases for the fast instruction on both track types ($F_{3,11}$= 21.60, p< .001; Fig. 2 right). There is no significant difference between the track difficulties.

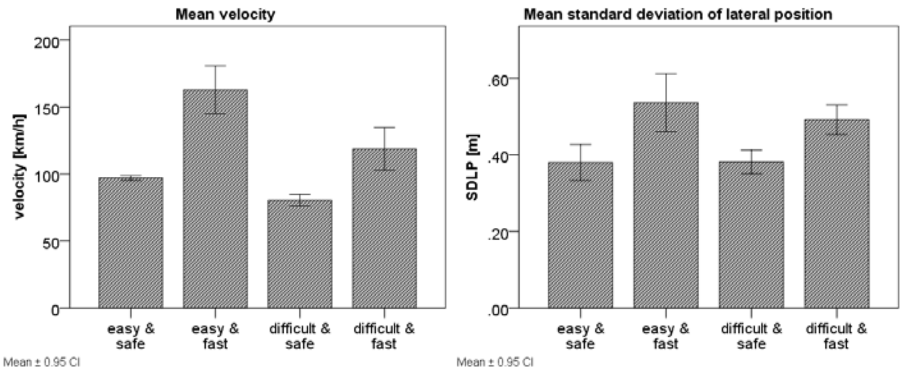

Fig. 2 Mean velocity (left) and standard deviation of lateral position (right) by track difficulty and riding instruction

Concerning the participants' subjective ratings the variation of track difficulty and riding instruction lead to different experienced workload ($F_{3,11}$= 17.11, p< .001 ; Fig. 3 left). Under the easy & safe condition riders report the lowest and under the difficult & fast condition the highest workload. No difference is found between easy & fast compared to difficult & safe.

The mean pulse mainly reflects changes in the riding instruction. Fast riding leads to a significantly higher pulse compared to safe riding ($F_{3,11}$= 9.61, p= .002 ; Fig. 3 right). The combination of driving safely on an easy track results in the lowest pulse values.

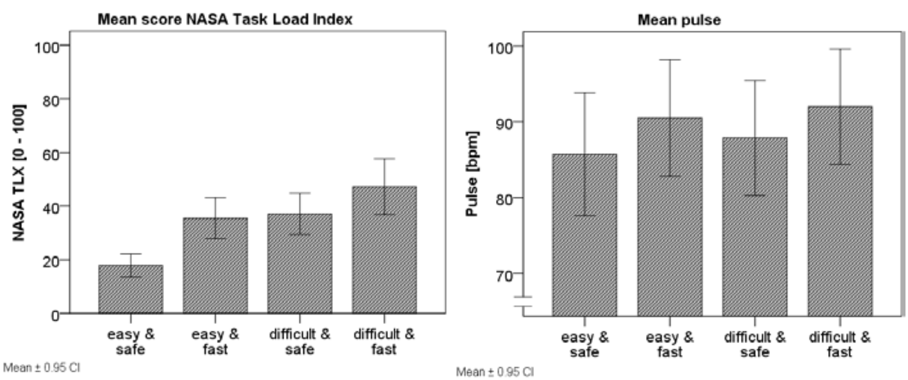

Fig. 3 Mean score on NASA Task Load Index (left) and pulse (right) by track difficulty and riding instruction

3.2 Study 2: effects of different secondary tasks

Experimental data were analysed with a repeated measures ANOVA using track difficulty and type of secondary task as within factors. The significance level was set at .05.

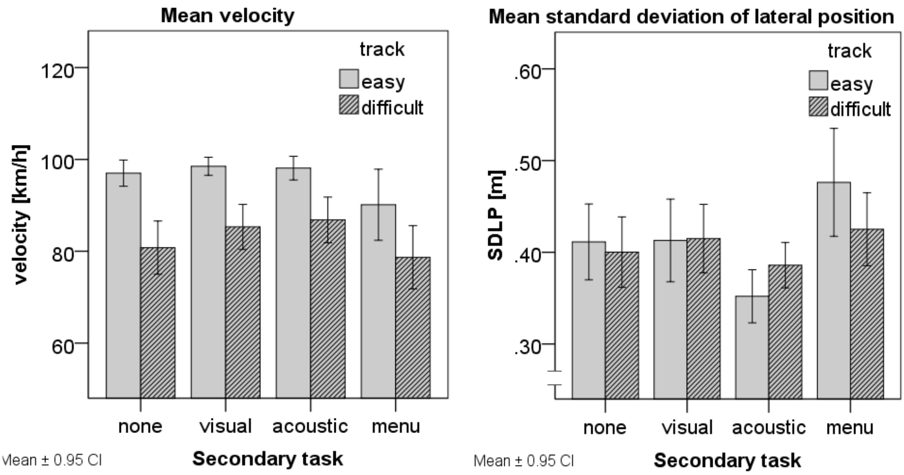

Fig. 4 Mean velocity (left) and standard deviation of lateral position (right) by track difficulty and type of secondary task

First of all, participants again ride faster on the easy track ($F_{1,12}$= 79.25, p< .001 ; Fig. 4 left). In general, the different secondary tasks influence riding behaviour. Specifically, a difference between types of secondary task ($F_{3,10}$= 3.86, p= .045) and a significant interaction between type of secondary task and track difficulty ($F_{3,10}$= 10.99, p= .002) is found.

Further investigation reveals that participants ride slowest in the menu condition on both tracks. Furthermore, they ride significantly faster on the difficult track when performing a visual or acoustic secondary task compared to the menu operation. Concerning lane fidelity an effect of the secondary task can be seen as well ($F_{3,10}$= 6.62, p= .010; Fig. 4 right). SDLP improves while operating an acoustic secondary task and deteriorates in the menu condition. Neither a main effect of track difficulty ($F_{1,12}$= 1.12, p= .310) nor an interaction ($F_{3,10}$= 2.11, p= .163) can be found.

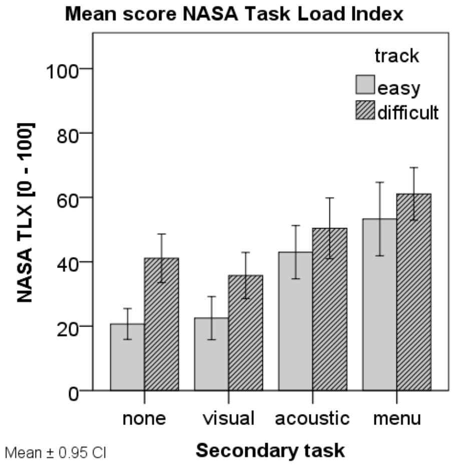

Fig. 5 Mean score on NASA Task Load Index by track difficulty and type of secondary task

There is a significant effect of track difficulty ($F_{1,12}$= 29.14, p< .001) as well as type of secondary task ($F_{3,10}$= 36.31, p< .001) and their interaction ($F_{3,10}$= 8.81, p= .004) for the subjective rating (Fig. 5). Participants report higher workload when riding on the difficult track. They experience less workload in the baseline condition as well as while operating the visual secondary task compared to the acoustic and menu condition. Additionally there is a significant difference between no secondary task and the acoustic condition for the NASA TLX score on the easy course, but not on the difficult track.

4 DISCUSSION

This paper presents options how to operationalize workload for motorcycle riders in a riding simulator setting and reports effects of different secondary tasks as a use case.

According to the riding instruction participants rode at different velocities indicating a successful variation of strain. This led to changes in lateral control, pulse and subjective measures indicating an increase in workload. The pulse measurement seemed to be mostly sensitive for the variation of the instructed riding speed. Nevertheless, negative aspects like the installation under protective clothing, costs, and noisy values, led us to not further follow this approach. Besides the adaptation of mean velocity, the effect of different track difficulties could be seen in the participants' subjective ratings. The results of the NASA TLX indicated that riding on a difficult track leads to a higher level of experienced workload, possibly rising from the increased demand with regard to foresighted driving and the constant assessment of the own riding capacity. To conclude, track difficulty and riding instruction seem to be proper possibilities to influence rider behaviour or respectively rider strain resulting in changes in workload. On the other hand, a variation in the parameters mentioned above, under standardized conditions of track difficulty and riding instruction, could serve as workload indicators.

Therefore, this approach was used in the second study. The effects of different secondary tasks could be seen in the riders' lateral and longitudinal performance as well as subjective ratings. The standard deviation of the lateral position revealed an interesting finding: when being engaged in a visual or acoustic secondary task, SDLP did not significantly change compared to no engagement. It even decreased at first when having higher workload. Only if visual-manual distraction increased considerably (menu condition), SDLP increased significantly. One possible explanation is the active compensation of riders. They try to focus more on their riding performance as they know about the distraction. This coping mechanism is obviously limited. The riders reported less workload and felt safer on the easy course and e.g. worked on the menu task more often and for longer time periods. This could provide an indication of the need to support riders concerning the usage of bord computers or OBIS or even to lock specific functions while riding.

In sum, it was shown that workload of motorcycle riders is a promising and not yet sufficiently covered field of research. Motorcycle simulation appears as a good tool to investigate riders' workload within boundaries of normal vehicle dynamics, without endangering the participants. Further studies on this subject are urgently needed to substantiate the impact of information and assistance during motorcycle riding more closely and contribute to a higher level of safety for powered two wheelers.

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