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Cyclists' situation awareness and physical load

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1 INTRODUCTION

Safe cycling in the urban environment requires the ability to detect and anticipate hazards early enough. In other words, it requires situation awareness in hazardous situations, or in short, hazard perception [1]. Acquisition and maintenance of situation awareness require both experience and cognitive effort [2].

Cycling can be physically demanding, even exhausting, activity. Physical activity has been shown to influence also cognitive performance. A moderate physical load may improve the performance compared to sedentary performance, but when the load increases enough, the performance becomes worse [3, 4]. As far as we are aware, the effect of physical load or exhaustion on cyclists' hazard perception has not been directly studied before.

In this pilot study, participants' situation awareness in cycling was tested using a video-based game. First, all participants played the first half of the game under low physical load. Then, the load was either kept the same for the Low group or increased to Moderate or High level. For the Low group, we expected a small improvement in the performance from the first half to the second as the participants become more familiar with the game. However, the main interest was how the Moderate and the High group would perform relative to the Low group. We expected that the Moderate group would improve their performance more than the Low group. Correspondingly, the High group should improve less than the Low group or even decrease their performance.

2 METHODS

34 healthy volunteers who exercised regularly were recruited to participate in the experiment, which consisted of two sessions on separate days. Data from 31 participants (16 females and 15 males, age 22–46 years, M=34.5, SD=6.7), were collected successfully and analyzed. In the first session, the fitness level of the participants was determined using a cycling ergometer test. The test estimates their maximal oxygen uptake (VO2max), and corresponding heart rate levels for their aerobic and anaerobic thresholds. Participants gave informed consent and filled a questionnaire which was used to screen for any contraindications for performing the fitness test. The setting was preassessed by the Ethical Review Board for Social Sciences and Humanities at the University of Helsinki.

In the second session, the participants cycled on the cycling ergometer and played a video-based game which measured their situation awareness. The game had 30 video clips. The order of the clips was randomized for each participant. Each clip was suddenly stopped and masked. Two or three locations were presented and the player's task was to select those locations where there was a potential hazard. Feedback was given for the answers. For details of the game, see Lehtonen et al. [5]. Eye movements were also recorded but the results are not yet ready.

The participants were randomized to three groups: Low (n=10), Moderate (n=10) and High (n=11). The load levels were based on the aerobic threshold as suggested by Davrance et al. [6]: The Moderate group the load was set 20 % below their aerobic threshold, and in the High group, the load was 20 % over the threshold. First, all the participants cycled with a minimal load for 5-10 minutes and they played the first block of 15 clips. Then, the Low group continued cycling with the minimal load for 15 minutes and finally played the second block of 15 clips, still with the minimal load. For the Moderate and the High group, after the first block, the load was gradually increased each 30 seconds (by 25 W for men, and by 20 W for women), until an individually determined load level was reached. After the load was increased, they continued cycling for 15 minutes and then played the last 15 clips of the game, still cycling with their individually determined physical load.

The accuracy of answers in the game was used to measure situation awareness. The main interest was the change of accuracy from the first block to the second as a function of the physical load. Average response time was used as a complementary measure because it reflects the changes in the accuracy. The response time tends to decrease when the accuracy increases [5].

Block (2) x Group (3) repeated measures ANOVA and two-sample t-tests were used for statistical analysis. Alpha level 0.05 was used as the threshold for statistical significance.

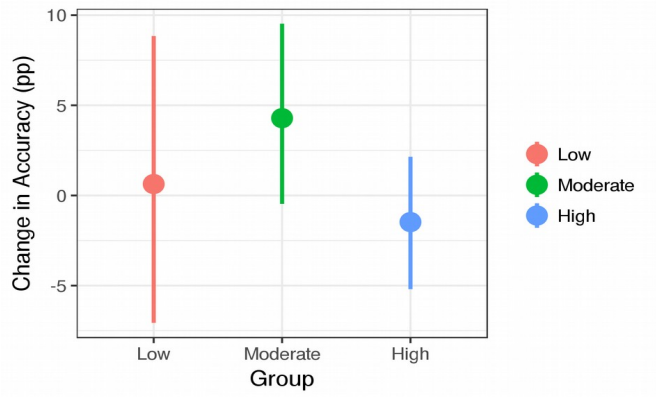

Figure 1: Change in the accuracy (percentage points) from the first half of the game to the second as a function of physical load group. Means and 95 % CI are displayed.

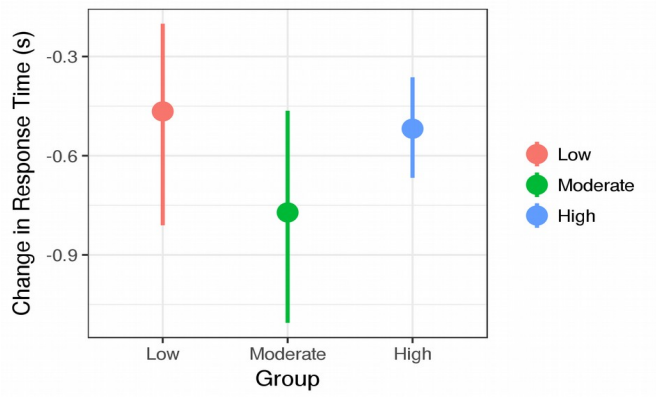

Figure 2: Change in the response time (s) from the first half of the game to the second as a function of physical load group. Means and 95 % CI are displayed.

3 RESULTS

Block (2) x Group (3) repeated measures ANOVA did not indicate statistically significant changes in accuracy (figure 1). Similar analysis regarding the response time indicated a decrease from the first block to the second, $F(1,28) = 49.15$, $p < .001$, $\eta_p^2 = 0.76$ (figure 2), but no interaction which would have indicated significant changes as a function of physical load. However, the data shows a pattern which is in the expected direction.

4 CONCLUSIONS

The results of the current pilot study could not confirm that a moderate physical load would improve but a high load distract the cognitive processes underlying the acquisition and maintenance of situation awareness. However, the pattern in the data suggests that this might have been due to a low number of participants in each group which leads to too low power to discover possible subtle effects of physical load. A follow-up study with a higher number of participants should be conducted. Overall, the effect of the physical load on cyclists' cognitive performance in traffic deserves further research. The participants in the study were young or middle aged, healthy and exercised regularly. The effect of physical load could be larger for persons with low fitness levels, e.g. elderly persons.

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