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Executive Summary - VR-Training Project

Overview of the project

The project was conducted in 2023 with two different cohorts: Linne and Dame. In the scenario of this VR project, users work in a virtual warehouse, moving and placing parcels using controllers. The training consists of 9 rounds, during which the system dynamically adjusts visual elements—such as lighting and object colors—based on users' behavior and performance to balance task difficulty after each round. Throughout the sessions, demographic and physiological data were collected. At the end of each round, participants were asked to rate their cognitive and physical load (stress indicators).

Research questions:

The purpose of this data analysis project was to answer these following questions:

1. Are there differences between the 2 data cohorts, Linne and Dame?
2. How are the stress indicators and the physiological measurements related?
3. Does this correlation change over the rounds?
4. Are there subgroups within the test subjects that stand out from the rest?

Used methods:

The study is cross-sectional with longitudinal elements. The cohorts were divided into 3 training version subgroups: Adaptive, Non-adaptive, Control. The data from the Control group was missing in one of the cohorts, therefore was excluded from further analysis.

Differences between the two cohorts were analysed by first comparing demographic data, including age range, gender proportion, BMI, and the distribution of cognitive and physical load. Among the physiological measurements, remarkable differences were observed in heart measurements, which were emphasized in the analysis.

The Spearman correlation was used to evaluate the monotonic relationships between the physiological measurements and self-rated cognitive and physical load from the participants.

When looking for subgroups, heatmaps were initially used to compare the correlation values between physiological measurements and perceived stress. These heatmaps were divided based on demographic properties, filtering through possible combinations for both cohorts. Scatterplots were used to take a closer look at the distribution of these variables as well as to identify subgroups. The 0.9 quantile was used to determine the threshold for high heart rate variability (RMSSD).

Result

The following differences between the two cohorts were observed: Dame had a wider age range (16–60+), more variation in BMI, while Linne was younger (20–30), had most BMIs around 24–26. Both have the same gender distribution in 2 training versions: Adaptive and Non-Adaptive. Cognitive and physical load were similar, but RMSSD trends diverged, with Dame showing higher heart rate variability (HRV) in Adaptive training and Linne the opposite. Despite these differences, the cohorts are similar enough to be combined for meaningful analysis. For the relationship between stress indicators and the physiological measurements: The clearest result is that blink rate showed a positive correlation and saccade velocity showed a negative correlation with stress indicators. However, with correlation values ranging from -0.15 to 0.1, the relationship between stress indicators and physiological measurements is very weak. Over 9 rounds of training the correlation between physiological measurements and stress indicators shows minimal changes with no consistent patterns, correlation values mostly falling within the range of -0.2 to 0.2. Certain subgroups stood out: Males with high perceived stress despite low to moderate heart rates were identified in both cohorts. Additionally, younger participants (20–30) exhibited high RMSSD at low stress levels.

Outlook

During the analysis, "unexpected results" were observed. For instance, heart rate and the stress indicators, which are typically expected to positively correlate, showed a very weak relationship. This outcome might be due to the VR tasks being relatively easy and the subjectivity in stress measurement: asking the participants to self-rate their stress could be quite subjective and imprecise.