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Cycling under stress: Analysing the impact of sociodemographic and psychological factors on cyclists' perceived safety – a German example

Schmidt-Hamburger, C. [1]*, Agola, D. [2], Hamel, C. [2], Zeile, P. [3], Haug, N. [3†]
*lead presenter
[1]celine.schmidt-hamburger@kit.edu, Karlsruhe Institute of Technology, Germany
[2] University of Stuttgart, Institute of Human Factors and Technology Management IAT, Germany
[3] Karlsruhe Institute of Technology, Germany
[†]All authors contributed equally to this work

Introduction

The German government's investment in promoting cycling from 2020 to 2023 underscores the recognition of cycling's manifold benefits for health, environment, and society. Despite these efforts, socially exclusive mechanisms such as the gender mobility gap persist (Gauvin et al. 2020), emphasising the need for inclusive cycling infrastructure planning that considers vulnerable groups (BMDV 2022). While various studies categorise cyclists into subgroups, there is a lack of typologies considering safety perception, which is crucial for identifying vulnerable groups (Anke et al. 2021; Félix et al. 2017). Gellers' (2006) four types of cyclists include differences in stress tolerance within different bicycle subgroups but only mention them descriptively. Caviedes and Figliozzi (2018) further concluded that bicycle studies lack stress-related data. Their paper only quantified the impact of traffic conditions and infrastructure on cyclists' stress levels, yet stress encompasses more than physiological factors. According to Schandry (2016), subjective-psychological conditions influence stress reactions more than objective-physical ones. Studies suggest that the perceived locus of control is associated with stress reactions. Individuals with varying personality traits on the Big Five Scale (Openness, Conscientiousness, Extraversion, Agreeableness and Neuroticism) exhibit distinct approaches to coping with external stressors (Penley & Tomaka 2002; Vollrath 2001). The state of research suggests that non-male people (Schulz et al. 2002) and older people are more likely to experience stress (Schoon 2010).

This study forms part of the ESSEM project, with the next section presenting the framework conditions. The research aims to understand factors affecting cyclists' perceived safety using the EmoCycling mixed methods approach to identify and analyse 'Moments of Stress' (MOS) in German bicycle infrastructure (Zeile et al. 2023). The study employs an exploratory statistical approach to identify vulnerable groups among bicycle users. This approach investigates the relationship between the number of MOS and (a) Gellers' four types of cyclists, (b) psychological personality traits, and (c) sociodemographic factors.

Accordingly, the hypotheses are the following:

H1: The category "interested but concerned" cyclist exhibits increased MOS among cyclists.
H2: Psychological factors such as personality traits, locus of control, or risk affinity affect MOS in different modes.
H3: Male cyclists tend to show a lower level of MOS than cyclists of other genders.
H4: Increasing age exerts an amplifying effect on the MOS.

Research Methodology

The ESSEM project, funded by the Federal Ministry for Digital and Transport's (BMDV) mFUND program, aims to identify areas of subjective insecurity in municipal cycling networks through iterative statistical and sensor data collection. The study records, localises, and maps participants' physiological reactions using the EmoCycling method, with empatica E4 wristbands capturing skin conductance (EDA) and skin temperature (ST) data. The data collection involves processing smartphone-based GNSS data in the E-Diary app for cycle routes integrated into the participants' everyday lives. Standardised questionnaires gather data on sociodemographics, cycling behaviour and personality traits (Big Five), locus of control, and risk affinity. The project spans three German model cities (Herrenberg, Ludwigsburg and Osnabrück) with 90 observations — and incorporates seasonal changes between fall 2022 and spring 2024 to ensure comprehensive analysis.

The algorithm by Kyriakou et al. (2019) provides information about the geo-localisation of the calculated Moment of Stress (MOS) based on ST and EDA. A pseudonym matches this 'stress' data with the questionnaire data to evaluate the relationship between physiological stress and personal data. Statistical analyses asses the data, starting with descriptive analysis to understand the collected data. Moreover, the dataset is categorised into four types of cyclists, as per Geller (2006), to examine their connection with the measured MOS. Additionally, the study examines psychological and sociodemographic factors from the questionnaire to explore their potential influence on the MOS.

Results

The sample data shows an even gender distribution, with 47.3% of participants being male, 50.5% female, and 1% identifying as diverse. The average age of participants is M = 47.73 years, indicating a slightly higher age than the average age of the German population (M = 44.6 years). The sample is dominated by a high proportion of individuals with a university or university of applied sciences degree, at 65.9%, higher than the nationwide reference value of 18.5% (Research Data Centres of the Statistical Offices of Federation and the federal states 2022). Further, the data suggests a diverse response in cycling types: 0% in the "no way, no how" category, 26.7% in the "interested but concerned" group, 65.6% in the "enthused and confident" segment, and 7.8% in the "strong and fearless" category.

Statistical analyses related to hypotheses H1 through H3 did not show any significant outcomes, suggesting the data could not support them. However, according to statistical analysis, H4 could not be rejected. Thus, age is the only consistent predictor, indicating that MOS increases with higher age.

Discussion and Conclusion

According to the early results of this case study, just a fraction of the analysed variables contribute to explaining the number of MOS. One potential explanation could be that the sample is relatively homogeneous. This homogeneity is reflected in the low variance in personality traits (neuroticism, perceived locus of control) and sociodemographic characteristics. Additionally, unaccounted personality traits or variables might explain the variations observed in the MOS.

Furthermore, stress as a subjective construct is difficult to understand and measure. When riding a bicycle, "stress" can be driven by external factors like construction sites, narrow lanes, or situational elements such as heavy traffic, which are challenging to quantify and incorporate

into a study. Therefore, future research should adopt standardised conditions and predefined routes to provide a more controlled environment.

References

Anke, Juliane; Francke, Angela; Petzoldt, Tibor (2021): RadVerS - Mit Smartphones generierte Verhaltensdaten im Verkehr – Differenzierung des Nutzerverhaltens unterschiedlicher RadfahrerInnengruppen: Teil 1 des Abschlussberichts. Technische Universität Dresden, Fakultät Verkehrswissenschaften, Professur für Verkehrspsychologie.

BMDV (2022): Nationaler Radverkehrsplan 3.0. Published by the Federal Ministry for Digital and Transport. Berlin.

Caviedes, Alvaro; Figliozzi, Miguel (2018): Modeling the impact of traffic conditions and bicycle facilities on cyclists' on-road stress levels. In: *Transportation Research Part F: Traffic Psychology and Behaviour* 58.

Félix, Rosa; Moura, Filipe; Clifton, Kelly J. (2017): Typologies of Urban Cyclists: Review of Market Segmentation Methods for Planning Practice. In: *Transportation Research Record* 2662 (1).

Gauvin, Laetitia; Tizzoni, Michele; Piaggesi, Simone et al. (2020): Gender gaps in urban mobility. In: *Humanit Soc Sci Commun* 7 (1).

Geller, Roger (2006): Four Types of Cyclists. Available online at Geller, R. Four Types of Cyclists. 2006. https://www.portlandoregon.gov/transportation/44597?a=237507.

Kyriakou, Kalliopi; Resch, Bernd; Sagl, Günther et al. (2019): Detecting Moments of Stress from Measurements of Wearable Physiological Sensors. In: *Sensors* 19 (17).

Penley, Julie A.; Tomaka, Joe (2002): Associations among the Big Five, emotional responses, and coping with acute stress. In: *Personality and Individual Differences* 32 (7).

Research Data Centres of the Statistical Offices of the Federation and the federal states (2022): Microcensus 2019, On-Site, Version 1.

Schandry, Rainer (2016): Biologische Psychologie. Mit Arbeitsmaterial zum Download. Originalausgabe, 4., vollständig überarbeitete Aufl. Weinheim: Beltz.

Schoon, John G. (2010). Pedestrian facilities. Engineering and geometric design. London: Thomas Telford.

Schulz, Peter; Schlotz, Wolff: Wolf, Jutta et al. (2002): Geschlechtsunterschiede bei stressbezogenen Variablen. In: *Zeitschrift für Differentielle und Diagnostische Psychologie* 23 (3).

Vollrath, Margarete (2001): Personality and stress. In: *Scandinavian journal of psychology* 42 (4).

Zeile, Peter; Haug, Nina; Schmidt-Hamburger, Céline et al. (2023). Emotion Sensing for (E-) Bicycle Safety and Mobility Comfort. In: *Journal of Digital Landscape Architecture*, 8.