New approaches to teachers' experience of stress: Do heart rate measurements with fitness trackers provide an efficient, inexpensive, and robust measurement method?

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Abstract

One or two sentences providing a **basic introduction** to the field, comprehensible to a scientist in any discipline.

Two to three sentences of **more detailed background**, comprehensible to scientists in related disciplines.

One sentence clearly stating the **general problem** being addressed by this particular study.

One sentence summarizing the main result (with the words "**here we show**" or their equivalent).

Two or three sentences explaining what the **main result** reveals in direct comparison to what was thought to be the case previously, or how the main result adds to previous knowledge.

One or two sentences to put the results into a more **general context**.

Two or three sentences to provide a **broader perspective**, readily comprehensible to a scientist in any discipline.

Keywords: heart rate; photoplethysmography; wearable electronic device; teaching

Word count: X

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Introduction

Physiological data such as heart rate are becoming increasingly important in research on stress experience. They represent an important indicator of physical or emotional stress, as increased workload is associated with increased heart rate (Sachs, 2014). Furthermore, they allow a more objective recording of stress than self-reports (Runge, Haarman, & Fisher, n.d.). However, capturing heart rate in an educational context requires the use of low-cost and non-invasive instruments. Fitness trackers worn on the wrist have the potential to be such a useful tool (Ferguson, Rowlands, Olds, & Maher, 2015).

To date, there is still little evidence on the usefulness of heart rate measurements using fitness trackers in teaching and learning settings (Ertzberger & Martin, 2016; Lowe, 2016). Runge et al. (n.d.) alone examined teacher stress in a relatively small sample (N = 4 teachers) and showed that high heart rate, high step count, and little sleep indicate more stress in teachers.

Thus, there remains a lack of robust studies on whether fitness trackers are an efficient, inexpensive, and robust measurement method for assessing teachers' experience of stress. Since, among other things, greater professional experience is associated with lower feelings of stress in the teaching profession (Fisher, 2011), this study will also consider the heart rate measurements of experienced and inexperienced teachers.

Aim of the study

Against this background, we investigated whether heart rate measurements using fitness trackers in a controlled teaching-learning setting are suitable to map differences between (1) anticipation, arousal, and rest phases. We expected heart rates to be higher in

the arousal phase than in the rest phases.

Methods

We report how we determined our sample size, all data exclusions (if any), all manipulations, and all measures in the study.

Participants

The sample consisted in total of $N = 63$ pre- and in-service teachers. The subjects were recruited from the Leipzig University or from German schools in Saxony via personal contact, e-mail lists and flyers. Data of two participants were excluded from the analyses due to insufficient data quality, yielding demographic data from $N = 61$ subjects.

The subjects (39 women; 63.93 %) had a mean age of 29.60 years ($SD = 10.40$; range: 19-59) and an average teaching experience of 4.66 years ($SD = 9.30$; range: 0-37).

18.03% of the subjects were (studying to become) teachers for primary school, 72.13% were (studying to become) teachers for secondary school and 9.84% were (studying to become) teachers for special education needs.

All study procedures were carried out in accordance with the ethical standards of the University's Institutional Review Board and the authors received a positive vote on the study procedures from the Ethics Committee Board of Leipzig University. All participants were informed in detail about the aim and intention of the study prior to testing. Participation in the study was voluntary and only took place after written consent has been given.

Material

Teachers' heart rate. We used a Fitbit Charge 4 to measure the teachers' heart rate. The device was attached 2-finger widths above the ulnar styloid process to the

subject's wrist following the manufacturer's instructions. To determine the heart rate, the Fitbit flashes green LEDs many times per second and uses light-sensitive photodiodes to measure the volume changes in the capillaries and then calculates how many times the heart beats per minute (bpm). Data were automatically wireless synced with an iPad via Bluetooth to a Fitbit account, and subsequently, the intraday second-by-second data were exported for each session using the opensource software Pulse Watch (PulseWatch. URL: https://iccir919.github.io/pulseWatch/public/index.html [accessed 2022-08-03]).

Teachers' self-assessment of arousal during the teaching phase.

Procedure

In a laboratory setting, three trained actors performed teaching disruptions in a counter balanced fashion while the subject taught a 15-minute micro-teaching unit prepared in advance. To record the subject's heart rate, the Fitbit Charge 4 was put on at least 10 minutes before the start of the lesson. The lesson was recorded by four cameras and an audio recorder. In addition, the subject wore eye-tracking glasses to record gaze behavior.

Subsequently, the subjects as well as the actors were given a short questionnaire, which contained items to collect demographic information as well as items about the previously given lesson on teaching quality using a validated questionnaire (EMU, Helmke et al. (2014)) and self developed scales on the teacher's presence behavior derived from the research literature via the online survey website SoSci Survey (4-point Likert scale; 1 = strongly disagree; 2 = disagree; 3 = agree; 4 = strongly agree). The completion of the questionnaire took approximately 5 minutes.

The experimenter then conducted a Stimulated Recall Interview (SRI), where the subject commented and rated the reactions to classroom events while watching the eye tracking video.

Finally, a Situational Judgment Test (SJT, Gold and Holodynski (2015)) was used to

assess the subject's strategic knowledge of classroom management. The subject was asked to judge alternative actions on school scenarios on a 6-point rating scale from 1 (A) to 6 (F) according to school grades. Data from the SJT were again collected as an online questionnaire via the website www.soscisurvey.de and lastet approximately 10 minutes.

The Fitbit watch was removed only after the last questionnaire to obtain heart rate at three different measurement time points: before, during, and after the lesson.

Data analysis

We used R (Version 4.1.3; R Core Team, 2022) and the R-packages *broom* (Version 1.0.1; Robinson, Hayes, & Couch, 2022), *cowplot* (Version 1.1.1; Wilke, 2020), *DescTools* (Version 0.99.45; Andri et mult. al., 2022), *dplyr* (Version 1.0.10; Wickham, François, Henry, & Müller, 2022), *forcats* (Version 0.5.1; Wickham, 2021), *ggplot2* (Version 3.3.5; Wickham, 2016), *ggpubr* (Version 0.4.0; Kassambara, 2020), *ggthemes* (Version 4.2.4; Arnold, 2021), *gridExtra* (Version 2.3; Auguie, 2017), *imputeTS* (Version 3.2; Moritz & Bartz-Beielstein, 2017), *janitor* (Version 2.1.0; Firke, 2021), *jtools* (Version 2.2.0; Long, 2022), *lm.beta* (Version 1.6.2; Behrendt, 2022), *lme4* (Version 1.1.30; Bates, Mächler, Bolker, & Walker, 2015), *ltm* (Version 1.2.0; Rizopoulos, 2006), *lubridate* (Version 1.8.0; Grolemund & Wickham, 2011), *MASS* (Version 7.3.55; Venables & Ripley, 2002), *Matrix* (Version 1.5.1; Bates, Maechler, & Jagan, 2022), *msm* (Version 1.6.9; Jackson, 2011), *needs* (Version 0.0.3; Katz, 2016), *papaja* (Version 0.1.0.9999; Aust & Barth, 2020), *polycor* (Version 0.8.1; Fox, 2022), *ppcor* (Version 1.1; Kim, 2015), *purrr* (Version 0.3.4; Henry & Wickham, 2020), *readr* (Version 2.1.2; Wickham, Hester, & Bryan, 2022), *readxl* (Version 1.4.0; Wickham & Bryan, 2022), *rstatix* (Version 0.7.0; Kassambara, 2021), *stringr* (Version 1.4.0; Wickham, 2019), *tibble* (Version 3.1.6; Müller & Wickham, 2021), *tidyr* (Version 1.2.0; Wickham & Girlich, 2022), *tidyverse* (Version 1.3.1; Wickham et al., 2019), *tinylabels* (Version 0.2.3; Barth, 2022), *viridis* (Version 0.6.2; Garnier et al., 2021a, 2021b), and *viridisLite* (Version 0.4.0; Garnier et al., 2021b) for all our analyses.

FitBit. All participants were given a FitBit Smart Watch Charge 4 to wear during the experiment.

Heart Rate

The heart rate of each subject were measured before, during and after the experiment.

Steps. Using the FitBit we measured the steps a person walked during the experiment as well. We validated the steps in six randomly selected videos by manual step counting. A step was considered to be the movement of the subject's foot forward, backward, or sideways. The measurement was not as reliable as hoped.

Results

Discussion and implication

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