Exploring Stress Creation in VR for Task-Based Training in Nursing

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Figure 1: Virtual environments for nurse training. Left: Intensive Care Unit, right: Apartment (Ambulant care)

ABSTRACT

The nursing profession is widely regarded as very stressful. Stress has been shown to have adverse affects on both nurses and patients. It is therefore important to decrease stress exposure, especially in safety critical environments. Virtual reality (VR) has become a wide-spread medium with use cases in many different industries, such as medicine, military, and aviation. The possibility of VR to create an immersive experience in a realistic depiction of the working environments, such as an ICU, including typical stressors makes it a good candidate as a training tool. This work outlines possible technologies and applications to create and measure stress for a holistic training experience.
Previous studies have shown positive effects of training in VR on stress or anxiety, but the costs for skills- and real laboratories with the required equipment are too high for some institutions to carry. Virtual reality can be a cost-adequate alternative for this sector. However, little research has been conducted on how to create stress in a virtual environment in order to better prepare for stressful situations. Therefore, we present a concept for researching stress induction in immersive virtual environments.

CCS CONCEPTS

• **Human-centered computing** → **Virtual reality**; *Haptic devices*; *Scenario-based design.*

KEYWORDS

Virtual Reality, Virtual Environments, Stress, Nursing

1 MOTIVATION

Occupational stress can be dangerous, especially in safety-critical environments. It has been shown that occupational stress experienced by nurses contributes to feelings of inadequacy, self doubt and lowered self esteem. Stress also negatively contributes to staff conflict and rapid staff turnover [1]. Furthermore, it is detrimental to the patients safety and, in the long term, for the nurses themselves, as enduring stress can lead to depression, burnout and post-traumatic stress disorder (PTSD) [2]. Primary sources of nursing stress are physical overload, emotional demand of patients and families, higher exposure to death and separation as well as poor communication and support [3]. However, if one is prepared to deal with the stress, it can actually make you work more efficiently [4]. Prachyabrued et al. identified several stress

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management approaches, one of which is pre-deployment training, a concept to prepare staff to psychological deal with future potential stressors [2].
Virtual reality (VR) is a promising tool to create rich, immersive environments for personnel to train in - environments, that would otherwise be to expensive or even too dangerous to recreate with sufficient realism. However, Freina and Ott have shown that nursing is an area that makes only little use of VR in training [5]. The focus in this work will emphasize on the creation of stress in nursing context as well as the appropriate technologies and methods for measuring activities, as well as physical and psychological stress.

2 RELATED WORK

In the past, research has been conducted on how to induce stress and increase situational awareness in workers, albeit in different professions. Other studies focused on the stressors in nursing and advice on how to minimize them.

Stress in simulated training situations

Prachyabrued et al. show that one can use stress inoculation training (SIT) in VR with pre-hospital emergency health care personnel (e.g. paramedics) to better prepare them for critical situations they are bound to experience during their work [2]. SIT attempts to improve stress resistance in an individual by delivering a skill set that enables the trainee to cope with the stressor in a more favorable way [6]. The authors showed that the repeated exposure desensitizes the user with regard to stress, because it renders experiences less novel. Furthermore, they show that using emotional connections have a strong impact on the stress response of the user of their VR software: following the three-act structure, commonly found in novels and video games, they present some users with a story line where users get to know their superior EMT in an introductory scene, shortly before the superior dies in an accident, eliciting a strong emotional response. For other users, the experience began differently - they did not get to know their supervisor beforehand, instead the software placed them in an ambulance on the way to an emergency. The situation was experienced using a VR headset and controlled using a workstation PC. In this experiment, galvanic skin response, heart rate and self-rating of stress as well the IPQ questionnaire were used for evaluating stress and the feeling of presence, respectively. Results have shown that participants who had the friendly encounter had a stronger stress response to the sudden death of their superior compared to those who did not see this introductory scene. However, the results of the stress assessment may be questioned because the participants were only rating their stress level on a scale from one to ten, and not on a standardized tool.
Shiban et al. use a modified version of the Trier Social Stress Test (TSST), which has been reworked for use in virtual reality (VR-TSST) [7]. This test was designed by Kirschbaum et al. in 1993 as a highly standardized framework to induce stress in participants. It includes public speaking, arithmetic, and anticipation [8]. The VR-TSST has been shown to elicit significant stress reaction in social situations, comparable to the in-vivo TSST. For a third group of participants, a virtual competitor has been added to the experience (VR+-TSST) However, the reported cortisol level from saliva tests yielded significantly different results between groups, with in-vivo participants showing the highest response rate. When compared with the VR+ version of the TSST, neither of the VR scenarios created a stronger reaction than the other. However, this work was focused on social situations and thus the scenario is not applicable for the task load and safety critical environments that can be found in nursing.
Popovic et al. created a closed loop, physiology-driven VR system to deliver SIT in PTSD patients and workers in high-stress fields [6]. The generated stimuli that are being shown to the patient (trainee) depend on the estimation and assessment of the current emotional state. The stimuli change that state and the results are being fed back into the stimuli generator. However, the authors only provided information on how the system works, not how effective it is.
Pallavicini et al. discuss the effectiveness of VR stressors in comparison with sound or text in exposure therapy [9]. In their study, they simulate technology breakdowns to test how much a cut in presence and thus complete loss of immersion influences the effect of exposure-based therapy for stress and anxiety. They altered the experience in the VRE twofold: they inverted head tracking randomly and they desynchronized the avatars lips from their voice. Results show an even lesser effectiveness in VR with broken presence in comparison to other means of delivering an anxiety inducing experience. The authors conclude that, in order for VR to be effective, the developers have to guarantee a high level of presence throughout the experience.
Lackey et al. show that the self-reported measures on the experience of a VR based training can predict stress and workload that is imposed by a subsequent live transfer task [10] . They studied, among other things, the stress response of US Army soldiers to a real (as opposed to virtual) training session for a room clearing task. Half of the soldiers were randomly selected to prepare for the task using VR, the other half received standard, non-simulated (real) training on the same task. The researchers' results indicate that VR training may be helpful in reducing stress and workload with criterion tasks and thus protect mental resources. However, there were no details on how detailed and multisensory the VR experience was. Therefore, it is hard to estimate how stress was evoked.
David Scherfgen built a traffic simulator to induce physical

and mental stress in cyclists [11]. The prototype consists of a three back projection screens (1.4m x 1m), a stationary mountain bike, and a VRE that simulates a traffic situation. Here, physical stress is created by having the user cycle the mountain bike, which also creates a higher sense of immersion. The mental stress is induced by augmenting the scene with oncoming cars and and randomly appearing obstacles. Users were asked to avoid collisions. During the experiment, both the amount and speed of cars and obstacles could be adjusted on the fly. Although no exact numbers were presented in the study, the author notes that a group of elementary school children participating in the study behaved similarly in the simulator as they would have in real traffic. Additionally, one participant was fitted with physiological sensors which recorded and a delta in stress-dependent bio markers when the traffic situation changed. The author did not mention to have used a multisensory approach, which would have increased the immersion and thus might have elicited a stronger stress response.

Clifford et al. present a multisensory training system for aerial firefighters and the simultaneous measurement of their stress response using heart rate variability as the metric [4]. Their system comprises a 270 degree cylindrical projection display, vibro-tactile seats and spatially rendered surround sound. The study design includes several users, although only one is the person of interest during each run. When compared to a high fidelity training (in an actual helicopter) and a low fidelity training (radio chatter only), they did not find significant differences in pre- and post test measurements. Participants asked for deeper immersion, something that could probably have been achieved by using a VR head mounted display.

Stress factors in nursing

In nursing, several stress factors have been identified. As for environmental stressors, noise is mentioned commonly in the literature [12, 13]. Morrison et al. showed that the constant noise level on a pediatric ICU (PICU) can increase heart rate and contributes to tachycardia [14]. Noise as a stress factor in an ICU is also mentioned by Vahedian-Azimi [15]. It increases patients risk for delirium and the length of stay in the ICU, in nurses it leads to higher stress level and potentially alarm fatigue [13].

Lavoie et al. further identified team effectiveness, task obstacles, organizational obstacles, and technology obstacles as relevant stressors [16]. However, their study was limited to nurses working in neonatal ICUs.

In a review regarding stress among nursing students, Alzayyat and Al-Gamal have identified stress factors that occur during the clinical part of the education [17]. Most often, students cited emotional stress (seeing patients suffer and/or die), complex workplace relationships with nurses and doctors, and high workload as reasons for being stressed. The same factors have been identified by Chatzigianni et al. in a cross-sectional study in Greece [18].

Vahedian-Azimi et al. collected similar stressors in their 2017 cross-sectional study on Iranian nurses [15]. They name organizational factors, namely a perceived increasingly high workload due to staff shortage, inadequate pay, technical issues, and psychological factors, such as threats, emotional violence and/or abuse through patients and their family, and bullying within staff. Generally, workplace ethics and violence is an often cited stressor [19, 20].

It is important to note that all of these stressors are individually perceived. Factors such as age, sex, educational level, marital status, and experience have been shown to be an influential factor on how individuals cope with stress [12, 15, 21].

3 STRESS MEASUREMENT

Stress consists of two major components: Stressors and the stress response. Stressors are stimuli in the environment that provoke the stress response, a "non-specific reaction of the body to any demand for change, involving a complex reaction pattern that often has physiological, cognitive, and behavioural components" [22]. In simpler terms, it is a response by the sympathetic nervous system to a perceived threat with the purpose of preparing the body to activate 'fight or flight mode' [23].

Stress is caused when demands on an individual exceeds that individuals resources, whether the demand is of physiological, cognitive, or emotional nature. On a more general level, it is an interplay between stress on the individual level, in the personal life, and the work environment [23]. Occupational stress specifically refers to job related stressors that occurs when the employee can not keep up with the demands their work places on them.

Measuring stress can be done subjectively, using self-administered questionnaires, and objectively, by taking physiological measures into account. Sharma and Gedeon identified multiple physiological factors and appropriate sensors in a 2012 survey, compare Figure 2 [24].

The (objective) physiological data can be obtained in real time using on-body sensors. While inside the VR experience, the users nervous system will react to the impressions. This reaction can be measured as alterations from values, that will be recorded during a calm phase, before the experiment begins (baseline recordings).

In order to subjectively (self-) assess stress levels, several questionnaires are available that ask questions about events in the past and how the participant feels about said events. The results of these questionnaires will help to quantify the effects of the virtual reality experience.

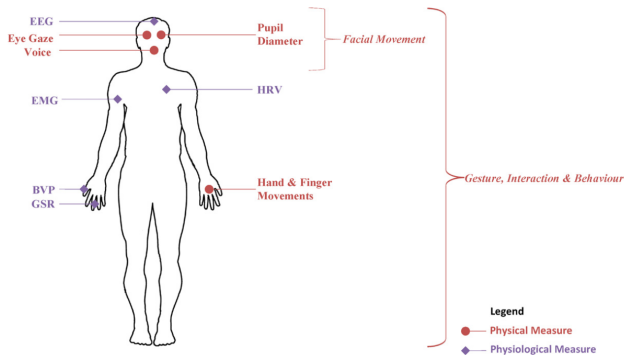

Figure 2: Common physical and physiological measures used in stress measurement.

Physiological measures.

Heart Rate (HR). The heart rate is calculated as the mean heart contractions (beats) per minute. It is controlled through the autonomic nervous system (ANS). The ANS consists of the sympathetic nervous system and the parasympathetic nervous system. Sympathetic stimulation, i.e. in response to stress or trauma, increases the heart rate, while parasympathetic activity decreases it. Although definite numbers are depending on the individual and their level of cardiovascular fitness, generally a faster heartbeat is a sign of stress [25].

Heart Rate Variability (HRV). HRV is defined as the variation over time of the period between consecutive heartbeats and thus dependent on the regulation of the heart rate. It can be used to assess the hearts ability to adapt to changing circumstances. The HRV has already widely been used as a primary measure for stress, as it is very useful in understanding the status of the ANS. A high HRV is a sign of a healthy heart, as it shows that the heart is able to quickly respond to external influences [26].

Galvanic Skin Response (GSR). GSR, also known as skin conductance or electrodermal skin response, has been shown to be a reliable indicator of stress in humans. In stressed individuals, an increase of moisture on the skin surfaces increases the conductivity of the skin. Vice versa, in calm individuals this conductivity decreases. Measuring GSR is highly suitable for monitoring activities of the ANS, as the sympathetic branch is dominant during stressful situations - which is the branch that solely controls the sweat glands [27]. Additionally, Shi et al. have shown that GSR can also be used as an objective indicator for the cognitive load of the test subject in real time and with fine granularity. They tested individuals on the use of a multimodal user interface and measured GSR. When they compared the recordings to measurements that were taken when the subjects where using a unimodal UI, they found that the cognitive load correlated with GSR [28].

Self assessment through questionnaires.

The Perceived Stress Questionnaire (PSQ). Levenstein et al. conceived the PSQ, a 30 item questionnaire that focuses on stress as representation of perceived strains [29]. It has a universal target population, its goal is to measure the subjective perception, evaluation and further processing of stressors [30]. The subjective perception is a decisive factor for the progression of different illnesses, which makes an exact knowledge about the perception paramount for improving therapeutic and medical interventions. The German version by Fliege et al. has been validated with a sample of women giving birth or having had a miscarriage, and also in a general household survey [31]. However, Gross et al. mention that 30 items can be a lot for bigger studies [30].

Dundee Stress State Questionnaire (DSSQ). Matthews et al. have developed the DSSQ in 2002 [32]. In a 2013 published paper, they review its use on the investigation of task-induced stress. They argue that tasks impose stress for they carry a high workload or come with time pressure or the likelihood of failure. Furthermore, operational settings and social factors influence task performance. Task-related stress thus can have "a variety of consequences such as an acute emotional response, performance impairments and long-term impacts on the operator's health and well-being" [33]. The authors note that it is vital for validity of the scale that the stress measure correlates with objective performance measure.
The DSSQ is a three-factor, 10 scale questionnaire with a shorter version existing. Its application allows to evaluate tasks, performance environments with respect to environmental stressors, and diagnostic monitoring.

The Perceived Stress Scale (PSS). Cohen et al. published the PSS in 1983 [34]. It is a 14 item questionnaire, that is designed to be easily grasped with rather general questions and thus not specific to any sub-population group. The PSS is an established tool for the self report of the psychological conceptualization of stress (as opposed to the environmental and biological approach). Perceived stress has been linked to reduced life satisfaction, and the PSS measures "the degree to which situations in one's life are appraised as stressful".

The authors also mention that of the original 14 items, 4 were dropped due to low factor loadings. The shorter version shows a slightly improved reliability [35].

4 RESEARCH APPROACH

Creating and augmenting detailed environments and designing tasks requires a systematic approach. The Human-Centered-Design process, as lined out in ISO 9241-210, provides a framework for this kind of research, specifically by

analyzing the context of use, defining the requirements, prototyping and executing tasks, and their evaluation.

Context analysis and requirement definition. After leading interviews with and focus groups with nursing staff, the resulted information can be used to derive typical tasks, which then have to be designed and implemented. In the focus groups, nurses were educated about how what virtual reality is and how it works. Further, we showed some interaction paradigms and explained the use of the controllers. The nurses were then asked to explore the virtual environments we had previously set up, see Fig-1. The resulting consensus between our participants was that, with current consumer technologies, it makes more sense to recreate process-based tasks instead of tasks that require the use of ones hands. Concurrently, we are exploring technologies to recreate the typical work load and influencing factors such as noise and light. These must be designed and implemented as well. Tasks must be carefully analyzed in order to transfer them into VR.

Task design and stress emulation / substitution. In order to induce / emulate stress in study participants, stress relevant features from real nursing tasks have to be recreated in the virtual environments. Tasks need to be designed to evoke a stress response similar to those identified in other research. The planned augmentation of stressful experiences requires additional hard- and software.

VR enables the recreation of stressful environments. Walking tasks can be emulated by using omnidirectional treadmills. Locomotion movements that happen in-place on the treadmill are translated into the virtual world, enabling the user to run and walk in the environment. Lights and noise can be implemented to create environmental stress, and virtual characters not only help to make an experience more complete, but they can also be used to induce emotional stress, such as the loss of a friend or by creating a hostile social situation.

To increase psychological workload, tasks should be designed in a way that they intersect with each other, such as alarms interrupting a thinking task, for example memorizing sequences or solving a puzzle or math task.

Evaluation. Lastly, the implemented tasks must be run and evaluated using real-time physiological measures as well as pre- and post experiment questionnaires, so we can compare different experiences with respect to the amount of stress it induces in the user. In order to measure stress, we plan on recording the previously introduced biomarkers as these are commonly used throughout the literature and yield objective results. For the experiments, the participants will be - depending on the task - sitting or standing in a quiet room. The equipment for VR will include the HMD and a headset with surround sound capabilities. Controllers may be optional, also depending on the task. Statistical calculations can be done in R or MatLab. Additionally, participants will be given standardized questionnaires from the field of psychology and human-computer interactions as to assess several aspects of the experience. These validated questionnaires have been used throughout stress related research. As for immersion, task load, and usability, there are also standardized tools such as the IPQ, SUS, and the NasaTLX.

5 CONTRIBUTIONS

Often, the exact nursing task cannot be mimicked in its entirety. Instead, in order to induce / emulate stress in study participants, the stress relevant features from real nursing tasks have to be extracted and recreated in the virtual environments. They need to be designed to evoke a stress response similar to those identified in other research. To induce stress, we plan on augmenting the existing, virtual nursing-related environments, with typical stressors. These are visible and audible alarms, social interactions with virtual characters (colleagues, patients, family), and physical tasks.
Based on this, the goal is to research the following questions: a) is the stress created in VR equal to the stress experienced in the real situation, b) how can missing stress factors, e.g. physical stress, be designed to maximize immersion. Measures of interest will be the amount of induced stress, task load of the virtual tasks, and the level of immersion experienced by participants. For that, it is necessary to figure out how to best transfer nursing tasks from reality to a virtual environment. We want to aid the nursing community by creating immersive training environments in which aspiring nurses can prepare for stressful situations. I hope to contribute techniques to converse tasks from the reality into VR with a high degree of realism, including the way tasks are carried out and the interaction with environment and virtual characters.

REFERENCES

[1] Martha J Foxall, Lani Zimmerman, Roberta Standley, and Barbara Bene Captain. A comparison of frequency and sources of nursing job stress perceived by intensive care, hospice and medical-surgical nurses. *Journal of Advanced Nursing*, 15(5):577–584, May 1990.

[2] Mores Prachyabrued, Disathon Wattanadhirach, Richard B Dudrow, Nat Krairojananan, and Pusit Fuengfoo. Toward virtual stress inoculation training of prehospital healthcare personnel: A stress-inducing environment design and investigation of an emotional connection factor. In *2019 IEEE Virtual Reality (VR)*. IEEE, 2019.

[3] Joel J. Hillhouse and Christine M. Adler. Investigating stress effect patterns in hospital staff nurses: Results of a cluster analysis. *Social Science & Medicine*, 45(12):1781–1788, December 1997.

[4] Rory M S Clifford, Sungchul Jung, Simon Hoermann, Robert W Lindeman, and Mark Billinghurst. Creating a Stressful Decision Making Environment for Aerial Firefighter Training in Virtual Reality. In *2019 IEEE Virtual Reality (VR)*. IEEE, 2019.

[5] Laura Freina and Michaela Ott. A literature review on immersive virtual reality in education: State of the art and perspectives. In *eLearning*

and Software for Education (eLSE). Carol | NDU Publishing House, 2015.

[6] Caro D. Next Generation Stress Inoculation Training for Life Saving Skills using Prosthetics. *Frontiers in Neuroengineering*, 2, 2009.

[7] Youssef Shiban, Julia Diemer, Simone Brandl, Rebecca Zack, Andreas Mühlberger, and Stefan Wüst. Trier social stress test in vivo and in virtual reality: Dissociation of response domains. *International Journal of Psychophysiology*, 110:47–55, 2016.

[8] Clemens Kirschbaum, Karl-Martin Pirke, and Dirk H. Hellhammer. The 'trier social stress test' – a tool for investigating psychobiological stress responses in a laboratory setting. *Neuropsychobiology*, 28(1):76–81, 1993.

[9] Federica Pallavicini, Pietro Cipresso, Simona Raspelli, Alessandra Grassi, Silvia Serino, Cinzia Vigna, Stefano Triberti, Marco Villamira, Andrea Gaggioli, and Giuseppe Riva. Is virtual reality always an effective stressor for exposure treatments? some insights from a controlled trial. *BMC Psychiatry*, 13(1):52, December 2013.

[10] S. J. Lackey, J. N. Salcedo, J.L. Szalma, and P.A. Hancock. The stress and workload of virtual reality training: the effects of presence, immersion and flow. *Ergonomics*, 59(8):1060–1072, August 2016.

[11] David Scherfgen. Integration physischer und mentaler stressfaktoren in eine VR-basierte simulationsumgebung. In *Lecture Notes in Informatics*, volume S8, pages 135–139. Köllen Druck+Verlag GmbH, Bonn, 2009.

[12] Julie L. Darbyshire, M. Müller-Trapet, J. Cheer, F. M. Fazi, and J. D. Young. Mapping sources of noise in an intensive care unit. *Anaesthesia*, 74(0), 2019.

[13] Vanessa Cobus and Wilko Heuten. To beep or not to beep? evaluating modalities for multimodal ICU alarms. *Multimodal Technologies and Interaction*, 3(1):15, 2019.

[14] Wynne E. Morrison, Ellen C. Haas, Donald H. Shaffner, Elizabeth S. Garrett, and James C. Fackler. Noise, stress, and annoyance in a pediatric intensive care unit. *Critical Care Medicine*, 31(1):113–119, 2003.

[15] Amir Vahedian-Azimi, Mohammadreza Hajiesmaeili, Mari Kangasniemi, Joana Fornés-Vives, Rita L. Hunsucker, Farshid Rahimibashar, Mohammad A. Pourhoseingholi, Leily Farrokhvar, and Andrew C. Miller. Effects of stress on critical care nurses: A national cross-sectional study. *Journal of Intensive Care Medicine*, 34(4):311–322, 2017.

[16] Mélanie Lavoie-Tremblay, Nancy Feeley, Geneviève L. Lavigne, Christine Genest, Stéphanie Robins, and Julie Fréchette. Neonatal intensive care unit nurses working in an open ward: Stress and work satisfaction. *The Health Care Manager*, 35(3):205–216, 2016.

[17] A. Alzayyat and E. Al-Gamal. A review of the literature regarding stress among nursing students during their clinical education: A review of stress among nursing students. *International Nursing Review*, 61(3):406–415, 2014.

[18] Dimitra Chatzigianni, Andreas Tsounis, Nikolaos Markopoulos, and Pavlos Sarafis. Occupational stress experienced by nurses working in a greek regional hospital: A cross-sectional study. *Iranian Journal of Nursing and Midwifery Research*, 23(6):450–457, 2018.

[19] Isaac Mensah Boafo. The effects of workplace respect and violence on nurses' job satisfaction in ghana: a cross-sectional survey. *Human Resources for Health*, 16(1):6, 2018.

[20] Shi-Hong Zhao, Yu Shi, Zhi-Nan Sun, Feng-Zhe Xie, Jing-Hui Wang, Shu-E. Zhang, Tian-Yu Gou, Xuan-Ye Han, Tao Sun, and Li-Hua Fan. Impact of workplace violence against nurses' thriving at work, job satisfaction and turnover intention: A cross-sectional study. *Journal of Clinical Nursing*, 27(13):2620–2632, 2018.

[21] Derek Johnston, Cheryl Bell, Martyn Jones, Barbara Farquharson, Julia Allan, Patricia Schofield, Ian Ricketts, and Marie Johnston. Stressors, appraisal of stressors, experienced stress and cardiac response: A real-time, real-life investigation of work stress in nurses. *Annals of Behavioral Medicine*, 50(2):187–197, 2015.

[22] Philip Banyard and Andrew Grayson. *Introducing Psychological Research*. Red Globe Press, 1 edition, 2015.

[23] Kerri Wright. Alleviating stress in the workplace: Advice for nurses. *Nursing Standard*, 28(20):37–42, 2014.

[24] Nandita Sharma and Tom Gedeon. Objective measures, sensors and computational techniques for stress recognition and classification: A survey. *Computer Methods and Programs in Biomedicine*, 108(3):1287–1301, December 2012.

[25] Juul Achten and Asker E Jeukendrup. Heart Rate Monitoring: Applications and Limitations. *Sports Medicine*, 33(7):517–538, 2003.

[26] U. Rajendra Acharya, K. Paul Joseph, N. Kannathal, Choo Min Lim, and Jasjit S. Suri. Heart rate variability: a review. *Medical & Biological Engineering & Computing*, 44(12):1031–1051, December 2006.

[27] Sue C. Jacobs, Richard Friedman, John D. Parker, Geoffrey H. Tofler, Alfredo H. Jimenez, James E. Muller, Herbert Benson, and Peter H. Stone. Use of skin conductance changes during mental stress testing as an index of autonomic arousal in cardiovascular research. *American Heart Journal*, 128(6):1170–1177, December 1994.

[28] Yu Shi, Natalie Ruiz, Ronnie Taib, Eric Choi, and Fang Chen. Galvanic skin response (GSR) as an index of cognitive load. In *CHI '07 extended abstracts on Human factors in computing systems - CHI '07*, page 2651, San Jose, CA, USA, 2007. ACM Press.

[29] Susan Levenstein, Cosimo Prantera, Vilma Varvo, Maria L. Scribano, Eva Berto, Carlo Luzi, and Arnaldo Andreoli. Development of the perceived stress questionnaire: A new tool for psychosomatic research. *Journal of Psychosomatic Research*, 37(1):19–32, January 1993.

[30] Christiane Gross and Katharina Seebaß. The Standard Stress Scale (SSS): Measuring Stress in the Life Course. In Hans-Peter Blossfeld, Jutta von Maurice, Michael Bayer, and Jan Skopek, editors, *Methodological Issues of Longitudinal Surveys*, pages 233–249. Springer Fachmedien Wiesbaden, Wiesbaden, 2016.

[31] Herbert Fliege, Matthias Rose, Petra Arck, Susan Levenstein, and Burghard F Klapp. Validierung des "perceived stress questionnaire"(psq) an einer deutschen stichprobe.[validation of the "perceived stress questionnaire"(psq) in a german sample.]. *Diagnostica*, 47(3):142–52, 2001.

[32] Gerald Matthews, Lucy Joyner, Kirby Gilliland, Sian Campbell, Shona Falconer, and Jane Huggins. Validation of a comprehensive stress state questionnaire: Towards a state big three. *Personality psychology in Europe*, 7:335–350, 1999.

[33] Gerald Matthews, James Szalma, April Rose Panganiban, Catherine Neubauer, and Joel Warm. *Profiling Task Stress with the Dundee Stress State Questionnaire*, pages 49–90. 02 2013.

[34] Sheldon Cohen, Tom Kamarck, and Robin Mermelstein. A Global Measure of Perceived Stress. *Journal of Health and Social Behavior*, 24(4):385, December 1983.

[35] Eva M. Klein, Elmar Brähler, Michael Dreier, Leonard Reinecke, Kai W. Müller, Gabriele Schmutzer, Klaus Wölfling, and Manfred E. Beutel. The German version of the Perceived Stress Scale – psychometric characteristics in a representative German community sample. *BMC Psychiatry*, 16(1):159, December 2016.