Aggressive behaviour, burnout and physiology

Predictors of aggression in patients and burnout symptoms in nursing staff: biosensors

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Sola Scriptura, Sola Fide, Sola Gratia,
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For Simone, Fenna, Elisa, and Benjamin

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Chapter 7
Changes in mean heart rate and skin conductance parameters in the thirty minutes preceding aggressive behaviour. Peter de Looff, Matthijs Noordzij, Henk Nijman, Robert Didden & Petri Embregts (submitted)

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PREFACE

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1

CHAPTER 1

Introduction

1. INTRODUCTION

According to a Dutch report by TNO (Dutch organization for applied natural sciences), working in healthcare is associated with an increased risk for burnout, absenteeism and turnover (Bossche, Klauw, Ybema, Vroome, & Venema, 2012). One of the main factors contributing to the development of burnout symptoms among healthcare staff is aggressive behaviour that is experienced on the job (Bossche et al., 2012). Bossche et al. reported that 24% of the employed population has experienced some form of aggression on the job, while in healthcare up to 47% of the employees have experienced some form of aggression (i.e., physical aggression, sexual harassment, bullying). Staff members who work in facilities that care for people with intellectual disabilities (ID) in particular, regularly experience aggressive behaviour from their patients (Crocker et al., 2006). For instance, over a 5-year period in Dutch treatment facilities for patients with ID, an average of one aggressive incident per patient per week was registered (Drieschner, Marrozos, & Regenboog, 2013).

Recently, it has been suggested that heart rate and skin conductance can be used as markers of (chronic) stress and fatigue (Khanade & Sasangohar, 2017), one of the primal indicators of burnout symptoms (Maslach, Schaufeli, & Leiter, 2001). Technological advances make it possible to monitor physiological markers like heart rate and skin conductance over a prolonged period of time and in real life (Garbarino, Lai, Bender, Picard, & Tognetti, 2014; Poh, Swenson, & Picard, 2010). Furthermore, heart rate and skin conductance have been studied extensively in populations that show aggressive behaviour and are considered predictive markers for violence and aggression (Lorber, 2004; Portnoy & Farrington, 2015). This dissertation focuses both on the associations between ambulatory physiological measurements and aggressive behaviour in patients and on the associations of these physiological parameters with (chronic) stress and burnout complaints in nursing staff.

1.1. Setting

The studies included in the present dissertation were all carried out at "De Borg", a cooperation of four (forensic) mental health facilities in the Netherlands: Trajectum, Ipse de Bruggen, Stevig Dichterbij and Fivoor. The facilities are located throughout the Netherlands. De Borg facilities have their origin both in intellectual disability healthcare and forensic psychiatry. The patients that are treated in the facilities of De Borg are people with mild intellectual disabilities or borderline intellectual functioning (MID-BIF; IQ 50-85, American Psychiatric Association, 2013; Wieland & Zitman, 2016) with a combination of severe behavioural or psychiatric disorders (Tenneij & Koot, 2007) and offending or otherwise dangerous behaviour (Drieschner et al., 2013). The patients are administered to de Borg facilities by civil or criminal conviction. These (forensic) patients with MID-BIF are individuals with complex behaviour who are unable to meet the standards of society. They show various comorbid psychiatric or behavioural disorders (Wieland, Haan, & Zitman, 2014), addiction to substances (van Duijvenbode et al., 2015), and experience problems in multiple areas of life such as relationships with family, partners or children (Hassiotis et al., 2007). Moreover, problems persist in emotional, social, and financial areas (Zijlmans, Embregts, Gerits, Bosman, & Derksen, 2011). Often, aggressive behaviour is one of the main reasons for referral (i.e., this applies for 81% of the patients) into De Borg treatment facilities (Tenneij, Didden, Stolker, & Koot, 2009). In general, in people with ID, prevalence rates of patient aggression vary from 9% to as much as 51% (Borthwick-Duffy, 1994; Crocker et al., 2006).

1.2. Aggression of patients and burnout among nursing staff

Aggressive behaviour negatively influences the well-being of (fellow) patients as well as that of nursing staff (Hensel, Lunsky, & Dewa, 2013). It has been reported that nearly 50% of healthcare professionals experience some form of aggression (Bossche et al., 2012). Over 75% of psychiatric nursing staff reports to be assaulted by a patient at least once in their career (Hatch-Maillette, Scalora, Bader, & Bornstein, 2007; Iozzino, Ferrari, Large, Nielssen, & Girolamo, 2015). Almost all psychiatric nurses experience verbal aggression on an annual basis, and about one out of every six psychiatric nurses also experience physical aggression on an annual basis (Nijman, Bowers, Oud, & Jansen, 2005). Experiencing aggressive behaviour might ultimately lead to burnout, absenteeism and high turnover (Bossche et al., 2012).

Research indeed indicates that chronic stress and burnout symptoms is a major problem causing high rates of turnover and absenteeism in nursing staff (Johnson et al., 2018; Schaufeli, Maslach, & Marek, 2017). In Europe and in the United States, prevalence rates of (mental) healthcare workers who experience high levels of burnout complaints vary from 10 to as high as 80% (Aiken et al., 2012; Morse, Salyers, Rollins, Monroe-DeVita, & Pfahler, 2012). Research has shown that among health care staff, particularly psychiatric nurses have a higher risk (up to 1,5 to 6 times as likely - depending on the sample that is compared) of developing a burnout than other nursing professions, such as internal, burn or surgical nurses (Sahraian, Fazelzadeh, Mehdizadeh, & Toobaee, 2008). Recent reviews indicate that high levels of burnout are associated with poor patient outcomes (Hall, Johnson, Watt, Tsipa, & O'Connor, 2016; Johnson et al., 2018). For example, aggression has a negative influence on both the duration of treatment as well as on the rehabilitation options into society for the patient that displays the aggressive behaviour (Crocker et al., 2006). Reducing aggressive behaviour of patients, and the levels of chronic stress and burnout of staff members is essential for improving the well-being of both nursing staff and patients. However, three meta-analyses show that traditional person or organization directed interventions designed for reducing chronic stress and burnout symptoms have positive, but only small effect sizes (Dreison et al., 2018; Panagioti et al., 2017; West, Dyrbye, Erwin, & Shanafelt, 2016). The most important methods for predicting burnout symptoms in Europe are based on questionnaires related to job stress models (Chirico, 2016) which can be a time consuming method for an organization. Therefore, an effort has to be made to explore other potentially relevant indicators of burnout symptoms that might be used in interventions like biofeedback which uses markers such as heart rate or skin conductance.

In the current dissertation, physiological markers such as heart rate and skin conductance are investigated both in connection to burnout symptoms of staff and in connection to aggressive behaviour of patients with MID-BIF. Below, earlier research on the associations between physiological markers and aggression is addressed first, followed by a summary of what is known about physiological markers of (chronic) stress and burnout.

1.3. Physiological markers and aggressive behaviour

As mentioned earlier, aggressive incidents occur regularly in treatment settings for patients with MID-BIF (Tenneij et al., 2009), and threaten not only the safety and well-being of staff members and other patients but also their own (Hensel et al., 2013). In the past decades, various methods for early detection and prevention of patient aggression have been developed, also in individuals with ID (Lofthouse, Golding, Totsika, Hastings, & Lindsay, 2017). They often consist of questionnaires and risk assessment tools to predict and potentially prevent inpatient aggression. For example, teaching both staff members and patients the early warning signals of aggression (Fluttert, Van Meijel, Bjørkly, Van Leeuwen, & Grypdonck, 2013) appears to be helpful in reducing the number of aggressive incidents. Besides these pen-paper methods, there is a growing interest in the association between aggression and physiological measures like heart rate and skin conductance (Lorber, 2004; Portnoy & Farrington, 2015) as a means to signal and 'predict' imminent aggressive behaviour in patients (Kuijpers, Nijman, Bongers, Lubberding, & Ouwerkerk, 2012; Noordzij, Scholten, & Laroy-Noordzij, 2012). Signalling increased risks of aggressive behaviour by means of physiological markers might in turn be used to develop and test aggression prevention strategies. Physiological markers like heart rate and skin conductance not only have been studied extensively in association with aggressive behaviour but also in connection to antisocial behaviour and psychopathic traits often related to this behaviour (Lorber, 2004; Ortiz & Raine, 2004;

Patrick, 2008; Portnoy & Farrington, 2015). However, most of this research has been done in laboratories. Recent technological advances enable the measurement of heart rate and skin conductance unobtrusively and in real-life for prolonged periods of time (Garbarino et al., 2014). However, collecting and processing of the data is somewhat troublesome as several factors influence the quality and utility of the data (Kleckner et al., 2017). For example, ambulatory devices provide the user with an abundance of data on multiple physiological markers. In addition, multiple parameters can be derived from the signals that are measured (Boucsein, 2012; Jarczok et al., 2013). Moreover, earlier studies used different time frames of measurement, methods of parameter extraction, artifact correction, software, recording devices or signal analysis (Boucsein, 2012; de Geus, Willemsen, Klaver, & van Doornen, 1995; Jarczok et al., 2013; Thayer et al., 2010). Therefore, the aforementioned factors influence the analyses and results of the physiological data. Although earlier research on physiological markers indicated that parameters of skin conductance and heart rate can be used in association with aggression (Lorber, 2004) and burnout (Khanade & Sasangohar, 2017), it is essential to take these factors into account.

Regardless of the complicating factors mentioned above, significant associations between physiological markers and aggressive behaviour have been found repeatedly, but the associations vary between different types of aggressive behaviour and the subsamples that were investigated. For instance, in an extensive meta-analysis of 95 studies, Lorber (2004) concluded that heart rate seems to be most prominently associated with aggressive behaviour, while skin conductance is most prominently associated with psychopathy. To be more precise, aggression is associated with lower heart rate in rest, higher heart rate reactivity and higher skin conductance reactivity (i.e., baseline measures compared to measures during a task) while psychopathy is associated with lower skin conductance in rest, lower levels of skin conductance during a task, and lower levels of skin conductance reactivity. In addition, Lorber (2004) concluded that the confidence in findings was greatest for the associations with psychopathy as far as the number of studies available for analysis was concerned.

A second meta-analysis by Ortiz and Raine (2004) on heart rate measures reported a lower resting heart rate, and lower heart rate during a stressor in samples of antisocial children. Interestingly, they concluded that there were no differences in effect sizes between relatively expensive and sophisticated equipment in comparison with relative inexpensive HR equipment. This is of interest for real life research as ambulatory devices vary greatly in price. In a third review of Patrick (2008) on physiological correlates of violence and aggression the findings for heart rate and skin conductance were summarized in an integrative review. In samples of aggressive children and adolescents there was an association between aggressive behaviour and lower levels of autonomic arousal (i.e., heart rate and skin conductance are controlled by the autonomic nervous system) at baseline in contrast with a higher autonomic arousal pattern for reactivity to stressful events. In concordance with the latter, research in samples of hostile-aggressive adults indicated the same higher autonomic arousal (skin conductance and heart rate) pattern for reactivity to stressful events. In adult samples this is especially true for interpersonal stressors, which is interesting as these are encountered on a daily basis, especially on a closed ward where people often live in a group. In adults with high psychopathic traits there is the tendency for low levels of skin conductance at rest as well as for lower levels of skin conductance during, and lower reactivity to, a task with negative stimuli (Patrick, 2008).

The most recent meta-analysis into the association between resting heart rate and violent behaviour was conducted by Portnoy and Farrington (2015). Analysing 115 effect sizes assessed in children, adolescents and adults, they found a mean effect size of -.20 for the association between resting heart rate and violent behaviour. In comparison, Ortiz and Rain (2004) found a mean effect size of -.44 in antisocial children. In the latter study, the effect size was -.76 for studies assessing heart rate during a stressor. Lorber (2004) found similar effect sizes between resting heart rate and conduct problems in children (-.33) and in adult aggression samples (-.38). In sum, the aforementioned meta-analyses consistently show small to moderate associations between aggressive and violent behaviour and heart rate (and also skin conductance) which suggests that these physiological parameters might be used as markers of imminent aggressive behaviour.

As mentioned before, however, the aforementioned studies were mostly conducted in laboratories or with an experimental task which limits the generalization of their conclusions to real life settings such as living on a ward of a mental healthcare facility. An effort to explore the association between aggressive behaviour and skin conductance on a psychiatric ward has been made in a case study (Kuijpers et al., 2012). The case study indicated that skin conductance can rise remarkably, even before aggressive behaviour becomes visible to the nursing staff on the ward. The authors used a wearable device to measure skin conductance throughout the day while monitoring any potential aggressive behaviour displayed by the patient. A subsequent pilot study (Nijman et al., 2014) included 47 patients to further investigate the association between aggressive behaviour and skin conductance. Patients were monitored for aggressive behaviour on two consecutive days while wearing an ambulatory device that measured skin conductance. This study indicated that the rise in skin conductance level is visible during a one to one-and-a-half-hour period preceding visible levels of patients' aggression (Nijman et al., 2014). However, both the case study and the pilot study had various limitations. For instance, the authors did not use software that could detect artifacts that are commonly found in physiological data obtained with ambulatory devices. The level of artifacts in the signal is dependent on the tightness of the device on the wrist and on movements from both the arm and the wrist. In addition, the authors did not account for baseline levels of skin conductance while these vary considerably between people (Boucsein, 2012) and during the day (Hot, Leconte, & Sequeira, 2005). Furthermore, the skin conductance data were aggregated over 30-minute periods which precluded analyses of changes in skin conductance over shorter time periods.

1.4. Physiological markers and (chronic) stress and burnout

As was mentioned in the introduction of this chapter, research has shown that psychiatric nurses in particular have a high risk of developing a burnout, also when compared to other nursing professions, such as internal, burn or surgical nurses (Sahraian, Fazelzadeh, Mehdizadeh, & Toobaee, 2008). In addition to the association between physiology (heart rate and skin conductance) and aggression, recent research has also suggested an association between physiology and burnout (Grossi, Perski, Osika, & Savic, 2015; Khanade & Sasangohar, 2017). Traditionally, burnout is measured with questionnaires to establish the level of burnout symptoms (Maslach et al., 2001). Over the past 45 years, several questionnaires have been developed that are designed to investigate burnout symptoms (Schaufeli, 2009). The most often used questionnaire is the Maslach Burnout Inventory (Maslach et al., 2001) which describes burnout on three subscales: emotional exhaustion, depersonalization, and personal accomplishment. The concept of burnout is not without controversy, however. Some authors suggest that the concept is indistinguishable from depression, or that it may be a subclinical form of depression (Schaufeli et al., 2017; Schonfeld, Laurent, & Bianchi, 2018). Although further research is necessary, the use of burnout as a workplace specific problem has shown useful in clinical practice (Maslach & Schaufeli, 2017).

For the prevention of burnout, there is a need for longitudinal studies that explore the moderating effects of risk and protective factors in the development of burnout (Danhof-Pont, Veen, & Zitman, 2011; Schaufeli et al., 2017). Several risk and protective factors are thought to moderate the development of burnout symptoms over time. Protective factors include relatively high emotional intelligence (Shead, Scott, & Rose, 2016), personality factors, such as extraversion and conscientiousness (Swider & Zimmerman, 2010), and social support (Schaufeli et al., 2017). Risk factors include chronic job stress (Schulz et al., 2009), stressful interpersonal relationships with patients, and patients' aggressive behaviour (Schaufeli et al., 2017; Winstanley & Whittington, 2002).

Chronic and acute stress can have detrimental effects on the body (Kamath, Watanabe, & Upton, 2016), and autonomic nervous system activity markers like heart rate and skin conductance have been suggested as indicators of acute or chronic stress and fatigue (Khanade & Sasangohar, 2017). Therefore, the use of nonintrusive, ambulatory physiological measures might aid in the detection of rising levels of burnout symptoms. For instance, studies have linked burnout with heart rate and heart rate variability (Henning et al., 2014; Jönsson et al., 2015; Lennartsson et al., 2016; Moya-Albiol et al., 2010), but no associations between burnout and skin conductance have been studied (Boucsein, 2012).

As for chronic stress and fatigue, a recent review suggested that autonomic nervous system activity markers like heart rate and skin conductance can be used as indicators for these conditions (Khanade & Sasangohar, 2017). Chronic stress and fatigue are closely related to burnout, which is one possible outcome of chronic job stress (Jarczok, 2013). However, several studies also showed a direct link between burnout and heart rate (Henning et al., 2014; Jönsson et al., 2015; Lennartsson, Jonsdottir, & Sjörs, 2016). Most notably, baseline heart rate is higher in patients with burnout as opposed to people without burnout (De Vente, Olff, Van Amsterdam, Kamphuis, & Emmelkamp, 2003; de Vente, van Amsterdam, Olff, Kamphuis, & Emmelkamp, 2015). Baseline heart rate might therefore be a potential indicator of (changing) levels of burnout symptoms, and be useful for prevention.

1.5. The present dissertation

In sum, in the earlier paragraphs it was noted that staff members caring for psychiatric patients and patients with ID often experience job stress and have an elevated risk of developing burn out symptoms. One specific stressor of the psychiatric nursing profession is the relatively high risk of being confronted with aggressive behaviour from their patients. The present dissertation aims to identify the physiological signals that are associated with aggressive behaviour in patients as well as with burnout symptoms in nursing staff. Moreover, it aims to detect protective and risk factors in the development of burnout symptoms as it has been shown that better staff outcomes are associated with better patient outcomes (Johnson et al., 2018). The main physiological indicators that are studied in the current dissertation are skin conductance and heart rate. Hence, this dissertation focuses on both the physiological markers of burnout symptoms in staff members and the physiological markers of aggressive behaviour of patients admitted to the facilities of De Borg. This dissertation specifically seeks to find an answer to three general questions:

1. Are heart rate and skin conductance associated with burnout symptoms in staff members?
2. What are potential risk and protective factors of developing a burnout in staff members? One of the main risk factors that will be investigated in this respect is how often the staff members have experienced aggressive behaviour from their patients.
3. Are heart rate and skin conductance associated with imminent aggression in patients?

With attempting to answer these questions we hope to contribute to both patient and staff well-being. The studies in this dissertation are largely presented in the chronological order in which they were conducted. Chapter 2 concerns a first small-scale feasibility pilot study, which aimed at measuring arousal levels of psychiatric nurses (in terms of their skin conductance levels) during their work on the ward. At the time this initial study was conducted, we were only able to measure skin conductance, and not heart rate, with a device called the Affectiva Q-sensor (see chapter 2 for a photo of the Q-sensor). The Q-sensor was the precursor of the Empatica E4, which is the device we used in the later larger scale studies described in chapters 5, 6 and 7 (for a photo of the Empatica E4 see chapter 5). The main goal of this first exploratory study was to assess whether specific working times and ward activities were associated with higher levels of arousal. Prolonged levels of increased arousal and the inability to de-arouse have been associated with stress and fatigue (see for instance Boucsein, 2012; Ekstedt, Akerstedt, & Soderstrom, 2004; Melamed et al., 1999). In addition, in the pilot study described in chapter 2, it was explored which Big Five personality factors may be associated with arousal levels at work.

After this first pilot study, it was decided to perform larger-scale studies, in which besides skin conductance, measurements of heart rate could be included by using the Empatica E4. Before conducting these larger-scale empirical studies, a systematic review of the literature was performed on what is already known about the associations between both heart rate and skin conductance on the one hand and job stress and burnout symptoms on the other. As part of this literature review and to prepare for the empirical studies, it was also investigated which – if any – guidelines are available for ambulatory assessments of the psychophysiological markers and the reporting of the results. As mentioned before, there is great variation in the factors that might influence the analyses of the physiological markers such as the time frames of measurement, methods of parameter extraction, artifact correction, software, recording devices or signal analysis.

For the larger-scale studies on job stress and burnout, a Dutch language version of a job stress questionnaire had to be validated that was specifically designed for detecting levels of job stress in people who work with patients with MID-BIF. Such a validated job stress questionnaire was needed to be able to perform the empirical studies on the associations between job stress and the potential psychophysiological markers of burn out that were conducted as part of this dissertation. The results of this psychometric study on the validity of the Dutch version of the Demands and Supports Questionnaire (DSQ, Rose, 1999) are reported in chapter 4.

In chapter 5, the associations between skin conductance and both job stress and burnout symptoms is studied in more detail in a sample of 110 staff members working in the four Borg facilities. In addition, specific risk and protective factors that were assumed to mediate and moderate a potential association between burnout and experiencing aggressive behaviour during the job were studied.

The study in chapter 5 extended into a longitudinal study on the development of burnout symptoms over time in the participating staff members. The potential use of skin conductance and heart rate as indicators of increasing levels of burnout symptoms over a two-year period were studied to investigate whether these measures might be useful in predicting burnout symptoms. The results of this longitudinal study are presented in chapter 6.

In chapter 7, the findings from a cross-sectional study into the association between patient aggression and both heart rate and skin conductance are described. For this purpose, 104 patients with MID-BIF residing in the facilities of De Borg wore an Empatica E4 wristband during a five-day period to investigate whether these measures can be used to 'predict' imminent aggressive behaviour. Nursing staff observed and reported any aggressive behaviour of the participating patients during this five-day period.

Finally, in chapter 8, the main findings of the studies and their practical implications are summarized, and directions for future research are discussed.

CHAPTER 2

Stress levels of psychiatric nursing staff

Looff, P. C. de, Kuijpers, E., & Nijman, H. L. I.

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ABSTRACT

During a total of 30 shifts, the arousal levels of 10 psychiatric nurses were assessed while working on a (forensic) psychiatric admissions ward. Arousal was assessed by means of a small device (wristband) by which the Skin Conductance Level (SCL) of the participating nurses was monitored. Each nurse was assessed during a full day, evening, and night shift. In the distribution of the SCL over the hours of the day, several elevations of the arousal levels were clearly visible during specific events. Additionally, an association was found between the neuroticism level of the staff members and their arousal level during their work.

1. INTRODUCTION

Results from a survey among 122 nurses indicated that psychiatric nursing as a specialty is considered the least respected in comparison to various other nursing specialties (e.g., oncology nursing, paediatrics, intensive care, labour and delivery nursing etc.; see Halter, 2008). Psychiatric nurses were judged by the respondents (Halter, 2008) to be less logical and dynamic, and seen as less skilled than nurses working in other domains of healthcare. Besides this negative image of the psychiatric nursing profession, mental health nurses, compared to the other nursing specialties, relatively often care for patients who lack insight into their own illness or condition. As a result of this, many psychiatric patients don't agree with their caregivers on the need to be hospitalized and treated to begin with. The fact that, psychiatric patients are often admitted against their will, makes building a good working alliance between the mental health professional and the patient relatively problematic in many respects. Considering this, it may not be surprising that nursing staff working on (locked) psychiatric admissions wards, run a relatively high risk of exposure to situations in which patients may intimidate, harass and threaten them (e.g. see Nijman, Bowers, Oud, & Jansen, 2005; Nijman, Allertz, Merckelbach, à Campo, & Ravelli, 1997). In addition, the workload of psychiatric nurses is increasing (Happell, 2009), and psychiatric nurses generally are expected to work in alternating day, evening and night shifts. All of these challenging characteristics (e.g., the negative image of the mental health profession, the exposure to aggressive and threatening behaviours, the high workload) of the mental health nursing profession may make the job relatively exhausting and stressful compared to other professions.

Findings from a survey study indicated that exposure of psychiatric staff members to aggression from their patients is also directly associated with an increased risk of having to call in sick for work (Nijman et al., 2005). As is the case with many other healthcare professions, many psychiatric nurses quit the profession each year. According to Happell (2009, p.1) a major cause of this is: "… because they are dissatisfied with the working conditions and find the associated physical and mental distress to be overwhelming". Apart from research on the prevention of workplace violence (e.g. see van de Sande et al., 2011), and trying to create "a positive workplace culture" (Happell, 2009, p.1) to retain nurses in the profession, it may well be that certain personality characteristics are needed to be able to deal with the many stressful, complex and unexpected situations that a psychiatric nurse encounters in his or her career. In a study among Dutch psychiatric emergency staff, it was found that caregivers working at a psychiatric emergency response unit had lower neuroticism levels in comparison to the general population (Penterman, Smeets, Staak, Özer, & Nijman, 2011). Individuals with strong neurotic traits have: "(…) the tendency to experience negative, distressing emotions and to possess associated behavioural and cognitive traits. Among the traits that define this dimension are fearfulness, irritability, low self-esteem, social anxiety, poor inhibition of impulses, and helplessness." (Costa & McCrae, 1987, p. 301). In the United Kingdom, Bowers et al. (2003) investigated the characteristics of staff members involved with the care of so-called "DSPD-patients" (Dangerous and Severe Personality Disorders) and found a negative correlation between Neuroticism and how secure these staff members felt in working with these DSPD-patients.

In the current small-scale pilot study, the arousal levels of a group of psychiatric nurses were assessed during their work on a (forensic) psychiatric admissions ward. The arousal level in this respect was operationalised in terms of the Skin Conductance Levels (SCLs) of the nurses, which rise as the activity of sweat glands increases, as a concomitant of physiological, psychological and emotional states which appear under stress (Boucsein, 2012; for more information, also see the "Methods" section of this paper). The aim of this study was to investigate whether specific working times were associated with higher levels of arousal and to gain insight into which ward activities were related to increased arousal levels. In addition, the association between certain personality traits of staff members and their arousal levels during their work were investigated. It was hypothesized that nurses with strong neurotic traits in particular would also show higher levels of arousal during their work on the ward.

2. METHODS

2.1. Study design

It concerns an exploratory pilot study conducted on a locked (forensic) psychiatric admissions ward in the middle of the Netherlands. The ward houses two separate units that share a joint staff office. These two units contain eleven and ten beds, respectively. These 21 admission beds are designated for the treatment of newly admitted (forensic) psychiatric patients of whom the vast majority suffer from florid psychotic symptoms.

Ten psychiatric nurses volunteered to wear small devices in the form of wristbands, by which their SCLs were recorded continuously, during a total of 30 shifts. To be more specific, each of the 10 participating staff members wore the device during a morning, evening and a night shift. This piloting of these devices on the 10 staff members was done to prepare for a larger scale study on the associations between (rises of) SCLs of psychiatric patients and aggressive incidents. In Figure 1, one of the used devices, a Q-sensor, is depicted. Q sensors are devices that are used to measure skin conductance and movement.

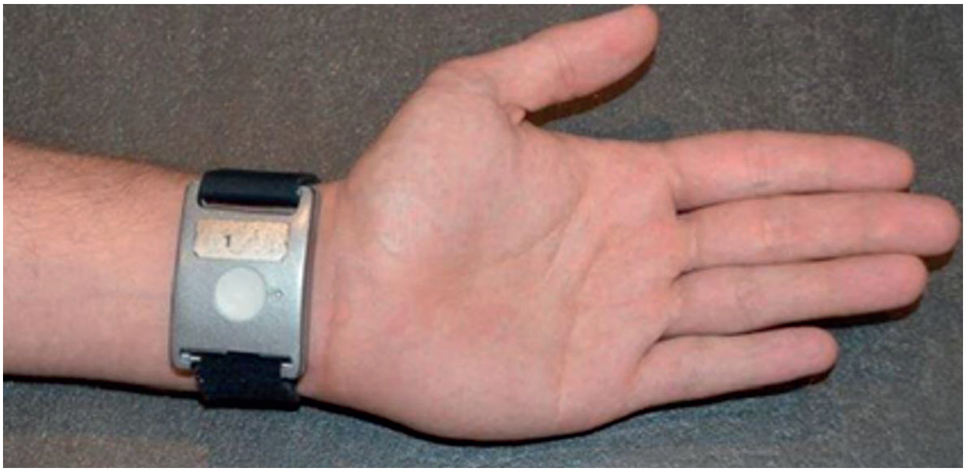

FIGURE 1. Photograph of a Q-sensor used to assess the skin conductance levels of staff members during a day, evening, and night shift.

To assess the neuroticism of the participating nurses, they also completed the Neuroticism, Extraversion and Openness – Five factor Inventory (i.e., the NEO-FFI in brief) developed by Costa & McCrea (1992). Underneath both assessments (i.e., the assessment of arousal in terms of the SCLs and the assessment of neuroticism by means of NEO-FFI) are addressed in more detail.

2.2. Assessments

Measurements of Skin Conductance Levels (SCLs), and rapid changes in skin conductance in response to triggers (Skin Conductance Responses; SCRs), have been used to assess (psychological) arousal for well over a century now (see Boucsein, 2012). SCLs and SCRs are assessed on the basis of the electrodermal resistance of the skin. The electrodermal resistance of the skin reduces and the conductance increases as the activity in the sweat glands increases (Boucsein, 2012). Changes in sweat gland activity in response to stressful or threatening stimuli occur very rapidly (in a few seconds skin conductance levels can increase drastically) and are not under voluntary control of subjects. In experimental psychological research in particular, for instance in samples suffering from phobia (de Jong, Merckelbach, Arntz, & Nijman, 1992), this technique has been often used. The number of studies of SCLs of psychiatric patients while being admitted on (locked) psychiatric admission settings, however, is limited (but for instance see Campo, Merckelbach, Nijman, Yeates-Frederikx, & Allertz, 2000). One of the obvious reasons for this is that measuring skin conductance, until recently, required a substantial amount of equipment to which the participant had to be attached to obtain these assessments. As far as we know, the studies that have been conducted on locked psychiatric admissions wards so far have all focussed on the arousal levels of the patients, but not on those of staff members who have to take care, and manage, the sometimes disruptive and aggressive behaviour of their patients.

In the current study, the SCLs of the participating nurses were recorded at two Hertz during a full day, evening, and night shift by means of the Q-sensor. In other words, for each of the staff members a full assessment of their arousal level while being on duty was obtained 'around the clock'.

2.3. Assessment of personality traits

The personality characteristics of the 10 participating nurses were assessed by means of the NEO-FFI (Costa & McCrae, 1992). The NEO-FFI is a brief version of the Neuroticism, Extraversion and Openness – Personality Inventory - Revised (i.e., the NEO-PI-R in brief) and was developed by Costa & McCrae (1992). The NEO-FFI is a self-report instrument consisting of 60 items by which five main personality characteristics are assessed. These five personality traits, which are also referred to as the *Big Five*, are: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. In the current study, it was hypothesized that Neuroticism in particular would be positively associated with a higher mean SCL of the psychiatric nurses while being on duty. The reliability and validity of the NEO-FFI have been found to be satisfactory to good in a number of studies (e.g., see Costa & McCrae, 1992; Holden, 1992), and for the Neuroticism scale in particular. To illustrate this, in the study of Holden performed in 1992, the reliability (internal consistency) of the Neuroticism scale was .87, and the convergent validity with the "Psychiatric Symptomatology" and the "Depression" scales from the Holden Psychological Screening Inventory were .61 and .63, respectively (Holden, 1992).

2.4. Statistical analyses

As the SCLs were not normally distributed (i.e. with the skewness of the distribution of electrodermal activity being 1.9 and a kurtosis of 4.1), a Friedman nonparametric test and a Wilcoxon rank sign test were used instead of an ANOVA. It was investigated which shift (day, evening or night shift) on average seems to be most stressful in terms of elevated SCLs. The association between the mean SCLs of the 10 nurses and their personality characteristics were explored by means of Spearman's r correlations. In these analyses, it was hypothesized that Neuroticism in particular would be connected to elevated (mean) SCL scores (e.g., see Norris, Larsen, & Cacioppo, 2007, but it should be noted that results on this in a general sense are inconsistent; see Boucsein, 2012, p.397). The association between neuroticism as measured with the NEO-FFI and the mean SCL for this reason was tested one-tailed with an alpha set at .05. The associations between the other four NEO-FFI personality dimensions (i.e., Openness, Conscientiousness, Extraversion and Agreeableness) and the mean SCL, were explored by two-tailed tests, with alpha set at 0.05. Finally, an anecdotal description of a situation is provided in which the arousal level of an individual staff member 'spiked' during a shift. This is done to provide anecdotal 'evidence' of the impact certain typical tasks that psychiatric nurses have to perform, can have on their stress levels.

3. RESULTS

3.1. Sample characteristics

The sample of 10 staff members consisted of seven women (70%) and three men (30%). Their average age was 30.2 years (s.d. = 7.7; range 23 – 46 years). Their scores on the big five personality traits as assessed with the NEO-FFI were 29.0 (s.d. = 5.5; 4.4th decile on average) for Neuroticism, 42.8 (s.d. = 5.1; 5.8th decile on average for Extraversion, 39.5 (s.d. = 3.8; 6.2th decile on average) for Openness, 46.1 (s.d. 4.0; 5.7th decile on average) for Altruism, and 46.3 (s.d. = 5.4; 5.5th decile on average) for Conscientiousness.

3.2. SCLs during day, evening and night shifts

In figure 2, the mean SCL of the 10 participating psychiatric nurses is depicted per 15 minutes. A look at this figure suggests that the SCL levels are highest during evening shifts. A Friedman non parametric test (as the SCL scores are not normally distributed) indicates that the mean SCL indeed significantly differs during the three shifts [Chi-square (2) = 7.8; p = 0.02].

In order to test the contrasts between the separate shifts, a Wilcoxon signed ranks test was used. The results indicate that the mean SCL of the nurses during evening shifts was elevated compared to both the day (p = 0.038), as well as to the night shift (p = 0.012). The difference between the day and the night shift did not reach significance (p = 0.49). In terms of the mean SCL of the 10 nurses, the mean SCL during evening shifts was 3.2 µSiemens (s.d. = 2.6), during night shifts the mean SCL was 1.8 µSiemens (s.d. = 1.7), and during day shifts it was 1.7 µSiemens (s.d. = 1.0) on average.

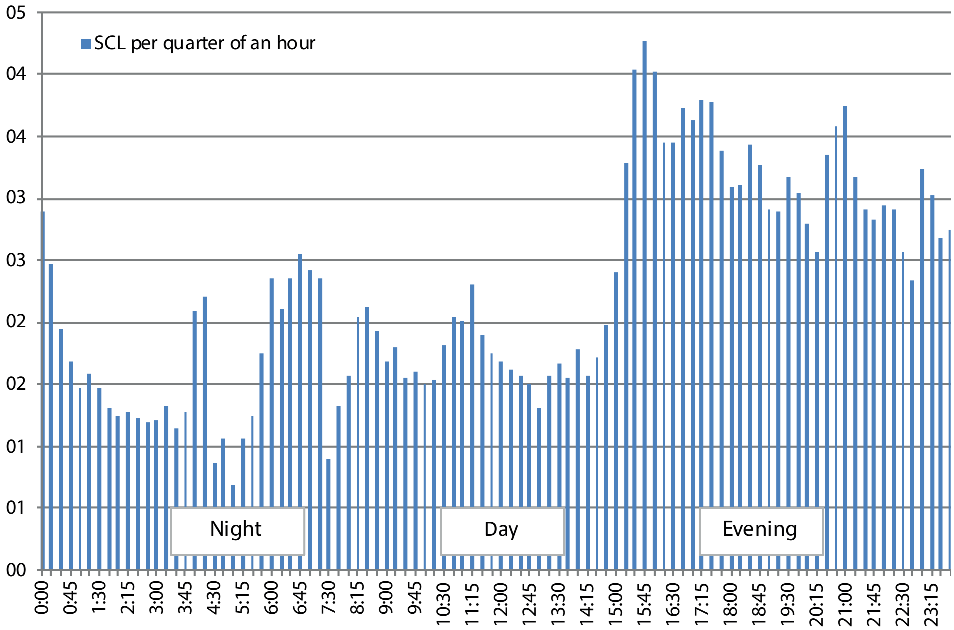

FIGURE 2. The SCL of the 10 participating psychiatric nurses depicted per quarter of an hour.

Apart from the overall increase during the evening shift, several *relative* increases of the SCL are visible at specific time frames in the graph. Visual inspection of the graph, going from left to right, reveals a first *relative* 'spike' of the average SCL between 4 and half past 4 during the night. Inquiry with the nursing staff revealed that each night a test of the alarm system of the ward is performed in that time frame. The noise of the alarm, which is likely to have been conditioned with real stressful situations on earlier occasions, possibly arouses a strong relative increase of the SCR. The next and more prolonged elevation of the SCL can be seen between 5.30 and 7 AM. The nurses we asked about this, attributed this elevation to having to prepare for the next shift, which means they have to inspect the ward, prepare the handover documentation, while at the same time, as the nurses of the ward put it, they are: "often are struggling hard to stay awake" in that time frame. The next small spike is visible around 8 to 9 AM. During this time patients (have to) get up, breakfast has to be prepared and many patients have to take their first medication. Again some modest elevation of the SCL between 11 and 12 AM, possibly being connected to handing out a second dosage of medication and preparing for lunch.

The most pronounced 'spike' of the SCL is between 3 and 4 PM, at 3 PM the evening shift comes in and a hand-over meeting is conducted. After that, the new shift goes to work on the ward. At around 5 PM, a modest *relative* elevation again is visible, which may be connected to the group gathering with all patients which takes place each day to evaluate the day, and the (preparation of) the evening meal following that meeting. Around 9 PM another relative increase of the SCL is visible. According to the ward nurses, this elevation may be connected to the ward rule that the patients are allowed at this time to get some more food and drinks for themselves from the kitchen. At that time, almost all patients leave their rooms and gather in the kitchen and living room. At 10 PM another small elevation is seen. At these time patients are expected to retreat to their rooms for the night. Finally, a *relative* elevation of the SCL is visible at around 11 PM which may be connected to a walking round at that time in which the ward and patients' rooms are inspected. According to the nurses, arguments over (sleeping) medication are also relatively common at this time of the day.

3.3. Associations between personality characteristics and the SCL

In Table 1 the (Spearman's rho) correlations between the personality traits as assessed with the NEO-FFI norm scores and the mean SCL of the 10 psychiatric nurses are presented. As can be seen in this Table, Neuroticism is most strongly and positively associated with the arousal level of the nurses (Spearman's rho = 0.58; $p < 0.05$; one-tailed). In other words, the results indicate that the higher a psychiatric nurse scored on Neuroticism, the higher the (psychological) arousal was while being on duty.

TABLE 1. Spearman's rho correlations between the NEO-FFI personality norms scores and the mean SCL of the 10 psychiatric nurses.

	Neuroticism	**Extraversion**	**Openness**	**Altruism**	**Conscientiousness**
Mean SCL	r = 0.58*	r = 0.37	r = -0.35	r = 0.37	r = -0.43
	p = 0.04	p = 0.29	p = 0.33	p = 0.30	P = 0.22
	(one-tailed)	(two-tailed)	(two-tailed)	(two-tailed)	(two-tailed)

Note.* p<.05 **

3.4. An illustration of a stress inducing nursing task

To illustrate how some of the tasks psychiatric nurses have to perform can impact their arousal level, the SCL level of nurse X. is depicted in Figure 3.

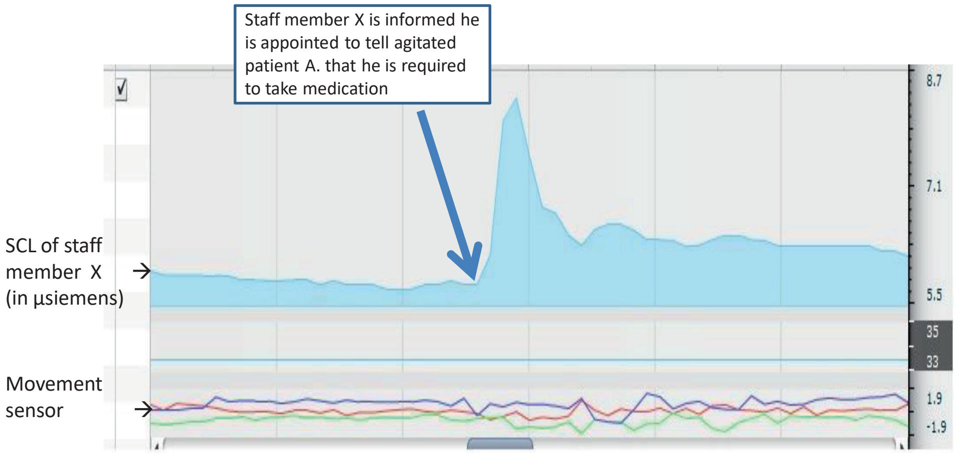

FIGURE 3. Illustration of the influence of a stress inducing nursing task on the SCL.

This nurse was informed that it was decided that Mr. A, a male psychotic patient who had displayed verbally threatening and intimidating behaviour for days in a row, would be required to take medication. In figure 3, the SCL of Nurse X. is displayed at the moment he was informed that he would have to be the so-called "spokesperson" about this issue to Mr. A.. In other words, nurse X. realises he has to bring this news to this severely agitated patient of which the psychiatrist and nursing team believe that he is already at the verge of engaging in assaultive behaviour. On this ward, it is policy to appoint one staff member as a spokesperson in case of difficult news. The moment nurse X. is being informed that he is appointed to explain to the patient he is expected to take medication, his SCL clearly spikes (see Figure 3), but his SCL also 'recovers' quickly.

4. DISCUSSION

Even though the current study was a small scale pilot study, some significant associations with the arousal levels of the studied nurses were found. To begin with, the mean SCL of the ward nurses was higher on average during the evening shift, compared with the day and night shifts. Even though there are indications that SCLs on average vary during the hours of the day (Hot, Naveteur, Leconte, & Sequeira, 1999; Pascal Hot, Leconte, & Sequeira, 2005), the found differences in the current study were marked, with the evening hours consistently showing higher (mean) SCLs compared to working hours during the day and night shifts. During the evening shift, the number of nurses on duty is the same as during the day shift, whereas the number of potentially stressful tasks (e.g., preparing and supervising evening diner, requiring patients to go to their room and stay there for the night) and situations (e.g., arguments about (sleeping) medications), as well as the number of patients on the ward, is high. While during the day, some of the patients may be gone to therapies or other activities outside the ward, all patients usually are locked in together on the ward during the evening shift. The present pilot study suggests that the arousal level of nurses during the evening shift is almost twofold that of the dayshift (i.e., mean SCLs being 3.2 μSiemens during evening shifts versus 1.7 μSiemens during day shifts), whereas the staffing level during the evening is equal to that during the day shift, while at the same time there are more patients at the ward during the evening on average.

Furthermore, in the current limited sample we found indications that the mean SCL while working on the ward was associated with the level of neuroticism of the nurses. Although highly speculative, it possibly is the capacity to recover from stressful events, in terms of a rather quick return of the arousal level near to baseline what makes a person being able to perform well and stay in the psychiatric nursing profession over a prolonged time. With the constant potential for unexpected incidents and situations to occur during a shift, the risk of an elevated arousal level not getting the chance or time to return to baseline levels may exist, which may eventually lead to exhaustion from a more chronic state of stress during working hours. Indeed, Norris, Larsen & Cacioppo (2007) demonstrated that persons with high neuroticism scores not only show more pronounced SCRs, but also have somewhat longer 'recovery' times to return to the SCL before the SCR. The psychiatric nursing job in particular, especially when working on a locked admissions ward, may be a job that has so many minor and major events happening all the time, and offers so little 'predictability', that staff members with strong neuroticism traits in particular, may not get enough time to recover from incidents or cognitions that impact the arousal level, leading to a state in which discrete SCRs sort of start 'overlapping,' or even 'stacking on' to, each other, which can result in a constant state of high arousal while on duty. In a general sense, real breaks from the job, such as coffee or lunch breaks, could possibly prevent this, but in practice, however, coffee breaks are often enjoyed at the staff office, or somewhere on the ward, which means that the nurse will still be noticing what is happening on the ward, and perhaps still be answering the ward phone and taking questions from patients. In case of an incident, the nurse on break is also expected to respond. Circumstances like these are likely to prevent breaks from having a substantially decreasing effect on the SCL. Clearly, speculations like these need further research in a much larger sample of psychiatric nurses and to be tested with a longitudinal design in which the mean SCL level of the participants can be connected to (future) rates of sick leave and attrition from the psychiatric nursing profession. In a study like that the reasons for leaving the profession should also be assessed in detail. With the very limited sample size of the present study in mind, the suggestions made above are only hypothetical and not more than that. Considering the high rates of sick leaves and attrition from the psychiatric nursing profession, however, we think such a study is warranted, and feel that the assessment of neuroticism along with the arousal levels of psychiatric nurses during their work, possibly even in direct connection to, and interaction with, the arousal levels of the patients they take care of, could be valuable to gain more insight in what makes the psychiatric nursing profession into such a difficult job.

CHAPTER 3

Associations of sympathetic and parasympathetic activity

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ABSTRACT

This systematic review examines the relationship between sympathetic and parasympathetic activity on the one hand and job stress and burnout on the other, and is registered at PROSPERO under CRD42016035918. Background: Previous research has shown that prolonged job stress may lead to burnout, and that differences in heart rate variability are apparent in people who have heightened job stress. Aims: In this systematic review, the associations between job stress or burnout and heart rate (variability) or skin conductance are studied. Besides, it was investigated which – if any – guidelines are available for ambulatory assessment and reporting of the results. Methods: We extracted data from relevant databases following the PRESS checklist and contacted authors for additional resources. Participants included the employed adult population comparing validated job stress and burnout questionnaires examining heart rate and electrodermal activity. Synthesis followed the PRISMA guidelines of reporting systematic reviews. Results: The results showed a positive association between job stress and heart rate, and a negative association between job stress and heart rate variability measures. No definite conclusion could be drawn with regard to burnout and psychophysiological measures. No studies on electrodermal activity could be included based on the inclusion criteria. Conclusions: High levels of job stress are associated with an increased heart rate, and decreased heart rate variability measures. Recommendations for ambulatory assessment and reporting (STROBE) are discussed in light of the findings.

1. INTRODUCTION

Job stress can be divided into momentary and prolonged stress. Particularly, prolonged job stress may lead to burnout (de Vente, van Amsterdam, Olff, Kamphuis, & Emmelkamp, 2015; Hasselberg, Jonsdottir, Ellbin, & Skagert, 2014; Jönsson et al., 2015), which has substantial negative socioeconomic consequences. Traditionally, job stress and burnout are measured with self-report questionnaires that are often based on a specific theoretical model. For instance, the Effort Reward Model defines job stress as an imbalance between the efforts and rewards on the job (Siegrist et al., 2004) while the often used Maslach Burnout Inventory defines burnout as a combination of exhaustion, cynicism and decreased personal accomplishment (Maslach, Schaufeli, & Leiter, 2001). In addition to cognitive, emotional, and behavioural effects, prolonged job stress has detrimental effects on cardiovascular functioning of human beings (Van Doornen, 2009), which is primarily controlled by the autonomic nervous system (Bergmann Sverrisdóttir, 2016). In this systematic review, we focus on the association between job stress and burnout on heart rate (variability) and skin conductance.

The human body maintains balance of key regulatory functions such as temperature, metabolism and heart rate through the autonomic nervous system (ANS; Bergmann Sverrisdóttir, 2016). This system consists of two major branches; a sympathetic nervous system (SNS) and a parasympathetic nervous system (PNS). Both branches play a crucial role in the immediate stress regulatory response of the body (Ulrich-Lai & Herman, 2009). The SNS facilitates behavioural activation in response to perceived threat (fight/flight response), resulting in, for instance, increased heart rate and sweat production. The PNS, on the other hand, facilitates homeostasis of the body (rest/digest situation), resulting in, for instance, reduced heart rate (Andreassi, 2006).

The human body maintains balanced through the ANS by *efferent* (neurons that carry impulses outward from the brain and spinal cord to an effector such as organs) and *afferent* (neurons that carry peripheral impulses to the brain or spinal cord) nerves (Craig, 2002). In the face of a stressor, which can be both physical and nonphysical (Ulrich-Lai & Herman, 2009), a range of complex reverberating systems is activated to deal with the stressor (Thayer & Lane, 2000) such as higher order brain processes, coordination of blood flow, heart rate, breathing rate, release of hormones, and activation of muscle fibre to react to the stressor (Thayer & Lane, 2000). In terms of time, the parasympathetic effects on heart rate act within milliseconds, while the sympathetic effects on heart rate and skin conductance act in seconds (Boucsein, 2012; Jarczok et al., 2016).

Heart rate is primarily controlled by tonic vagal (parasympathetic) inhibition of the heart. The vagus nerve primarily acts on the sinoatrial node (responsible for pace of the heart rate), while the SNS primarily acts on the atrioventricular node (responsible for the force of contraction). The inhibitory effects of the vagus nerve result in slower heart rate while disinhibitory effects increase heart rate (Ulrich-Lai & Herman, 2009; Warner & Russell, 1969).

The Polyvagal theory explains the flow from body to brain from an evolutionary perspective. According to this evolutionary perspective, the vagus nerves (which is the tenth cranial nerve) plays a key role in the ANS. The myelinated branch of the vagus nerve is assumed to be the most sophisticated part and to control SNS activity (Porges, 2007, 2009). Lower PNS activity therefore indicates less control of the myelinated branch, resulting in less inhibition of the fight/flight characteristic of the SNS. Although the Polyvagal perspective on PNS and SNS control is under debate (Farmer, Dutschmann, Paton, Pickering, & McAllen, 2016; Gourine, Machhada, Trapp, & Spyer, 2016), there is a relatively broad consensus that especially dysregulation of the PNS underlie emotional and behavioural problems. In line with this, in chronic stressed participants, a hypoactive PNS is usually observed with disinhibition of sympathoexcitatory circuits with the phenomena of increased HR and increased blood pressure. As a result of prolonged energy mobilization different phenomena occur such as allostatic load (McEwen, 1998), irritability (Thayer & Lane, 2000) or a feeling of exhaustion (Craig, 2002). Feeling stressed or burned out from work is the result of a complex interplay between the brain, spinal cord, and ANS in which the interoceptive afferent neural system is responsible for becoming aware of the physiological state of the body (Craig, 2002), and is mainly caused by the afferent function (80%) of the vagus nerve (Groves & Brown, 2005).

According to Vrijkotte et al. (Vrijkotte, van Doornen, & de Geus, 2000), the detrimental effects of job stress are the result of sympathetic activation in combination with parasympathetic withdrawal. In the following paragraphs we will first focus on the stress response in relation to job stress and burnout in order to provide the reader with some common conceptualizations of job stress and burnout. Following this, we will discuss heart rate and skin conductance measures that were analysed in this review.

According to Boucsein (2012), stress "can be defined as a state of high general arousal and negatively tuned but unspecific emotion, which appears as a consequence of stressors (i.e., stress-inducing stimuli or situations) acting upon individuals. Stressors can be defined as subjective and/or objective challenges exceeding a critical level with respect to intensity and/or duration" (p.381), which is in accordance with the theory of cognitive appraisal (Folkman, 1984). A stress reaction can be described in cognitive, emotional and physiological responses (Moksnes & Espnes, 2016). The cognitive and emotional responses traditionally have been measured with self-report questionnaires, whereas the physiological response can be quantified through both biomedical (e.g., blood, urine, and saliva) and autonomic nervous system markers (blood pressure, respiration rate, heart rate, and skin conductance) (Boucsein, 2012; Brindle, Ginty, Phillips, & Carroll, 2014; Moksnes & Espnes, 2016).

More specific cases of stress, i.e. job stress and burnout have been described in association with autonomic nervous system markers. These markers have increasingly been the subject of research over the past decades (Byrne & Alvarenga, 2016). Technological advances enable users to monitor these markers over a prolonged period of time using ambulatory devices. Both autonomic nervous system markers of heart rate and Electrodermal Activity (EDA; often recorded as skin conductance, or skin resistance, (Boucsein, 2012, p.2)) have been shown to be related to job stress and burnout, and are the primary focus of the current systematic review.

1.1. Theoretical models on job stress and burnout

Burnout has been proposed as one possible outcome of prolonged job stress since the 1980's (Cherniss, 1980). Job stress and burnout are mostly measured with self-report questionnaires. The two most often used models to assess job stress are the demand-control model (Karasek, 1979) (and the more recent demand-control-*support* model (Häusser, Mojzisch, Niesel, & Schulz-Hardt, 2010)) and the effort-reward imbalance model (Siegrist, Klein, & Voigt, 1997; Siegrist et al., 2004). The first model distinguishes between demands and control on the job. Demands are measured in terms of time, quantity, and mental variables on the job whereas control is measured as the amount of decision latitude, growth possibilities, and the amount of creativity one is able to put in one's work (Loerbroks et al., 2010). There is a reciprocal relationship between demands and control, where an imbalance towards high demands/low control is used to describe job stress. The second theoretical model distinguishes effort and reward on the job. Efforts are measured with variables such as demands, workload, and work pressure whereas reward is measured in terms of monetary incentives, self-esteem, and career opportunities (Siegrist et al., 2004). An imbalance between the two is referred to as high cost and low gain. Siegrist et al. (2004) put it as follows: "in the long run, the imbalance between high effort and low reward at work increases illness susceptibility as a result of continued strain reactions" (p. 1485).

Next to job stress, burnout is also defined in various theoretical models. A well-known and influential model of Maslach (Maslach, Jackson, & Leiter, 1996) characterizes burnout as a feeling of exhaustion and depersonalization, with low levels of personal accomplishment. Exhaustion includes feelings of being used up or emotionally drained by one's work (Morgan, Cho, Hazlett, Coric, & Morgan, 2002). Depersonalization is characterized by feelings of callousness towards other people, while low personal accomplishment is described in terms of the perceived impact of one's work. Considering that burnout is a possible severe reaction to (prolonged) job stress, we hypothesize that if burnout is the result of job stress, the effect of burnout on the autonomic nervous system might have an even stronger influence than the effect of job stress alone.

In the following paragraphs we will first discuss some common heart rate measures followed by the skin conductance measures that were analysed in this systematic review.

1.2. Physiological measures of job stress and burnout

Heart rate (HR) can be analysed both in terms of beats per minute and in terms of the inter-beat interval (IBI). The mathematical analysis of Heart Rate Variability (HRV) is based on the variation of the IBI interval (Stapelberg, Neumann, Shum, McConnell, & Hamilton-Craig, 2016), and can be divided in the amount of parasympathetic or mixed (both parasympathetic and sympathetic) activity that is reflected (Alvarenga & Byrne, 2016; Andreassi, 2006; Jarczok et al., 2013, 2016; Thayer et al., 2010). HRV can be calculated in both *time domains* and *frequency domains* (Task Force Electrophysiology, 1996) (and nonlinear analysis, but this was not included in the current review). Three *time domain* measures are used in the current review and are based on the variation in peak to peak interval. The standard deviation of these peak-to-peak intervals is also referred to as the standard deviation of normal-to-normal intervals (SDNN), which is a measure of overall HRV (Task Force Electrophysiology, 1996). In addition, the percentage of adjacent cycles greater than 50ms apart (PNN50) and the root mean square of successive differences (RMSSD) are used. A *Frequency domain* measure is also included. These measures are based on the analysis of peak-to-peak (RR) interval sequences (Stapelberg et al., 2016) as well. The frequency components can be calculated as the distribution of power (i.e. variance of the peak-to-peak interval) as a function of frequency. The high frequency (HF) power is thought to primarily reflect parasympathetic activity while the other measures reflect mixed activity (Jarczok et al., 2013). Only the HF component is included in the current review (0.15-0.4 Hz).

The measures in the current review are predominantly parasympathetic (PNN50, RMSDD, HF) or sympathetic (EDA measures) in nature. Besides HR, a second mixed measure was included (SDNN) that is traditionally viewed as HRV (Task Force Electrophysiology, 1996). SDNN is sometimes considered as the total measure of autonomic nervous system activity (see for an overview (Jarczok et al., 2013, p. 1813)).

There is considerable heterogeneity in methodology and measurement that might influence the recordings of HR. For instance, studies report rest measures (Eller, Blønd, Nielsen, Kristiansen, & Netterstrøm, 2011; Hintsanen et al., 2007), 24 hour recordings (Borchini et al., 2014; Herr et al., 2015), HR measures during controlled breathing (Hintsanen et al., 2007) or during a specific task (Ohira et al., 2011). In addition, ECG (electrocardiogram) devices (Clays et al., 2011; Loerbroks et al., 2010; van Amelsvoort, Schouten, Maan, Swenne, & Kok, 2000), blood pressure devices (Hamer et al., 2006; Rau, Georgiades, Fredrikson, Lemne, & de Faire, 2001) or ambulatory PPG (photoplethysmography) sensors (Henning et al., 2014) are used. Studies report on measures during work (Moya-Albiol, Serrano, & Salvador, 2010), leisure time (Vrijkotte et al., 2000), rest (Kang et al., 2004) or at night (Rau et al., 2001). Studies report on untransformed values (Hamer et al., 2006; Kotov & Revina, 2012), linear transformations (Herr et al., 2015; Uusitalo et al., 2011) or both (Kang et al., 2004). Bivariate measures are sometimes reported (Hintsanen et al., 2007; Jarczok et al., 2016) or studies report on adjusted models (Lennartsson, Jonsdottir, & Sjörs, 2016; Van Doornen, 2009). These choices might seriously influence the results that are reported. Moreover, there is significant diurnal variation in both HR (Bexton, Vallin, & Camm, 1986; Kamath & Fallen, 1991) and EDA (Pascal Hot et al., 2005) which makes the comparability between studies that use different lengths of recording or different time intervals challenging.

EDA is relevant with respect to skin conductance or skin potential (Andreassi, 2006). It is one of the most sensitive markers of arousal (Boucsein, 2012; Boucsein & Ottmann, 1996), and solely the result of the sympathetic activation of the autonomic nervous system (Boucsein, 2012). Although EDA has been studied extensively in experimental research on (among others) anxiety, stress, depression, and personality, it has not often been reported as a marker specifically in association with job stress. This might be due in part to the equipment that was needed to measure EDA in the workplace (e.g., multiple sensors on the fingers and/or hand palm). Recent technological advances make it easier and less intrusive to measure EDA (Kuijpers, Nijman, Bongers, Lubberding, & Ouwerkerk, 2012; Poh, Swenson, & Picard, 2010). EDA has both tonic (level) and phasic (responses) components. The typical form of a response is well described (Boucsein, 2012), and several parameters can be extracted such as the height, rising time, area under the curve, or decay time of a response. For this review we will focus on the skin conductance level (SCL), the number of non-specific skin conductance responses per minute (ns.SCR) and the height (amplitude) of the non-specific responses (SCR.amp), as these have been associated most with emotional load in job-related EDA research (see Boucsein, 2012, pp. 460-462). Boucsein (2012) reported results from a few studies on the association between EDA and job stress. There is a tendency of increased SCL, ns.SCR, and SCR.amp with increased strain and stress. Therefore, these markers will also be addressed in this systematic review.

A recent systematic review on job stress and HRV concluded that "stress at work is generally associated with increased risk of disease and worsened health profiles as indicated by decreases in vagally-mediated HRV." (see Jarczok et al., 2013, p. 1814). Where these authors looked at both mixed and vagally (parasympathetic) mediated HRV measures in association with job stress, we will focus on these measures (RMSSD, PNN50, HF, HR, SDNN), as well as on EDA in association with both job stress and burnout. Moreover, we will also assess the direction of the associations, even if the effect is non-significant (Jarczok et al., 2013). In addition, the former review analysed both total as well as subscales of job stress, while this review will solely rely on total validated scales for both job stress and burnout. Only the full scales of the questionnaires were used as the current review focused on the association between both EDA and HR(V) with job stress and burnout. This served as a means to compare the results on 'job stress', and is an important distinction with the Jarczok et al., (2013) review that investigated the more general 'workplace stressors' as both full and subscales were considered. For instance, Jarczok et al., (2013) reported that need for control significantly decreased HF in the Hanson (Hanson, Godaert, Maas, & Meijman, 2001) study. Although need for control is a subscale of the job stress questionnaire, it is not necessarily considered to be job stress. People can experience heightened demands, but if control is not decreased there is not a 'pure' association with job stress as a full scale. The results are thus only applicable to workplace stressors, but not job stress. As the current review compared job stress to burnout, only full scales were considered to compare the job stress-burnout association instead of making comparisons between depersonalization and demands for instance.

This systematic review could therefore be considered, at least in part, as both a replication, update and an extension of their previous work. In sum, we want to know what the association is between job stress/burnout and HR(V)/EDA, which parameters might prove useful, and which recording periods are favourable over others to analyse.

Based on the outcomes of the previous review, three specific hypotheses are formulated. First, it is expected that there are positive associations between job stress/burnout and HR and EDA. Second, negative associations between job stress/burnout and HRV are expected. Third, the association between burnout and HR(V)/EDA is stronger than the association between job stress and HR(V)/EDA as burnout is a possible result of severe, enduring and prolonged job stress. Participants will include the employed adult population comparing validated job stress and burnout questionnaires examining heart rate and electrodermal activity. In addition, the timeframes that are used to assess the physiological measures vary considerably, therefore this review also aims to provide some guidelines of measurement and reporting.

2. METHOD

2.1. Literature search and screening criteria

The literature search focused on the relationship between job stress and burnout on the one hand, and EDA, and HR(V) on the other. The review protocol was registered in the international prospective register of systematic reviews (PROSPERO) with ID number CRD42016035918. We used the Preferred Reporting Items for Systematic reviews and meta-analysis (PRISMA) to guide the reporting on the systematic review (Moher et al., 2015). The databases that were searched for this systematic review were Psych INFO, Medline, Embase, and Web of Science. For this, we used the subscription of the Radboud University in Nijmegen, the Netherlands. The search engines, and accordingly, the search terms of the databases differ; for this reason, we included the search terms in Appendix A which included search terms on HR, HRV, EDA, burnout and job stress. The search terms were peer-reviewed by three librarians using the Peer Review of Electronic Search Strategies (PRESS) checklist (McGowan et al., 2016), which resulted in some additional suggestions, the narrowing of search terms and addition of relevant keywords. As the task force guidelines for HR measurement were published in 1996 (Task Force Electrophysiology, 1996) and needed some time to be adopted, it was decided to include articles from 2000 upwards. Zotero (v. 5.0.52) and Refworks were used to process the references.

The final search was conducted on December 23rd 2016. The final searches yielded a total number of 1,814 studies. Besides citation snowballing, every included study author (only the corresponding authors) was contacted to ask if they were aware of any further or so-called 'grey' literature, which yielded an additional 13 studies. In the end, we included 38 articles (see Figure 1).

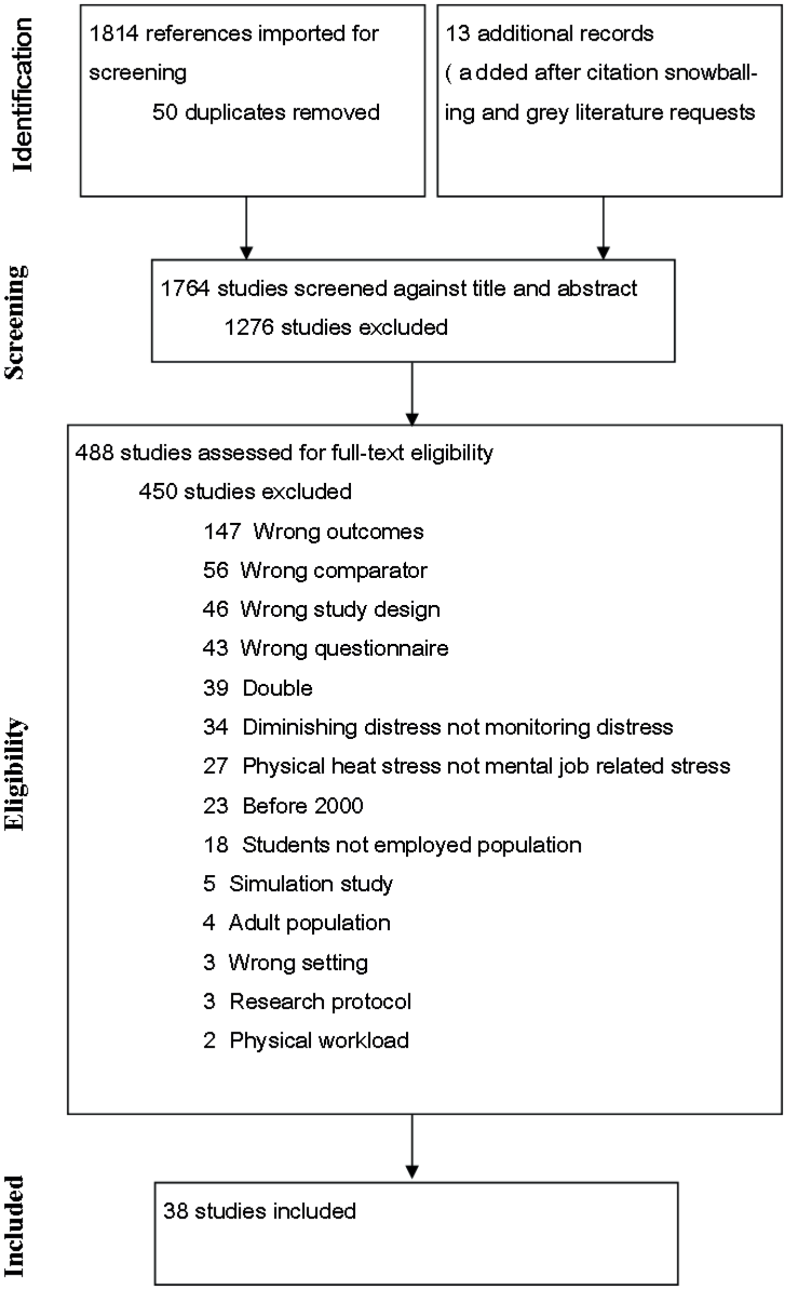

FIGURE 1. PRISMA flow chart of the systematic review process.

2.2. Study Selection

The following inclusion criteria were applied:

1. The studies focused on the employed adult population and should concern job stress or burnout related measures, as predictor variables and HR(V) or EDA as outcome variables.
2. The studies focused on baseline, workdays, leisure time or combinations of those.
3. The studies included a validated subjective measure of job stress or burnout.
4. The included studies were English articles published between 2000 and 2016.

We had no further requirements as far as the study design or participants were concerned. Comparisons were made based on validated questionnaires. The HR(V) and EDA measures were divided in separate outcomes for rest, task, workday, leisure, sleep time or combinations of the entire period. We performed an initial screening with three (PCdL, HN, PE) reviewers to establish if the inclusion and exclusion criteria were transparent. For this purpose, two sets of 50 randomly sampled articles were used to establish interrater agreement. This initial screening resulted in 85% interrater agreement on the title and abstract screening, and consensus on transparency of the inclusion and exclusion criteria.

We set out to perform a meta-analysis as this would allow for explaining heterogeneity in effect sizes through moderator analysis (Card, 2015, pp. 198-228). However, most of the articles did not report on bivariate correlations or means. A meta-analysis therefore would have resulted in a limited number of processed articles. We could have opted for the use of partial correlations, but there is debate on the use of them (Rothstein & Bushman, 2015), even if the results of the bivariate and partial analyses are reported separately. Because we were unable to perform moderator analyses in a meta-analysis we decided to do an exploratory analysis on sample size, sex differences and age as these are expected to moderate the association between psychophysiology and job stress/ burnout.

2.3. Coding and Reporting

Two authors double coded the effect directions and significance levels of the included articles (performed by PCdL and LJMC), and the interrater agreement was 88%. After a consensus meeting, both authors agreed on 100% of directions and significant associations. In addition, the articles were coded on the HR(V) or EDA outcomes, and the period of analysis, the time of the HR(V) and EDA measurement, the applied stress model (job stress, burnout), the time of stress measures, and the cut-off used for making subgroups of the participants. Furthermore, several other measures were coded (21 of 38 articles were double coded by (PE, HN, RD)). The risk of bias assessment for all articles are presented in Appendix C. In order to avoid simply looking at *p*-values (vote counting), we also looked at the direction of the comparisons. A positive direction means that higher levels of job stress and burnout were associated with higher levels of HR(V) and EDA. In case the articles reported mean differences or correlation coefficients these were used to describe the found effects. If no tables or information was available, the wording of the authors was coded. For instance, Uusitalo (2011) only reported all significant correlations in a table and concluded in the text that "the pure vagal time-domain index RMSSD was the only HRV measure which correlated with ER-imbalance" (p. 835). Since that was the only significant effect, it was assumed that the other investigated measures in the study, that is both HF and SDNN, were non-significant. These measures were therefore set to "no effect" and significance level as "not reported" because we also did not have information on the direction of the association. If tables were available we extracted the direction of the association from the tables, if no significance test was applied to the subgroups in those tables we reported that the significance was n.r. (not reported). All significance levels were set at $p < .05$. All available data is included with the article to both enhance reproducibility and compliance with the PLOS policy.

3. RESULTS

3.1. Study characteristics

We included 38 articles which reported on 119 outcome measures (Table 1). All reported outcomes in these 38 articles turned out to be HR(V) measures; No EDA studies met the inclusion criteria. In the initial full text review, we did identify 4 EDA studies that were possibly eligible, but they were excluded because of the use of a non-validated job stress questionnaire (2 studies) or because it was a simulation study (1 study), or a real-life stress exposure (1 study).

Nineteen of 38 study authors responded to requests of grey literature or additional information. For four authors we were unable to retrieve a valid email address.

3.2. Association between both burnout and job stress with (para) sympathetic measures.

The first hypothesis states that there is a positive association between HR and job stress/burnout. The associations between HR/SDNN and job stress/burnout are summarized by recording period in Appendix B. There were thirty-five reported outcomes on HR, of which 32 outcomes are reported in the Appendix. As can be seen in Appendix B, the majority of articles on HR and job stress/burnout found positive associations. The three non-reported outcomes were difficult to categorize (see Table 2). First, Poorabdian et al. (Poorabdian, Mirlohi, Habibi, & Shakerian, 2013) reported on an omnibus Chi-square test of which it was unclear at which time point the measures were taken. However, the direction of the association was significantly positive. Second, only one reported outcome for the Moya-Albiol et al. (2010) study was significantly negative while one outcome was mixed. The study reported a significant negative association caused by measures in the middle of the workday. Third, Borchini et al. (2014) reported on a non-significant positive relationship during a period of leisure and night. Therefore, in sum, twelve reported outcomes were significantly positive effects. The ratio of significant effects is in favour of a positive association (12 positive effects vs 2 negative effects; 12:2). Finally, seventeen outcomes reported on SDNN, of which three reported outcomes were significantly negative, and one was significantly positive.

TABLE 1. Descriptive characteristics of the articles.

Nr of articles included	38
Nr of reported outcomes	119
Sample size range	17-9924
Articles age range[a]	26.9- 51.2
Articles with only female samples[b]	6
Articles with only male samples	11
Articles with mixed samples[c]	18
Articles with no report on sex distribution	3
Articles reported on burnout	9
Articles reported on ERI	7
Articles reported on JDC	18
Articles reported on ERI and JDC	3
Articles reported on Organizational Injustice	1

Notes. [a]Seven articles did not report on age; [b]It should be noted that the article by Hintsanen et al. [39] reported on men and women separately. Both men and women were analysed separately; [c]The remaining 18 articles ranged from 8-95% as far as the inclusion of women was concerned.

TABLE 2. Code sheet from the included articles.

Study	HRV	Effect direction (+ = positive, - = negative)	Significant at the p<.05 level? (y/n)	Time HR assessment	Stress Measure	Study design; Year; Country	Sample Description	N analysis; N reported	Age Mean; Range; %Female; Stress division
(Bishop et al., 2003)	HR_w	+	y	every 30 min during a workday	JDC	C; -; Singapore	Singapore Police Officers	108; 118	26.9; 19-50; -; SD
(Borchini et al., 2014) and (R. Borchini, personal communication, March 1st, 2017)	HF_l	-	n	2 24 hour days continuous	JDC and ERI both used to identify high strain	L; 2010; Italy	CVD susceptible nurses	36	38.1; -; 83.3; E/R D/C
	HF_wln	-	y						
	PNN50_l	-	n						
	PNN50_wln	-	n						
	RMSSD_lln	-	n						
	RMSSD_wln	-	n						
	SDNN_lln	-	n						
	SDNN_wln	-	y						
	HR_lln	+	n						
	HR_wln	+	n						
(Butterbaugh et al., 2003)	HR_r	ne	n	-	JDC	C; -; -	Newly employed female nurses	58	-; -; 100; D/C
(Chandola et al., 2008)	HF_r	-	y	5 min RR was used	JDC	L; 1985-2004; Great Britain	Civil servants	3290	-; 35-56; -; Mdn
	SDNN_r	-	y						
(Clays et al., 2011)	HF_wln	-	n	24 hours including workday, HRV measures are based on 24 h	JDC	C; 1976-1978; Belgium	Healthy male factory workers	653; 770	47; 40-55; 0; Sum
	PNN50_wln	-	n						
	SDNN_wln	-	n						
	HR_wln	+	y						
(Collins, Karasek, & Costas, 2005)	HF_w(l)ln	-	y	48 hours, including work and rest days	JDC	C; -; United States	Healthy employed day shift working men from a community health plan and N=6 from a stress reduction program	34; 36	45; 35-59; 0; Tri
	HF_w	-	n						
	SDNN_w(l)ln	+	n						
	SDNN_w	-	n						
	HR_w(l)ln	+	n						
	HR_w	+	y						

TABLE 2. *(Continued)*

Study	HRV	Effect direction (+ = positive, - = negative)	Significant at the p<.05 level? (y/n)	Time HR assessment	Stress Measure	Study design; Year; Country	Sample Description	N analysis; N reported	Age Mean; Range; %Female; Stress division
(van Doornen et al., 2009)	HF_l	-	n	24 hour workday	Burnout (Maslach)	C; -; Netherlands	Male managers of a Dutch telecommunications company	88	43.3; -; 0; HLC
	HF_n	-	n						
	HF_w	-	n						
	HR_l	-	n						
	HR_n	+	n						
	HR_w	+	n						
(Ekstedt, Akerstedt, & Söderström, 2004)	HR_n	+	y	24 hour, but HR measured at rest before awaking at 7 am +/- 1 hour	Burnout (Shirom Melamed)	C; -; Sweden	Employees of IT company	24	30.5; 24-43; 58.3; HLC
(Eller et al., 2011)	HF_r	-	n	18 hour ECG starting on a workday in both 2006 and 2008, but only 15 min log transformed seated rest in analysis	ERI	L; 2006-2008; Denmark	White collar workers in the public administration males	61	51.2; -; 0; E/R
	HF_r	-	y						
	HR_r	+	y						
	HR_r	+	y						
(Eriksson, Schiöler, Söderberg, Rosengren, & Torén, 2016)	HR_r	+	y	5-10 min resting period	JDC	C; 2001-2004; Sweden	Working population	1552	46; 24-71; 52; D/C
(Fauvel, Quelin, Ducher, Rakotomalala, & Laville, 2001)	HR_r	ne	n	Measured during 15 minutes of seated rest	JDC	C; 1995-2001*; France	workers of a chemical company	281	37.3;18-55; 8; HL
	HR_t	+	n						
	HF_r	+	n						
	HF_t	+	n						
(Hamer et al., 2006)	HR_r	+	n	10 min BP (measured last 5 min of a 10 min resting period)	ERI	C; 2003-2004; Great Britain	full time employed men	92	33.1; -; 0; E/R
	HR_t	-	y	8 min BP measured during a role playing and mirror tracing tasks					

TABLE 2. *(Continued)*

Study	HRV	Effect direction (+ = positive, - = negative)	Significant at the p<.05 level? (y/n)	Time HR assessment	Stress Measure	Study design; Year; Country	Sample Description	N analysis; N reported	Age Mean; Range; %Female; Stress division
(Hanson et al., 2001)	HF_w(l)	-	n	During a working day, but for the office clerks the measurements continued into the evening (until 21.30)	ERI	C; -; Netherlands	Health professionals and office clerks	70	36.3; -; 44; E/R
(Henning et al., 2014)	RMSSD_n	ne	n	24 hour Amb measurement, but the unit of analysis is data between 2 am and 4 am	Burnout (Copenhagen Burnout Inventory)	L; -; New Zealand	junior doctors	17	-; 20-?; 65; Mean
	RMSSD_wl	ne	n						
(Hernández-Gaytan et al., 2013)	HF_w	-	n	24 hour ECG workday, 8 hour shift and 16 hour on call time	JDC	C; 2007-2008; Mexico	resident doctors	54	-; 23-36; 33; Mdn
	SDNN_w	-	n						
(Herr et al., 2015) and (R. Herr, personal communication, February 22nd, 2017)	HF_n	+	y	24 hour ECG	OI	C; 2007; Germany	White collar workers	179	46.4; -; 0; Sum
	HF_wln	+	n						
	RMSSD_n	+	y						
	RMSSD_wln	+	n						
	SDNN_n	+	y						
	SDNN_wln	+	n						
	HF_n	-	n				Blue collar workers	222	44.3; -; 0; Sum
	HF_wln	-	n						
	RMSSD_n	-	n						
	RMSSD_wln	-	n						
	SDNN_n	-	n						
	SDNN_wln	-	n						

TABLE 2. *(Continued)*

Study	HRV	Effect direction (+ = positive, - = negative)	Significant at the p<.05 level? (y/n)	Time HR assessment	Stress Measure	Study design; Year; Country	Sample Description	N analysis; N reported	Age Mean; Range; %Female; Stress division
(Hintsanen et al., 2007)	HR_r	-	n	3 min controlled breathing	ERI	C; 2001-2002; Finland	Employed people working full time males	406	32.2; 24-39; 0; E/R
	HF_r	+	n						
	PNN50_r	+	n						
	RMSSD_r	+	n						
	HR_r	+	n					457	32.3; 24-39; 100; E/R
	HF_r	-	n						
	PNN50_r	-	y						
	RMSSD_r	-	y						
(Jarczok et al., 2016)	RMSSD_n	-	y	24 hour workday continuous	ERI	C; 2010-2012; Germany	Mannheim Industrial Cohort (MICS)	9924; 9937	41.9; 18-65; 19; E/R
	RMSSD_wl	-	y						
(Johnston et al., 2016)	HR_w	+	n	2 12 hour workdays	JDC and ERI	C; -; Great Britain	Qualified nurses in a general hospital on medical and surgical wards	100	36.4; -; 93; Sum
(Jönsson et al., 2015) and (P. Jönsson, personal communication, February 16th, 2017)	HR_t	-	n	1 hour ECG during task and recovery with a baseline reading	Burnout (Shirom Melamed)	Lab; -; -	Employed population with N=14 Former ED (Burnout) patients, n=17 pre ED stage workers and n=20 controls	51	48.7; 33-61; 51; HLC
	HF_t	+	n						
(Kang et al., 2004)	HF_r	-	n	5 minutes in the morning	JDC	C; 2003; South-Korea	Male shipyard workers	169	46.7; 41-?; 0; D/C
	SDNN_r	-	n						
(Karhula et al., 2014)	HR_n	-	n	3 non-consecutive 24 hour days including a morning shift, night shift and recovery day. Data used for analysis was at least 4h of sleep after which the 30 min segment with the lowest heart rate was used for analysis.	JDC	C; 2008; Finland	Female nurses	95	47.2; 31-59; 100; mdn and mean
	HF_n	ne	n						
	RMSSD_n	ne	n						

TABLE 2. *(Continued)*

Study	HRV	Effect direction (+ = positive, - = negative)	Significant at the p<.05 level? (y/n)	Time HR assessment	Stress Measure	Study design; Year; Country	Sample Description	N analysis; N reported	Age Mean; Range; %Female; Stress division
(Kotov & Revina, 2012)	HF_w	-	y	8 hour workday	Burnout (Boiko)	C; -; Russia	First-aid doctors	44; 84	-; 26-65; 56; HLC
	PNN50_w	+	n						
	RMSSD_w	-	n						
	SDNN_w	-	n						
(Lee et al., 2010)	HF_r	+	n	Measured 3 times in each subject after completion of 1 day, 1 night and 1 evening shift in a 5 min rest period after 5 min of rest.	JDC	C; -; South-Korea	Employees of consumer goods company	56; 140	29.1; 25-44; 0; D/C
(Lennartsson et al., 2016)	HF_r	-	y	5 minutes in the morning in supine position	Burnout (Shilom-Melamed)	Lab; -; Sweden	Employed, working and on sick leave burnout patients, non-clinical burnout subjects and healthy controls	161	40; 20-65; 60; HLC/HL
	RMSSD_r	-	y						
	SDNN_r	-	y						
(Loerbroks et al., 2010)	RMSSD_l	ne	n	24 hour wln measure	ERI	C; 2003-2004; Germany	Employees from an airplane manufacturer	591; 657	41.6; 17-65; 12; E/R
	RMSSD_l	ne	n		JDC				
	RMSSD_n	ne	n		ERI				
	RMSSD_n	ne	n		JDC				
	RMSSD_w	ne	n		ERI				
	RMSSD_w	ne	n		JDC				
(Morgan et al., 2002)	HF_r	+	y	10 min in supine position	Burnout (Maslach)	C; -; United States	Soldiers	41	-; -; -; HL
(Moya-Albiol et al., 2010)	HR_w	-/ne	y/n	3 times a day 30 min during seated rest	Burnout (Maslach)	C; -; Spain	Full- time school teachers	64; 80	42.8; -; 80; Mean
(Nomura, Nakao, Karita, Nishikitani, & Yano, 2005)	HR_r	+	n	After 5 min of rest measures were taken at rest	JDC	C; 2003; Japan	Employees from IT company	396; 437	30; 24-39; 0; D/C

TABLE 2. *(Continued)*

Study	HRV	Effect direction (+ = positive, - = negative)	Significant at the p<.05 level? (y/n)	Time HR assessment	Stress Measure	Study design; Year; Country	Sample Description	N analysis; N reported	Age Mean; Range; %Female; Stress division
(Ohira et al., 2011)	HR_r	+	y	During baseline and 2 learning tasks	JDC	Lab; -; Japan	Full time employed men	20	32.6; -; 0; D/C
	HF_r	+	n.r.						
	HF_t	+	n.r.						
(Poorabdian et al., 2013)	HR_?	+	n.r.*	-	JDC	C; 2007-2009; Iran	Male personnel at a petrochemical plant	500	42.5; 22-64; 0; HL
(Rau et al., 2001)	HR_n	ne	n.r.	Every 15 minutes over 24 hours during a normal working day	JDC	C; 1985-?; Sweden	Employed hypotensive (n=74) and hypertensive (n=75) men	81; 149	50.1; 35-55; 0; Mean
	HR_w	ne	n.r.						
(Riese, Van Doornen, Houtman, & De Geus, 2004)	HR_w(l)ln	ne	n	2 days, for 24 hours on a workday and one on a leisure day	JDC	L; 1997-1998; Netherlands	Healthy female nurses	159	35.9; 25-50; 100; Median
	RMSSD_w(l) ln	ne	n						
(Salavecz, Kopp, & Steptoe, 2010)	HF_l	-	y	Measured over the working day	JDC	C; -; Hungary	Women working in Budapest	169	-; -; 100; -
(Teisala et al., 2014)	RMSSD_w	-	n	3 24 hour workdays, HRV measures are based on 24 h, not all participants three days. One day (n=10, two days (n=70), three days (n=1).	Burnout (Bergen)	C; -; -	Employed people	81	34; 26-40; 0; Mean
(Uusitalo et al., 2011)	HF_w	ne	n	2 36 hour workdays	ERI	C; -; Finland	Healthy hospital workers	19; 22	42; 24-57; 95; E/R
	RMSSD_w	-	y/n						
	SDNN_w	ne	n						

TABLE 2. *(Continued)*

Study	HRV	Effect direction (+ = positive, - = negative)	Significant at the p<.05 level? (y/n)	Time HR assessment	Stress Measure	Study design; Year; Country	Sample Description	N analysis; N reported	Age Mean; Range; %Female; Stress division
(van Amelsvoort et al., 2000)	HR_n	-	n	24 hour workday	JDC	C; -; Netherlands	Shift workers and daytime workers as controls, working in the manufacturing industry, waste incinerator industry and hospitals	135; 155	30.8; 18-55; 19; D/C
	HR_w	+	y						
	HF_n	-	n						
	HF_w	-	n						
	SDNN_n	-	n						
	SDNN_w	+	n						
(Vrijkotte et al., 2000)	HR_l	+	y	2 24 hour workdays and 1 24 h non workday	ERI	C; 1996-1997; Netherlands	White collar workers of a computer company	109	47.2; 37-57; 0; E/R
	HR_n	+	n						
	HR_w	+	y						
	RMSSD_l	-	n						
	RMSSD_n	-	n						
	RMSSD_w	-	n						

Notes. JDC = Job demands control; ERI = Effort reward imbalance; OI = Organizational injustice; C = Cross-sectional; L = Longitudinal; Lab = Laboratory; HR = Heart rate; HF = High frequency; RMSSD = Root mean square of successive differences; PNN50 = percentage of adjacent cycles that are greater than 50 ms apart; HRV = Heart rate variability; SDNN = Standard deviation of all N-N intervals; RR = R to R intervals; SD = Standard deviation; E/R = Effort divided by reward; D/C = Demand divided by control; Mdn = Median; Sum = Sum score; Tri = Triangulation of data; HL = Based on high low scores; HLC = Based on clinical high low scores; _l = measured during leisure time; _r = measured during rest; _w = measured during a workday; wln = measured during a period including workday, leisure time and night; n = measured during a night; _t = Measured during a task; n.r. = Not reported; ne = No effect.

The second hypothesis states that there is a negative association between the reported parasympathetic outcomes and job stress/burnout. Reported outcomes on HF, RMSSD and PNN50 were included in this systematic review. The association between parasympathetic measures and job stress/burnout are also summarized in Appendix B. Thirty-four outcomes were reported on HF. Only 33 outcomes are reported in Appendix B as Hanson et al. (Hanson et al., 2001) reported on a non-significant negative association for work leisure period, which was not a defined category in our study. Seven reported outcomes were significantly negative, two were significantly positive. Twenty-seven outcomes were reported on RMSSD, five of the reported outcomes were significantly negative, one was significantly positive. One study outcome was mixed on the conclusion; on the first day of the assessment no effect was found, whereas on the second day a significant and negative effect was found (Uusitalo et al., 2011). Six outcomes were reported on PNN50. Only one of the reported outcomes was significantly negative. One further remark has to be made for Appendix B. For PNN50, two of the outcomes were measured *in rest*. One of the outcomes was reported on a significant negative effect for the female sample (Hintsanen et al., 2007) while the other reported outcome was positive, but non-significant for the male sample.

To summarize, we found 13 significantly negative reported outcomes for the parasympathetic outcomes, compared to 3 significantly positive reported outcomes. The relatively high number of negative effects seems to be in support of the second hypothesis, at least as far as the HF and RMSSD outcomes are concerned. However, most of the 67 reported outcomes were non-significant.

3.3. Burnout and job stress

The third hypothesis states that the association between burnout and HR(V)/EDA is stronger than the association between job stress and HR(V)/EDA. Six outcomes were reported on the HR-burnout association, however, only one was significantly positive (Ekstedt et al., 2004), with the caution that the burnout group was entered as a dummy variable and part of a multiple regression analysis. Twenty-nine outcomes were reported on the HR-job stress association. Eleven outcomes were significantly positive. These results indicate the opposite of the hypothesis, the association between job stress and HR seems to be found more often than the association between burnout and HR.

As for the parasympathetic outcomes, seven outcomes were reported on the HF-burnout association. Only one reported outcome had a significant negative effect. Twenty-seven outcomes were reported on the HF-job stress association. Five reported outcomes were significantly negative. Five outcomes reported on the RMSSD-burnout association. Only one reported outcome had a significant negative effect. Twentytwo outcomes were reported on the RMSSD-job stress association. Four reported outcomes were significantly negative, one of the effects was mixed (Uusitalo et al., 2011). Note that there are two articles and 11 reported outcomes using both JDC and ERI to divide subjects in high/low strain. In sum, these results do not indicate that the parasympathetic association between burnout and HRV is found more often than the association between job stress and HRV.

3.4. Exploratory analysis

Because we were unable to perform a meta-analysis and for purposes of generating hypotheses, we explored whether the effects changed as a result of sample size, sex, or age (Table 3). In order to get a good contrast between samples, the results were analysed by median splits based on these three variables. We expected HR to have a positive association with job stress and burnout. For the parasympathetic measures, a negative direction was expected. Interestingly, articles with higher sample sizes, and thus presumably providing more power to find a true effect, indeed found twice as much of the hypothesized effects than articles with lower sample sizes. The interpretation of the sex split is less clear as the samples are mixed, but the samples with a higher percentage of women seem to have more negative parasympathetic effects (11 vs 1). No age effects were found.

TABLE 3. Amount of positive (HR) and negative (parasympathetic) significant reported effects.

		HR (35)		**Parasympathetic (67)**	
	Median split	**Range**	**# positive effects**	**Range**	**# negative effects**
Sample size	lower	20-95	4 (18)	17-135	4 (34)
	higher	100-1552	8 (17)	159-9924	9 (33)
Sex proportion	lower	0 % females	7 (18)	0-12% females	1 (35)
	higher	8-100% females[a]	4 (16)	19-100% females [b]	11 (30)
Age	lower	26.9-42.5	5 (17)	29.1-41.6	5 (30)
	higher	42.8-51.2	7 (17)	41.9-51.2[c]	5 (28)

Note. The number of reported outcomes is in brackets. HR = heart rate.
All reported outcomes were median split on sample size, sex or age.
[a] A median split was performed on the basis of the percentage of females as in a general median split it would be arbitrary which of the female outcomes would be included in the higher % sample.
[b] The median split was performed on the basis of the percentage of females. The sample was not exactly split in half because the median included a study with 6 reported outcomes. Therefore, it would be arbitrary which of the reported outcomes would be included in the higher or lower percentage sample. We avoided this problem by including 30 outcomes in the higher % sample and 35 in the lower % sample.
[c] The median split was performed on the basis of age. The sample was not exactly split in half because the median included a study with 6 reported outcomes. Therefore, it would be arbitrary which of the reported outcomes would be included in the higher or lower age sample. By including 28 outcomes in the higher age sample (and 30 in the lower) we avoided this problem.

4. DISCUSSION

This systematic review focuses on the relationship between job stress and burnout on the one hand and parasympathetic and sympathetic activity on the other hand. The current review could be considered as both a replication, update and an extension of previous work on this topic. The overall aim of this review was to better understand the association between job stress/burnout and HR(V)/EDA, which parameters might prove useful, and which recording periods are favourable over others to analyse.

4.1. Main Findings for the Hypotheses

The first hypothesis stated that there is a positive association between HR measures and job stress/burnout. First, support for this hypothesis came from both the high number of positive associations and the ratio of positive and negative effects (12 vs. 2), which clearly showed that the likelihood of a positive association between HR and job stress/burnout is higher. In other words, the results of this review support that high levels of job stress and burnout are associated with an increased HR. Second, one-third of all reported outcomes (12/35) showed a significant positive association between HR and job stress/burnout. However, if we leave burnout out of the analysis, 11 of 29 of the effects for job stress were positive. The number of articles on burnout included in this systematic review was too small to draw any firm conclusions. As van Doornen et al., (2009) also pointed out, the daily hassles of job stress may be incomparable with scales of exhaustion, depersonalization and personal accomplishment as a result of enduring job stress, but further research is necessary to investigate this claim.

Hypothesis 2 stated that there is a negative association between parasympathetic outcomes, indicated by HRV parameters, and job stress/burnout. Support for this hypothesis came from both the number of negative directions and the ratio of negative and positive effects (13 vs. 3), which showed that the likelihood of a negative association is higher. In addition to the ratio, one fifth (13/67) of all reported outcomes showed a significant negative association. If we leave burnout out of the analysis, one sixth (7/42) of the effects were negative. Twelve of the 19 articles included by Jarczok et al. (2013) were also included in this systematic review. The twelve articles included in both systematic reviews showed comparable results, although Jarczok et al. (2013) included fewer reported outcomes for the parasympathetic measures than in our study (38 articles). In Jarczoks' sample, half of the parasympathetic outcomes were significantly negative (17/33) on the (sub)scales. Our analysis resulted in a significant negative effect in only one fifth (6/29) of the outcomes on the full scales, which explains the difference as the unit of analysis of the scales is different. For example, Jarczok et al. (2013) also included effects of the separate scales for demands, control, effort or reward of the JDC and ERI (workplace stressors vs job stress) models while we only considered articles that reported results on the entire scale. However, the direction of the effect in both studies (i.e. the study by Jarczok et al. (2013) and the current study) was overwhelmingly negative, that is, higher levels of job stress are associated with lower parasympathetic activation. It is worth mentioning that the correlation between HF and RMSSD is usually high (>.90, see for instance Clays et al., 2011). Therefore, it seems intuitive to expect a significant association of RMSSD if HF also has an effect, and vice versa, which results in an overestimation of the effects found in our study, due to multicollinearity. Finally, although SDNN is not a primarily sympathetic or parasympathetic outcome measure, there was a tendency towards a negative association between SDNN and job stress/ burnout in our study.

The third hypothesis stated that there is a stronger association between psychophysiological measures and burnout than between psychophysiological measures and job stress. However, this hypothesized relationship could not be confirmed. One explanation for this might be the small number of included articles on burnout. Another potential reason might be that people with burnout symptoms do not experience job stress symptoms anymore as they are on sick leave which might have a calming effect on the body, and thus the (para)sympathetic measures.

In conclusion, it is important to state that most of the reported outcomes were non-significant, and for some articles that reported that there was no effect, we could not determine the direction of association. We did find partial support for the two hypotheses regarding a positive direction for the HR measures and a negative direction for the associations of parasympathetic measures with job stress and burnout. The ratio for the HR measures (12 vs. 2) was slightly higher than the ratio for the parasympathetic measures (13 vs. 3). Also, some evidence was found that articles with a larger sample size more often found a significant association. However, the third hypothesis regarding a stronger association between psychophysiological measures and burnout as opposed to job stress was not supported.

4.2. Methodological considerations

Related to the findings for the three hypotheses, four observations can be made regarding methodology and measurement. First, most reported HR outcomes came from rest (n = 11) measures. The number of reported parasympathetic outcomes was almost twice as high, most measures were taken at rest (n = 16), workday (n = 13), for 24 hours (n = 14), and at night (n = 13). It is remarkable that only few articles used rest measures since these seem to be most easily obtained, although some researchers may disagree. However, a rest protocol does assure that there is no movement or psychosocial demand on the participants, which might result in an artifact free signal. Also, there is some heterogeneity within these rest measures. Borchini et al. (2014) pointed out that a strict standardized ECG protocol is necessary to obtain precise results. We recommend to include rest as a baseline measure in future studies. The baseline measure could also be used to adjust for between-person variation in psychophysiological recordings. It is worth noting that both HR and EDA show diurnal variation which suggests that this has to be taken into account as well when obtaining rest measures (Bexton et al., 1986; Hot et al., 2005; Kamath & Fallen, 1991).

Second, regarding the prolonged measurements of HRV there are two points worth noting. First, Uusitalo et al. (2011) suggest that nonlinear measures of HRV are less movement prone. In comparison with frequency domain measures, they argue that time domain and nonlinear HRV might prove to be more stable and suitable for situations in which a person may show a lot of movement resembling the real-life situations. Only few included articles report on controlling for physical activity, which is expected to have an influence. It is recommended to adjust for these movement artifacts if possible. In addition, Kamath et al. (2016) mentioned the influence of respiration on the HF component of frequency domain measures; as breathing decreases, HF decreases as well. The authors state that HF measures can only be obtained in case one controls for breathing which might not be possible for all mobile devices that are currently on the market. We recommend careful consideration controlling for movement and breathing if possible.

Third, Clays et al. (2011) point at the fact that one cannot compare all parameters obtained in different time intervals as they are dependent on time of analysis. For instance, SDNN is highly dependent on the length of the recording, and there are apparent differences in the duration of measurement intervals between studies. SDNN is typically used for 24-h recordings only. This is in line with remarks made by Kamath et al. (2016) that long term measurements are preferably analysed by time domain methods, and short term measures are preferably analysed by frequency domain methods. With time domain measures it is difficult to discriminate between sympathetic and parasympathetic measures. In the current review, five of the outcomes on rest measures, which are usually 3-15 minutes long, were time domain measures as opposed to 11 outcomes on the frequency domain. There is a need for guidelines on the use of time domain or frequency domain methods and the duration of assessment from different laboratories (Kamath et al., 2016). Although a recommendation on duration of measurement is beyond the implications of this review, we would recommend reporting exact timeframes, methods of analysis, and transformations and filters applied to compare data more easily, even if mobile devices are not used in laboratories, but in real life situations.

Fourth, a final notion on real-life measurement is made by Rau et al., (2001). The authors suggest that the assessment of leisure time differs between studies, which may consequently lead to differences in findings. Some studies operationalize leisure time as the time between work and sleep while others consider resting days as leisure time. We recommend the use of after work leisure time as a separate terminology from a day that is completely without work.

Many of the reported outcomes are not independent. Therefore, we evaluated how many of the significant associations came from the same study. For the HR outcomes, the 12 significant positive outcomes came from 11 articles, whereas the 19 non-significant reported outcomes came from 14 articles (no significance test was reported for 3 outcomes; and 1 study reported mixed effects.) Thus, there appeared to be more independency among the significant associations than among the non-significant associations, which increases the reliability of the significant relationships. For the parasympathetic reported outcomes, the 13 significant negative outcomes came from 10 articles, whereas the 49 non-significant outcomes came from 22 articles (no significance test was reported for 2 outcomes; and the association for 3 outcomes was in the opposite direction of our hypothesis – positive instead of negative). Again, there was more independency among the significant associations than among the non-significant associations.

Regarding the exploratory analyses, it is worth noting that for sample size both sympathetic and parasympathetic measures show a tendency to obtain more associations in the hypothesized directions if the sample size is larger. A larger sample size often means a higher power, which implies a higher chance of obtaining a true effect, in this case a positive relationship between HR and a negative relationship between parasympathetic functioning and job stress/burnout which increases our trust in the relationships that we found. We do not want to extrapolate conclusions based on sex as we had less female samples, which is an indication that more female samples are needed in future studies to increase our confidence.

4.3. Directions for further research

A particular strength of the current study is that the results reported by Jarczok et al. (2013) were replicated. This is especially relevant as psychological research is currently dealing with a replication crisis (Collaboration, 2015). Second, this review extended the former one by only considering the full scales of job stress, adding the concept of burnout, and including EDA as a purely sympathetic marker. A third strength of this review is the additional search that was performed for gray literature by emailing all included authors. In spite of this strength, this study has a limitation on 'vote counting'.

If bivariate correlations or adjusted models with the same covariates are unavailable, it is difficult to summarize the true effect. The problem with vote counting is that it does not consider the magnitude of an effect, and control for heterogeneity or moderation is impossible. A second limitation is that we were unable to perform a meta-analysis which makes the results less compelling than they could have been.

We also have some additional recommendations. First, there is high variability in the number of covariates and bivariate or partial correlations reported. We strongly recommend to report both bivariate relations and adjusted models as this can seriously alter the effects that are found. This becomes even more evident as we consider that, as mentioned earlier, there is dependency between the reported outcome measures as they are all based on (variation in) HR, and some outcome measures have high correlations (i.e. the correlation between HF and RMSSD is usually high (>.90, see for instance Massin, Derkenne, & Bernuth, 1999). We recommend that studies use the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology; Vandenbroucke et al., 2007) statement to guide reporting for future studies.

Second, the use of validated questionnaires is highly recommended, there was an abundance of studies using only one job stress question making it unclear what the construct of the measure was (none of those non validated studies were included in this review). As the subjective meaning of job stress differs between jobs and people within these jobs, for comparability a thorough investigation is important.

Third, in burnout research there is often a predisposed clinical cut-off. In the job stress samples this is not always the case as some report on the quadrants while others use a median split or a 20/80 division. It is recommended to use the same validated cut-offs. A problem with comparability between articles arises as some articles included relatively healthy employees while others included a relatively large number of stressed individuals. In addition, providing the data along with the publication would allow for a meta-analysis of individual data.

Fourth, it is essential to report on both sex and age as there are few articles that report differences between men and women (Eller et al., 2011; Hintsanen et al., 2007). The concept of job stress might not be applicable to men and women alike as Riese et al. (2004) already mentioned. The original constructs might hold true more to men than to women. The psychophysiological profile of stress and burnout in women might be different.

Of course the question remains to what extent self-report questionnaire measures correspond to physiological measures of job stress. HRV is often used as a measure of stress while it does not always match the subjective stress that people experience. It would therefore be worth constructing a psychophysiological profile in which the within-subject baseline is taken into account, which would be possible with a baseline measurement. People differ from each other in baseline measures. It is unclear if their baseline is the same in all circumstances, let alone if the baseline can change in situations where they get stressed. In other words, people might have a moving baseline. However, the vast majority of research until now has been cross-sectional in nature, and comparisons were made between subjects or between groups. The baseline of the subjects is only considered in some of the more recent research (see for instance Teisala et al., 2014).

The fact that there is a small difference in the number of reported parasympathetic associations between our study and the study by Jarczok et al. (2013) stresses the importance of reporting all bivariate correlations or means on all scales, for this will enable a meta-analysis, as was also suggested in more recent research (Wulsin, Herman, & Thayer, 2018). Moderation analysis can then be performed on different sets of confounders and covariates. The current systematic review includes articles that use a variety of confounding adjustments and covariates, which makes it difficult to compare them.

Lastly, no EDA studies were found that met our criteria. A few studies were considered for inclusion. For instance, Cendales-Ayala et al. (2016) did a simulation study in which it was shown that high demands in bus drivers resulted in significantly increased EDA. Considering the sympathetic nature of the EDA, we expected to find more studies. However, only recently it is possible to obtain EDA measures via mobile devices, such as wristbands, in real life during prolonged periods of time. Based on this development we expect to find more studies on EDA and job stress in the near future.

4.4. Conclusion

In conclusion, this study examined whether HR was positively associated with job stress and burnout. In addition, it examined whether there was a negative association between parasympathetic markers, and job stress and burnout. Support was found for both hypotheses. No support was found for the hypothesis that the association with burnout was stronger than it was for job stress. There is a need for more extensive reporting of effect directions, and on female samples, which were underrepresented in the current review. In this sample job stress was mostly related to increases in HR and decreases in RMSSD, HF and SDNN. Maybe these measures can be used as indicators and warning signals of increases in job stress, whereas the relationship with burnout is less clear.


4

CHAPTER 4

Longitudinal confirmatory factor analysis of a Dutch version of the Demands and Supports Questionnaire

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Submitted

ABSTRACT

Background The adverse consequences of job stress in mental health nursing staff working on forensic psychiatric wards are of great interest. Diagnostic tools designed to amplify an open dialogue with staff members can improve their level of well-being and work performance.

Method This study explored the psychometric properties of a Dutch version of the Demands and Supports Questionnaire (DSQ, Rose 1999), a 41-item questionnaire designed to measure job stress. 347 questionnaires were administered to nursing staff in four forensic psychiatric hospitals for individuals with mild intellectual disabilities or borderline intellectual functioning. A longitudinal confirmatory factor analysis was used to validate the questionnaire.

Results The factor structure of the demands scale was validated for configural invariance. The three factor support scale was not validated due to missing data, but a two factor model with good model fit was explored.

Conclusions. Complete measurement invariance for the DSQ was not established. Therefore, caution is needed in comparing mean factor levels over time. Several recommendations are made to adjust the questionnaire for use in a forensic psychiatric setting.

1. INTRODUCTION

This study examined the psychometric properties of a Dutch version of the Demands and Supports Questionnaire (DSQ, Rose, 1999) for forensic nursing staff working with patients with mild intellectual disabilities or borderline intellectual functioning (MID-BIF). The questionnaire is a useful tool that monitors well-being and stress levels of staff members who work with patients with MID-BIF, and can be used as a starting point for a dialogue on the demands and supports experienced by staff members. This is thought to increase their level of well-being and work performance. This is especially relevant as poor staff outcomes are associated with poor patient outcomes (Johnson et al., 2018).

To conceptualise stress, several models have been proposed over the past decades which resulted in two often utilised models and validated questionnaires; the demands control support model (Karasek, 1979), and the effort reward imbalance model (Jarczok et al., 2013; Siegrist et al., 1997, 2004). The model used by Rose (1999) is more in line with the first model, because the DSQ is based on the occupational stress model (Payne, 1979, 1980) which also considers demands, supports and constraints to be essential aspects of work performance and well-being. Rose (1999) suggested that an increase in demands and/or constraints leads to higher levels of stress while support can act as a moderator to reduce stress levels (Devereux et al., 2009). The DSQ was specifically designed for environments where employees work with individuals with intellectual disabilities (Devereux et al., 2009; Rose, 1999) in which demands and supports are related to the nature of the intellectual disabilities. For the current study it was investigated whether the DSQ could also be used in Dutch forensic psychiatry where people with MID-BIF are treated.

1.1. Measurement Invariance

Questionnaires are usually developed to assess an underlying phenomenon or construct, and are used to compare groups or follow people over time (Schoot et al., 2012). For this purpose, questionnaires need to measure identical constructs, and have the same meaning over time or between groups (Putnick & Bornstein, 2016). This can be assessed with measurement equivalence or measurement invariance (MI), which is a necessary condition for comparison of latent constructs between groups or over time (Vandenberg & Lance, 2000). It means that the participants interpreted both the questions as well as the constructs similarly between groups or over time (Schoot et al., 2012), and is a necessary condition before any comparison between groups or over time can be conducted. If MI is not established then the questionnaires cannot be compared between groups or over time (Schoot et al., 2012). Confirmatory factor analysis (CFA) is often deployed to test for measurement invariance (Brown, 2015). CFA can be used on multi group or longitudinal data (Liu et al., 2017) with the main difference being the dependence in the longitudinal data, which is applied to the dependence of the covariance of the unique factors (in comparison with multi group CFA). Several different hypotheses are tested under different levels of MI. The configural invariance model freely estimates the factor loadings, intercepts, and variance-covariance matrices from the corresponding factors. The factor loadings are set equal over time in the weak (or metric) invariance model, with the addition of equal intercepts in the strong (or scalar) invariance model. The strict (or residual or invariant uniqueness) invariance model also sets the unique factor variances equal over time (Liu et al., 2017; Putnick & Bornstein, 2016). If scalar invariance is established this would allow comparison of means or sums of factors over time (Schoot et al., 2012).

Both the demand and support subscales of the English version of the DSQ have been validated and used in previous research (Rose, 1999; Rose et al., 2003). The Cronbach's alpha for the demand and support subscales was found to be .84, and .82, respectively. The four factors of the demands scale are "Social Role/ Contact", "Resident Interaction", "Domestic Issues", and "Work Pressure". The three factors of the support scale are "External Support", "Organisation and Management", and "Social Support and Training". We translated this questionnaire for use in Dutch settings and wanted to test whether the factor structure is comparable in both the English and the Dutch version. Moreover, it was tested whether the DSQ measures the same constructs over time as MI is an essential prerequisite before drawing any relevant clinical or scientific conclusions (de Beurs et al., 2015).

2. METHOD

2.1. Participants and Procedure

Participants were 110 nursing staff members who work within four forensic psychiatric hospitals for patients with MID-BIF. All employees from the hospitals were invited through intranet advertisement and folders. No exclusion criteria were used, the only inclusion criterion was that staff members worked on the ward. All participants were invited for data collection at a 6-month interval. We included participants in four waves of data collection between June 2015 and July 2017 as the participants were part of a larger longitudinal study. The DSQ was filled out by the participants on all four waves. We started out with 110 participants in the first wave, 95 in the second, 74 in the third, and 68 in the final wave, totalling 347 completed questionnaires. Sample attrition was mainly caused by absence or turnover. 65 of the 110 participants were female (59%) during the first wave of data collection, and 42 of the 68 participants were female

(62%) during the last wave. The age of the participants ranged from 21 to 59 (mean = 35.5 years, SD = 10). The average time employed on the ward was 4.4 years (SD = 3.9). There were on average 12 patients residing on the wards where the participants were working (SD = 3.5), and participants worked with 6 colleagues in one shift on average (SD = 1.56).

Approval for the current study was granted by the scientific committee and committee of ethics of the faculty of Social Sciences of the Radboud University (ECSW2015-1901-282) followed by an approval of each hospital's scientific committee. Written informed consent was given by the staff members who participated. Study size was arrived at with an a priori power analysis for a one-group repeated measures analysis with 95% power, and an effect size of .02 which showed that a minimum of 87 participants were needed. The questionnaire was used in a longitudinal study into job stress and burnout, but no specific power analysis for the CFA was performed. Several recommendations on sample size in factor analysis have been given indicating a 5 participants versus 1 variable ratio, a 10:1 ratio (Field, 2013; Norris & Lecavalier, 2010), or 10 cases per variable (Wolf et al., 2013). We felt that with two scales of approximately 20 questions and 347 completed questionnaires a confirmatory factor analysis was warranted.

2.2. Instrument

Demands, supports and constraints were assessed using the DSQ developed by Rose (1999). The questions are scored on a 5-point Likert scale ranging from low (1) to high (5). The rating of 4 and 5 on the support scale is considered to be support, while ratings of 1 and 2 on the support scale are considered to be constraints. The rating of 4 or 5 on the demand scale is considered to be a demand. On both scales there is a rating which is neutral (3) or does not apply (0).

The 23 items on the Demands scale have four factors: (1) Social Role contact (for example, "Having little contact with other workers" or "Having too many residents"), (2) Resident Interaction ("Demands of residents" or "Severity of the disability") (3) Domestic Issues ("Cooking" or "Cleaning") and (4) Work Pressure ("Continuing change" or "More work than time available"). The four factors on the demands scale of the English version of the DSQ explained 39.5% of variance. The internal consistencies of the scales were .74, .64, .76 and .69 respectively.

The 18 items on the Support scale are grouped into three factors: (1) Organisation and Management (for example, "Freedom in deciding what to do" or "Morale of other staff") (2) Social Support and Training ("Support from colleagues" or "Results of working with residents") and (3) External Support ("Support from psychologist" or "Family"). The three factors extracted on the support scale explained 43.1% of the variance. The internal consistencies of the scales were .85, .75, and .72, respectively. Only item loadings above 0.4 were included in the English questionnaire.

Three authors who are fluent in both the English and Dutch language, independently translated the 41 questions of the DSQ, followed by an agreement meeting of these 3 authors on the final translation. The following item was dropped from the demands scale which did not apply to staff working in a forensic setting: "It's being moved from house to house that makes my job demanding".

2.3. Statistical analysis

The analytical procedures consisted of a longitudinal confirmatory factor analysis (CFA) in the lavaan package (version 0.6-1) in R (R Core Team, 2014; Rosseel, 2012). The items were categorical Likert scale items ranging from 1-5 on both scales. There was one option available to participants (0 'does not apply'), these values were set to missing for the analyses. The mean- and variance adjusted diagonally weighted least squares estimator was used (WLSMV) with missing values set to pairwise deletion, in line with the recommendations (Liu et al., 2017). However, several variables had missing values on the items and therefore the DWLS (diagonally weighted least squares) estimator with ML (maximum likelihood) was used. There were three hierarchical models tested in the current analyses for both the demand and the support scale. The first model assesses whether "the same general pattern of factor loadings holds across time" (Liu et al., 2017, p.492). The model should provide adequate fit to allow testing for the other two models (weak and strong invariance). The weak (or metric) invariance model (model 2) adds the constraint that the factor loadings are identical over time (Liu et al., 2017) while the strong (or scalar) model (model 3) "adds the constraint that for each indicator, the threshold level of going from one response category to the next is identical over time" (Liu et al., 2017, p.492). See Putnick and Bornstein for instance, who provide a clear visual example of the different types of invariance (Putnick & Bornstein, 2016).

For assessing model fit between models, the Chi square difference test is the most often utilised (Schoot et al., 2012), but is dependent on sample size. Moreover, in categorical ordered CFA models it is also recommended to assess local fit indices (residuals; modification indices) as the change in practical fit indices like RMSEA and the comparative fit index (CFI) might be biased (Liu et al., 2017). As for the fit-indices, it is recommended to report the Tucker-Lewis index (TLI), the root mean square error of approximation (RMSEA), and the standardised root mean square residual (SRMR) (Putnick & Bornstein, 2016; Vandenberg & Lance, 2000). The CFI and TLI should have a lower bound of .90 for adequate fit, and >.95 is considered 'good' fit (Vandenberg &

Lance, 2000). RMSEA should not exceed .08, but should preferably be <.06 while the SRMR should not exceed .10, and preferably be <.08 as indicative of excellent fit.

3. RESULTS

A CFA of four components on the demands scale and three components on the support scale was examined. The response categories over the 4 time points indicated a sparse data problem, which means that the software is unable to estimate the threshold values for the categorical variables (Liu et al., 2017). An example of this would be if at Time 1 participants used the full range of the Likert scale (1-5) to answer an item while at Time 2 only response categories 2-5 were used. The solution to this problem is to merge category 1 and 2, and categories 4-5, which results in 3 categories. The category “does not apply” was left out of the analysis as this is not part of the Likert scale, and set to missing. The descriptive statistics of both scales are reported in Table 1 together with the Cronbach alpha’s for each factor at each time point (T1-T4). Notice that the “External Support” factor of the support scale has items with a considerable amount of missing data (n <20). Furthermore, some scales have reliabilities below .6 at some time points. Aron and Aron (2003) point out that a good questionnaire should have an internal consistency of at least .6. Cronbach’s alpha for the total Demand scale is .84 at T1, and for the total support scale it is .62 at T1. This result is comparable to Rose (1999) for the demand scale (.84 vs. .84), but not for the support scale (.82 vs. .62).

3.1. Demands

In Table 2 the fit indices for the invariance models are presented. The configural invariance model had acceptable model fit, above the .90 lower bound threshold for both the CFI and TLI. Moreover, the RMSEA was below the .06 threshold. The SRMR exceeded the .10 threshold, and is defined as the standardised difference between the observed and predicted correlation (Hu & Bentler, 1999). This might indicate misspecification, therefore, the residuals and variances were checked. A negative error variance on item 18 was found which was constrained to the mean variance over the four time periods (.22) following recommendations (Chen et al., 2001). This did not improve the model fit indices. Next, the factor loadings were restricted in the metric invariance model. The null hypothesis of metric invariance had to be rejected in favour of configural invariance as the anova indicated a significant deviation (Chi square difference = 208.7; df difference = 54; p<.0.001). As complete metric invariance had to be rejected this indicates that items might be biased due to differential item functioning which prohibits the use of the scale to measure growth over time. For this reason, the modification indices for the metric invariance model are reported in Appendix D.

TABLE 1. Descriptives of merged DSQ item scores at four different time points (T1-T4).

Scale	Factor name	Variable	Item	T1		
				n	**mean**	**sd**
Demand	Social Role/ Contact	D6	Having little contact with other workers	105	0.21	0.49
		D7	Home	102	0.41	0.65
		D13	Having too many residents	108	0.62	0.73
		D14	Overtime	108	0.49	0.73
		D15	Not having enough useful things to do	106	0.20	0.52
		D20	Feeling isolated from colleagues	103	0.17	0.47
	Resident Interaction	D5	Demands of residents	110	1.39	0.85
		D8	Playing an important part in resident care	110	1.46	0.77
		D11	Severity of disability of residents	110	1.20	0.87
		D12	Shift system	110	1.23	0.87
		D16	Behaviour of residents	110	1.65	0.68
		D21	Lack of results	108	0.92	0.84
		D22	Boredom	105	0.10	0.39
	Domestic Issues	D9	Relatives of residents	106	0.52	0.71
		D10	Cooking	94	0.32	0.55
		D17	Cleaning	100	0.22	0.46
		D18	Laundry	96	0.11	0.38
	Work Pressure	D1	Being always under pressure	108	0.92	0.80
		D2	More work than time available	109	1.32	0.77
		D3	Boss	108	0.71	0.76
		D4	Continuing change	109	1.41	0.78
		D19	Having too few staff on shift	108	0.89	0.73
Support	Organisation and Management	S1	Boss	107	1.49	0.59
		S5	Freedom in deciding what to do	106	1.64	0.50
		S7	Morale of other staff	110	1.50	0.60
		S9	Amount of work time available	104	1.12	0.63
		S17	Keyworker role	107	0.92	0.63
		S18	Individual programme planning	109	1.71	0.48
	Social support and training	S2	Colleagues	109	1.81	0.42
		S4	Training received	104	1.74	0.46
		S6	Results of work with residents	109	1.75	0.51
		S8	Family	106	1.80	0.45
		S10	Friends	87	1.60	0.60
		S11	Knowing role in organization	109	1.63	0.57
	External support	S3	Occupational Therapist	43	1.35	0.61
		S12	Doctor	91	1.64	0.57
		S13	Psychologist	85	1.71	0.55
		S14	Speech therapist	8	1.00	0.53
		S15	Physiotherapist	12	1.25	0.62
		S16	Amount paid	93	0.76	0.70

	T2			T3			T4			
	n	**mean**	**sd**	**n**	**mean**	**sd**	**n**	**mean**	**sd**	**Cronbach's alpha***
	93	0.14	0.41	74	0.23	0.54	67	0.13	0.42	T1 = .69; T2 = .63; T3 = .69 ;T4 = .51
	87	0.38	0.67	70	0.40	0.73	65	0.54	0.77	
	93	0.51	0.70	74	0.64	0.71	68	0.53	0.72	
	94	0.43	0.65	71	0.61	0.76	66	0.41	0.70	
	93	0.18	0.49	72	0.10	0.34	67	0.13	0.39	
	92	0.21	0.43	72	0.17	0.44	65	0.12	0.41	
	95	1.45	0.77	74	1.41	0.79	68	1.47	0.82	T1 = .65; T2 = .72; T3 = .72; T4 = .74
	94	1.41	0.75	74	1.43	0.74	68	1.43	0.80	
	95	1.34	0.82	74	1.46	0.78	67	1.31	0.86	
	94	1.07	0.92	73	1.16	0.87	67	1.16	0.91	
	94	1.76	0.56	74	1.61	0.68	68	1.74	0.61	
	93	0.89	0.85	74	0.97	0.83	68	0.91	0.77	
	94	0.09	0.32	73	0.11	0.39	65	0.11	0.36	
	91	0.60	0.71	70	0.66	0.76	64	0.69	0.83	T1 = .79; T2 = .76; T3 = .81; T4 = .68
	83	0.37	0.64	68	0.44	0.66	60	0.45	0.72	
	88	0.35	0.57	70	0.40	0.67	65	0.37	0.67	
	81	0.21	0.47	67	0.28	0.55	61	0.20	0.48	
	95	0.80	0.81	74	0.89	0.85	68	1.00	0.83	T1 = .68; T2 = .76; T3 = .63; T4 = .61
	95	1.36	0.74	74	1.41	0.76	68	1.24	0.76	
	95	0.62	0.73	74	0.72	0.71	67	0.61	0.67	
	95	1.36	0.81	74	1.42	0.79	68	1.34	0.82	
	94	0.74	0.72	74	0.81	0.75	68	0.91	0.81	
	91	1.47	0.54	73	1.49	0.58	63	1.67	0.48	T1 = .34; T2 = .59; T3 = .60; T4 = .57
	92	1.68	0.57	73	1.66	0.51	68	1.74	0.48	
	95	1.64	0.52	74	1.57	0.62	68	1.54	0.58	
	93	1.31	0.68	71	1.08	0.73	65	1.20	0.64	
	93	0.87	0.68	70	1.00	0.70	66	0.94	0.52	
	94	1.67	0.47	73	1.73	0.45	67	1.76	0.46	
	94	1.87	0.34	73	1.79	0.44	67	1.85	0.36	T1 = .47; T2 = .51; T3 = .50; T4 = .61
	90	1.71	0.48	71	1.77	0.48	64	1.77	0.43	
	94	1.69	0.55	73	1.64	0.63	67	1.72	0.52	
	89	1.73	0.54	66	1.70	0.61	63	1.70	0.50	
	78	1.72	0.48	54	1.63	0.52	53	1.55	0.64	
	95	1.60	0.57	71	1.70	0.52	67	1.69	0.47	
	32	1.75	0.44	35	1.49	0.61	26	1.42	0.58	T1 = .48; T2 = .62; T3 = .62; T4 = .61
	81	1.63	0.53	63	1.52	0.59	53	1.75	0.43	
	79	1.65	0.51	60	1.57	0.53	52	1.75	0.44	
	12	1.25	0.62	14	1.36	0.63	5	1.40	0.55	
	22	1.32	0.57	16	1.56	0.51	14	1.36	0.63	
	73	0.84	0.69	61	0.69	0.65	56	0.73	0.77	

TABLE 2. Model fit indices for the Demand scale.

	Model fit test statistic	df	p	Scaled chi-square difference test statistic			CFI	TLI	RMSEA	SRMR
				difference	df difference	p				
Model 1 (configural)	4701.5	3554	<0.001	N/A	N/A	N/A	.91	.90	.05	.22
Model 2 (weak)	4910.2	3608	<0.001	208.7	54	<0.001	.90	.89	.06	.22
Model 3 (strong)	4957.8	3674	<0.001	47.57	66	.96	.90	.90	.06	.22

TABLE 3. Model fit indices for the Support scale without External Support factor.

	Model fit test statistic	df	p	Scaled chi-square difference test statistic			CFI	TLI	RMSEA	SRMR
				difference	df difference	p				
Model 1 (configural)	1005.8	980	.27	N/A	N/A	N/A	.99	.99	.02	.17
Model 2 (weak)	1175.0	1010	<0.001	169.2	30	<0.001	.95	.94	.04	.18
Model 3 (strong)	1229.1	1068	<0.001	54.1	58	.62	.95	.94	.04	.18

3.2. Support

The configural invariance model for the support scale did not converge due to missing values (>90%) on several items. Analysis of the items on the support scale indicated missing values on some of the items of the "External Support" factor. Participants mostly responded 'does not apply' (i.e. this is set to missing in a Likert scale analysis) to items concerning a speech therapist (n = 312), occupational therapist (n = 215), and physiotherapist (n = 287). To a lesser extent this also applied to the doctor (n = 59), psychologist (n = 73), and amount paid (n = 68). Therefore, the External Support factor was dropped from the configural invariance model to be able to make suggestions for further research. The fit indices for the invariance models of the two factor solution are presented in Table 3. The configural invariance model had good model fit, above the .95 threshold for both the CFI and TLI. Moreover, the RMSEA was well below the .06 threshold. The SRMR exceeded the .10 threshold. Next, the factor loadings were restricted in the metric invariance model. The null hypothesis of metric invariance for the two factor model had to be rejected in favour of configural invariance as the anova indicated a significant deviation (Chi square difference = 169.2; df difference = 30; p<.0.001).

4. CONCLUSIONS

This study is the first to assess MI of the Dutch version of the DSQ which is useful for detecting stress levels in mental health nursing staff who work with people who have MID-BIF. The results suggest that the structure of the Demands scale is comparable to the English version (Rose, 1999), based on the longitudinal CFA, and showed acceptable fit. However, the factor structure for the Support scale was not replicated in our sample, however, the two factor solution did show adequate fit. The consistency for both the total demand as well as the total support scale was good (Aron & Aron, 2003), but consistencies for separate factors varied somewhat over time, which is an indication that the correlations between items on a factor change over time. Moreover, metric invariance and scalar invariance were not established which might lead to bias in the interpretation of a change in scores over time (de Beurs et al., 2015). It suggests that changes over time cannot be interpreted as real changes over time, and should be interpreted with care (Chungkham et al., 2013). Although configural invariance could be established for the demand scale, and in part, for the support scale there are some noteworthy differences between the English and Dutch version of the DSQ, and consequently has implications for its use in forensic psychiatry. The reason for the differences may be due to organizational differences between a forensic psychiatric setting and a residential setting. One of the goals of our study was to establish if the DSQ could be used in a forensic setting, and over time. Rose (1999) evaluated the questionnaire in a residential treatment facility where the support staff was expected to clean and do the laundry in case the patients weren't able to do so. In Dutch forensic psychiatry wards, those tasks are outsourced or part of increasing the adaptive self-help skills of patients, e.g. stimulating them to do their own laundry, instead of doing the laundry for them. Moreover, one item was excluded in the Dutch version (i.e., moving from house to house) based on the applied criteria. Patients in forensic psychiatry don't live in houses as in the English sample, but are living on the ward. In addition, several items on the External Support scale were somewhat problematic as far as the application to the job is concerned. Analysis of the separate items resulted in possible reasons for differences with the English version. First, nursing staff in forensic psychiatry does not interact with an occupational therapist, physiotherapist, or speech therapist that often, especially if the ward is more closed in nature. The relevance of those items seem to be negligible in our current sample. This implies that those therapists don't appear to be relevant to the support experienced by staff members. Second, the answers to questions on the "psychologist" and "physician" was virtually the same. Both can have the role of lead therapist on the ward for particular patients in the Netherlands. Third, the questionnaire has no demand questions on the hostile and dangerous behaviour of patients which could be considered an additional, and potentially very impactful, demand in forensic psychiatry (Winstanley & Whittington, 2002). Lastly, the recommendations for performing an EFA like the one reported by Rose (1999) have changed somewhat. Rose (1999) used principal components analysis with a scree plot and varimax rotation to arrive at the factor structure. Current recommendations suggest factor techniques such as principal axis factoring with parallel analysis and some form of oblique rotation might be better suited, but there is still a fierce debate on recommendations (See for instance (Fabrigar & Wegener, 2011; Gaskin & Happell, 2014; Norris & Lecavalier, 2010; Williams et al., 2010)).

Several limitations of the current study are worth mentioning. First, metric invariance was not established which limits the utility of the questionnaire in its current form over time. Metric invariance would mean that the constructs have the same meaning to participants across administrations (Brown, 2015; Putnick & Bornstein, 2016; Vandenberg & Lance, 2000). Second, establishing scalar invariance would justify the comparison of means over time (Brown, 2015), and has to be done with care as this was not established. It also limits the utility of the questionnaire in repeated measure designs. Third, the questionnaire does not include any items on aggression. The addition of demands on dangerous or hostile behaviour might be warranted. Fourth, in our sample there was a considerable amount of missing data, especially on the support scale where some items only had 5% of values as most participants answered 'does not apply'. Wolf et al. (2013) point out that 50% larger samples are needed if models have 20% missing data per indicator. Fifth, there is a considerable amount of people who left the job or were on sick leave which prohibited them from filling out the questionnaire which resulted in missing values, and might affect the analysis. Sixth, no back translation of the questionnaire was undertaken, which could have influenced the validity of the translation. Lastly, we did not consider correlations between the DSQ and generalised job stress questionnaires like the demands-control-support model which has several overlapping constructs. An interesting venue for future research would be the validation of the (Dutch version of the) DSQ with such a questionnaire.

In sum, the factors of the demands scale seem suitable considering the fit of the configural invariance model and can be used in these forensic settings. Full scalar MI was not established, and therefore caution is needed in comparing mean factor levels over time. Some adjustments might be made on the modification indices of the demand scale that were reported in Appendix D. Future research should focus on elaboration of the support scale for stable solutions or might consider using a two factor solution for use in forensic psychiatry.


5

CHAPTER 5

Burnout symptoms in forensic psychiatric nurses and their associations with personality, emotional intelligence, and client aggression: a cross sectional study

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ABSTRACT

Introduction. Aggressive behaviour of forensic patients is associated with burnout symptoms in nursing staff. The role of staff characteristics as moderators is unclear.

Aim. We explored the association of type and severity of aggressive behaviour as experienced by nursing staff and staff's burnout symptoms. In addition, the moderating roles of personality characteristics and emotional intelligence were studied. Moreover, the usefulness of ambulatory skin conductance assessments in detecting arousal related to burnout symptoms was studied.

Method. 114 forensic nursing staff members filled out questionnaires and wore an ambulatory device.

Results. Experiencing physical aggression was positively associated with staff's burnout symptoms. Stress management skills, a subscale of emotional intelligence, but not personality, moderated this relationship. Skin conductance was not associated with burnout symptoms. Remarkably, the association between aggression and burnout symptoms was highest for staff reporting a higher number of stress management skills.

Discussion. Longitudinal research is necessary to establish causality between patient aggression and staff burnout symptoms. In addition, further research is necessary on the validity of the aggression measure used in the current study.

Implication for practice. Nursing staff who experience physical aggression frequently should receive social support for this, and staff who report high stress management skills should be monitored more carefully after having been confronted with aggression.

1. INTRODUCTION

Burnout is the last stage of a chronic occupational exhaustion process (Schaufeli, Maslach, & Marek, 2017), and is characterized by exhaustion, cynicism and inefficacy (Leiter, Bakker, & Maslach, 2014). It is described as a stress-related syndrome which can have a major impact on the personal well-being of mental health nurses and quality of psychiatric care (McTiernan & McDonald, 2015; Volpe et al., 2014). Especially psychiatric nurses have a higher risk of burnout than other nursing professions (Dennis & Leach, 2007; Gascon et al., 2013; Hanrahan, Aiken, McClaine, & Hanlon, 2010; Sahraian, Fazelzadeh, Mehdizadeh, & Toobaee, 2008). Several questionnaires on burnout have been developed, but the most often used questionnaire describes burnout on three scales: emotional exhaustion, depersonalisation and decreased levels of personal accomplishment (Maslach et al., 1996; Schaufeli et al., 2017).

Besides the often found association between job stress and burnout (Doerr & Nater, 2017; Hsu, Chen, Yu, & Lou, 2010; Schulz et al., 2009) there is an increasing body of research on the association between burnout and aggression (Leiter et al., 2014; Winstanley & Whittington, 2002). Both the type and severity of aggression have to be taken into account (Hensel, Lunsky, & Dewa, 2012). One type of aggression that is frequently studied is physical aggression, although the number of studies on other forms of aggression has increased over the past decade as well (Campana & Hammoud, 2015). Reviews have indicated that both verbal and physical aggression experienced by nurses is associated with negative psychological outcomes (Edward, Ousey, Warelow, & Lui, 2014; Edward et al., 2016). This association between aggression and negative outcomes has also been established with burnout as both physical and other forms of aggression are associated with higher levels of emotional exhaustion (Evers, Tomic, & Brouwers, 2001; Gascon et al., 2013) and depersonalisation (Leiter et al., 2014). Moreover, the severity of aggression has also been found to be associated with higher levels of emotional exhaustion (Hensel et al., 2012).

Several personality characteristics have also been associated with burnout. A meta-analysis by Swider and Zimmerman (2010) for instance, revealed that four of the big-five personality characteristics are associated with burnout (i.e. not Openness). Swider and Zimmerman (2010) found a positive association between burnout and neuroticism, and negative associations between burnout and extraversion, conscientiousness and agreeableness. It is argued that the moderating role of personality characteristics in association with burnout should be investigated (Schaufeli et al., 2017). A study in nursing staff who work with patients with intellectual disabilities (Chung & Harding, 2009) also found associations between burnout and personality characteristics such as higher neuroticism, lower extraversion and higher conscientiousness. Besides personality, a recent review reported that emotional intelligence and burnout dimensions were negatively associated (Mérida-López & Extremera, 2017). Also, studies on stress in nursing staff caring for patients with intellectual disabilities indicated that high emotional intelligence (EI) is a protective factor for burnout (Gerits, Derksen, Verbruggen, & Katzko, 2005). Indeed, research has shown a negative association between EI and burnout (Beauvais, Andreychik, & Henkel, 2017; Zysberg, Orenshtein, Gimmon, & Robinson, 2017), which was mediated by job stress. The role of personality and EI in the burnout-aggression association was investigated in the current study (Hensel, Lunsky, & Dewa, 2015).

Another recent review suggested that measures of autonomic nervous system activity like heart rate and skin conductance (SC) can be used as indicators of acute or chronic stress and fatigue in nurses (Khanade & Sasangohar, 2017). As burnout is a possible outcome of chronic job stress, this study investigates the association between the autonomic nervous system and burnout symptoms. Heart rate and heart rate variability have been linked to burnout before (see e.g., Henning et al., 2014; Jönsson et al., 2015; Lennartsson et al., 2016; Moya-Albiol et al., 2010; Teisala et al., 2014). However, to our knowledge, no research has been conducted on the association between SC and burnout.

In sum, this study examined the association between burnout symptoms in forensic nursing staff and aggressive behaviour of patients with intellectual disabilities admitted to a forensic psychiatric hospital. A review showed that aggression is associated with burnout (Hastings, 2002), but it is largely unknown what factors contribute to this mechanism (Hensel et al., 2015). In addition, this study examined if skin conductance was associated with burnout symptoms as research indicates that autonomic nervous system markers might be useful in detecting burnout (Khanade & Sasangohar, 2017).

The following three research questions were studied:

1. Patient aggression as experienced by nursing staff is positively associated with burnout symptoms reported by staff.
2. This association is moderated by personality traits and emotional intelligence.
3. Can ambulatory assessments of skin conductance be useful for detecting burnout symptoms in nursing staff?

2. METHOD

2.1. Participants and Setting

We included 114 nursing staff members (59% female) of whom 105 completed all questionnaires (92% participation rate). They worked in four Dutch forensic psychiatric hospitals for patients with intellectual disabilities and severe challenging behaviours, such as aggressive behaviour. Co morbid disorders of the patients consist of, but are not restricted to, schizophrenia, depression, autism, substance abuse, and anger-related issues. The forensic hospitals are located across the Netherlands. Patients are referred to the hospitals if treatment in general treatment facilities are ineffective. The goal of admission is rehabilitation through prolonged treatment on behavioural outcomes, social skills, substance abuse, vocational training etc.

2.2. Ethical Approval and conduct

Approval for the current study was granted by the scientific committee and committee of ethics of the Faculty of Social Sciences of the Radboud University at Nijmegen (ECSW2015-1901-282). All participants were treated in accordance with the Declaration of Helsinki for research on human participants.

2.3. Procedure

A power analysis for a multiple regression analysis with 95% power, alpha set at .05, and an effect size of .2 on 4 predictor variables revealed that we needed at least 98 participants. We managed to include 114 participants in our sample. Nursing staff members were initially invited and informed about the aim of the study through email, posters and flyers. Written informed consent was obtained for all participants after they received all necessary information on the study. To be included in the study, participants had to work on the forensic psychiatric units, and work during a day and/ or evening shift.

First, participants were asked to complete a personality and an EI questionnaire. Next, staff wore a wristband called the Empatica E4 which measured SC during a full day or evening shift (night shifts were excluded). Following SC assessment, participants were invited to complete questionnaires on burnout symptoms, job stress (generally perceived job-related stress) and patients' aggressive behaviour (as perceived during the last six months).

FIGURE 1. A photograph of the Empatica E4

2.4. Materials and Measures

Burnout symptoms were assessed with a validated Dutch version of the Maslach Burnout Inventory (Maslach et al., 1996) which consists of 20 items divided over three subscales: Emotional Exhaustion (e.g., “I feel exhausted because of my work”), Depersonalisation (e.g., “I have increasing feelings of indifference towards other people since I have this job”), and Personal Accomplishment (e.g., “I feel that I have a positive influence on the lives of other people because of my work”). Emotional exhaustion and depersonalisation are positively correlated with burnout while personal accomplishment is negatively correlated with burnout. Items are rated on a 7-point Likert-type scale ranging from 0 (never) to 6 (every day). The cut-off for clinical levels of burnout for each scale are: Depersonalisation $\geq$ 2, Personal Accomplishment $\leq$ 3.66, and Emotional Exhaustion $\geq$ 2.2 (van Doornen et al., 2009). Scores for each subscale are combined and compared to normative data from mental health nurses resulting in low, medium or high burnout (Schaufeli & Dierendonck, 2000). Cronbach’s alpha coefficients for the three subscales of the Dutch version are .64, .81, and .86 respectively (Schaufeli, Bakker, Hoogduin, Schaap, & Kladler, 2001), which is considered questionable to good.

Patient aggression was assessed with items on frequency and intensity of different types of aggressive behaviour as they were experienced by the nursing staff on the ward during the last 6 months. We constructed this scale based on the items used in the Modified Overt Aggression Scale+ (Crocker et al., 2006) and the Modified Overt Aggression Scale (Oliver, Crawford, Rao, Reece, & Tyrer, 2007). The items addressed verbal aggression, physical aggression, aggression against objects, auto aggression, and sexual aggression. For each item we asked staff how many times (frequency, ranging from never to very often) and how intense (intensity, ranging from not severe to very severe) these types of aggression were experienced at work during the past 6 months resulting in a number between 1 and 10 for each type of aggression (i.e. participants rate all items on a scale of 1-10 for both the frequency and intensity scales). In the present study, Cronbach's alpha coefficients for both frequency and intensity scales were .73 and .77, respectively, which is considered acceptable. Severity of aggression is defined as the product of frequency and intensity.

Personality was assessed with a validated Dutch version of the NEO Five Factor Inventory, a 60-item version of the Big Five Personality Inventory (Costa & McCrae, 1992). The scale measures five personality traits: neuroticism, extraversion, conscientiousness, openness and agreeableness. Each item is scored on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The Cronbach's alpha coefficients for the 5 subscales of the Dutch version ranged from .64 to .88 (Hoekstra, Ormel, & de Fruyt, 1996), which is considered questionable to good. Each subscale is standardized to stanines with a mean of 5 (1 *SD* = 2). Stanines are standardized scores ranging from 1-9 and are particularly useful for comparing scores to a normal distribution.

Emotional intelligence was assessed using a validated Dutch 133-item version of the Bar-On Emotional Quotient Inventory (Bar-On, 2006). The items were scored on a 5-point Likert scale ranging from 5 (very often true) to 1 (very seldom true). The questionnaire results in one general EQ-score and five subscale scores related to intrapersonal ability, intrapersonal skills, amount of adaptability, stress management skills and general mood. The Cronbach's alpha coefficients for the 5 subscales ranged from .69 to .86 (Zijlmans, Embregts, & Bosman, 2013), which is considered questionable to good. None of the participants in the present study were excluded based on the so-called inconsistency index above 12, which indicates unreliable answering tendencies (Zijlmans et al., 2013). Each subscale is standardized to a mean of 100 (*SD* = 15).

Job-related stress was assessed using an item of the Demands and Support Questionnaire (DSQ) developed by Rose (1999). The questionnaire was developed on the basis of the occupational model of stress (Payne, 1979) to identify possible sources of job stress for people working with patients with intellectual disabilities. As no Dutch version was available, the instrument was translated independently by 3 of the authors of this paper, after which differences in wording were discussed and solved in consensus. Cronbach's alpha coefficients for the 2 subscales were .84 and .62 respectively, which is considered questionable to good. A 5-point Likert-type scale on the perceived job stress in general was included in the analysis (i.e., "How much stress do you generally experience in your job?").

Skin conductance (SC) was obtained during shifts by means of the Empatica E4 (Garbarino, Lai, Bender, Picard, & Tognetti, 2014). This is a wristband designed to measure SC, heart rate, body temperature and movements. SC was measured in µSiemens and the data were corrected for artifacts created by movement with the use of a program called eda explorer developed by MIT (Taylor et al., 2015). The MIT research team also provided a python 2.7 peak detection script. Based on recommendations made by Boucsein (2012), the following parameters were extracted: SC response, rise time, decay time, amplitude, width, non-specific responses per minute, and SC level. All SC data was controlled for by body temperature as a possible confounder, as the humidity and temperature between days vary and influence the SC. Responses with an amplitude of 0.02 µSiemens were considered for the analyses.

2.5. Design and statistical analyses

The first research question regarding the positive association between patient aggression as experienced by nursing staff and staff's burnout symptoms was addressed using Pearson correlations and bias corrected and accelerated bootstrap confidence intervals (Field, 2013). Potential confounders were controlled for with partial correlations: staff's gender, job stress, job-related satisfaction, age in years, years employed in healthcare, years employed at this facility, and years employed on the ward. The second research question was addressed using a moderated mediation model (model 8; Hayes, 2013) with the PROCESS macro in SPSS v24, and several predictors were included in this model. The sumscore of emotional exhaustion and depersonalisation was used as a measure of burnout symptoms in the moderated mediation model. Moderated mediation is a regression based approach known as conditional process analysis. The models can be used to test both mediation and moderation effects. Personality and EI were added as moderators in the association between patient aggression and burnout while job stress was added as a mediator. The results of the analysis can be reported in a path based model (Hayes, 2013). For answering the third research question on the usefulness of SC assessments in association with burnout symptoms, Spearman rho's were calculated between the outcomes of the burnout scales and the parameters of SC.

3. RESULTS

3.1. Participants

The age of participants ranged from 21 to 59 years (mean = 35.2, *SD* = 9.7), and the mean number of years that staff members were employed on the wards was 4.2 (*SD* = 3.9). On average, there were 12 patients residing on each ward (*SD* = 3.2). On average, the participants completed the questionnaires within 2 days of wearing the device (Mean = 2.4 days; *SD* = 10; range = 0-44 days). Data were collected between June 2015 and January 2016.

3.2. Patient aggression as experienced by nursing staff and staff's burnout symptoms

Two-tailed Pearson correlations with 95% bias-corrected and accelerated (BCa) bootstrap confidence intervals were calculated between patients' aggressive behaviour and staff's burnout symptoms (see Table 1). Two results are worth noting. First, *intensity* of physical aggression is significantly correlated with emotional exhaustion and depersonalisation. Second, *frequency* of physical aggression is significantly correlated with depersonalisation. Both aggression-depersonalisation effects in Table 1 diminished after controlling for job stress. However, the correlation between the intensity of physical aggression and emotional exhaustion remained significant. In addition, the other (controlled for) variables did not alter the significant aggression-burnout association reported in Table 1. Thus, after controlling for confounding variables with partial correlations there is a positive association between physical aggression as experienced by staff and burnout symptoms (e.g. emotional exhaustion and depersonalisation). Multicollinearity was checked for and VIF was <10.

3.3. EI, personality and job stress in the conditional process analysis

One hundred and eight staff members filled out the job stress scale and items on patient aggression as experienced by nursing staff. Results indicate that job stress is positively correlated with the intensity of physical aggression (Table 2). Moreover, job stress is associated with verbal aggression, and aggression against objects for both intensity and frequency. As for burnout symptoms, job stress is significantly correlated with emotional exhaustion ($r = .52$, $p < .001$), depersonalisation ($r = .24$, $p < .05$), and personal accomplishment ($r = -.26$, $p < .01$).

TABLE 1. Unadjusted Pearson correlations between Burnout symptoms and frequency and intensity of aggression.

	Frequency of Aggression	Intensity of Aggression	Severity (combined)
Emotional exhaustion			
Physical Aggression	.07 [-.13,-.26]	.35** [.15,.53]	.24* [.03,.44]
Verbal aggression	-.02 [-.29,-.25]	.16 [-.05,.35]	.09 [-.15,.32]
Aggression against objects	.02 [-.20,.21]	.17 [.00,.34]	.11 [-.09,.30]
Auto aggression	.11 [-.10,.32]	.14 [-.06,.34]	.14 [-.05,.34]
Sexual aggression	.17 [-.01,.35]	.16 [-.03,.36]	.18[-.03,.37]
Depersonalisation			
Physical Aggression	.21* [.01,.40]	.24* [.03,.42]	.25** [.05,.43]
Verbal aggression	.05 [-.15,.25]	-.06 [-.24,.13]	-.01 [-.19,.18]
Aggression against objects	.07 [-.12,.26]	.05 [-.15,.25]	.07[-.14,.27]
Auto aggression	.08 [-.11,.29]	.09 [-.10,.29]	.09[-.11,.30]
Sexual aggression	.10 [-.10,.29]	.15 [-.05,.34]	.14[-.04,.33]
Personal accomplishment			
Physical Aggression	-.09 [-.25,.09]	-.14 [-.30,.06]	-.13[-.29,.03]
Verbal aggression	.08 [-.07,.23]	.03 [-.17,.23]	.05[-.13,.24]
Aggression against objects	-.01 [-.20,.18]	-.07 [-.28,.17]	-.05[-.24,.15]
Auto aggression	.00 [-.18,.17]	-.02 [-.20,.16]	-.01[-.19,.18]
Sexual aggression	-.13 [-.31,.06]	-.06 [-.26,.15]	-.10[-.30,.09]

N=106 * p<.05 ** p<.01
Pearson correlations with 95% BCa bootstrap CI's reported in brackets

TABLE 2. Pearson correlations between JOB STRESS and 6-month frequency, intensity, and combination of aggression.

	Frequency	Intensity	Severity (combined)
Physical Aggression	.17 [-.04,.37]	.37** [.19,.52]	.31** [.12,.49]
Verbal aggression	.25**[.06,.43]	.23* [.06,.39]	.27** [.08,.43]
Aggression against objects	.27** [.09,.44]	.20* [.02,.37]	.26** [.07,.43]
Auto aggression	.14 [-.07,.34]	.16 [-.05,.36]	.16 [-.05,.36]
Sexual aggression	.15 [-.07,.35]	.15 [-.07,.34]	.16 [-.06,.35]

N=108 * p<.05 ** p<.01
Pearson correlations with 95% BCa bootstrap CI's reported in brackets

In all models, the burnout symptoms were calculated as the sum score of emotional exhaustion and depersonalisation as these were significantly correlated with patient aggression. The moderated mediation model we tested was model 76 (Hayes, 2013) (see Figure 2), which represents the hypothesized model. The separate scales for personality and EI were entered one by one. Remarkably, the models did not show significant interaction effects for the personality factors (not reported here), except for extraversion on the physical aggression–job stress association. In addition to extraversion, of the five EI-subscales and total EI, only stress management skills was a moderator in the hypothesized model. Neither the other personality factors nor total EI resulted in significant interactions.

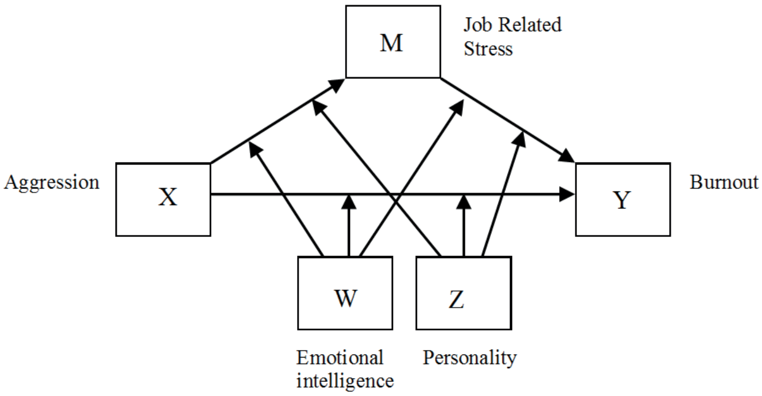

FIGURE 2. A conceptual model (76) of the assumed hypothesis.

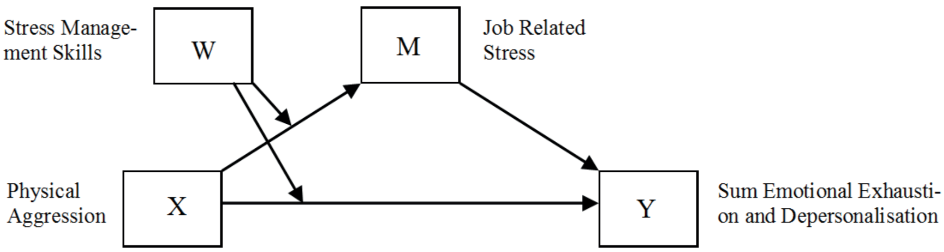

FIGURE 3. A conceptual model (8) of the refined hypothesis.

Next, extraversion and stress management skills were added to the model as moderators. However, of these two moderators, extraversion was non-significant, and was therefore left out of the analysis. Lastly, model 8 (Hayes, 2013) with stress management as a moderator was fitted (see Figure 3). As is standard practice (Hayes, 2013), in the final model all variables were mean centered and unstandardized coefficients were used. We drew 10.000 bias corrected bootstrapped samples. The statistical model resulting from these procedures is presented in figure 4.

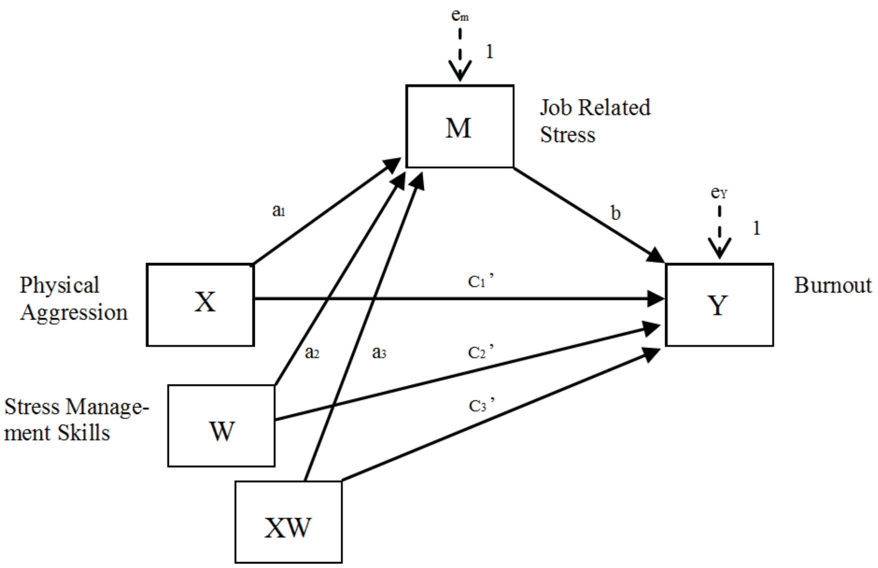

FIGURE 4. Statistical Model of the conditional process (model 8).

As can be seen in Figure 4 and Table 3, the effect of physical aggression (X) on job stress (M) is dependent on the interaction between physical aggression (X) and stress management skills (W). This interaction is negative and non-significant (a3). The effect of physical aggression (X) on job-related stress (M) is dependent on the amount of stress management skills (W) reported by nursing staff. Staff who reported to have better stress management skills (W) report lower levels of job stress (M). Job stress (M) positively mediates (b, $p < .001$) the relationship between physical aggression (X) and burnout (Y). This indicates that higher levels of job stress (M) are associated with higher levels of burnout symptoms (Y).

TABLE 3. Model Coefficients for the conditional process model (model 8).

Antecedent	Consequent							
	M (Job Related Stress)				Y (Burnout)			
		Coeff.	SE	p		Coeff.	SE	p
X (Physical Aggression)	*a1*	.053	.016	.002	*c'1*	.041	.03	.145
M (Job Related Stress)					*b*	.711	.163	<.001
W (Stress Management Skills)	*a2*	-.005	.002	.047	*c'2*	-.011	.004	.005
X*W	*a3*	-.001	.001	.055	*c'3*	.003	.001	.003
Constant	*i1*	2.917	.067	<.001	*i2*	.637	.487	.194
		R2=.174 F(3,101)=7,1,p<.001				R2=.328 F(4,100)=12,2,p<.001		

The *direct* effect between physical aggression and burnout symptoms can also be derived from Table 3 (c'3, p = .003). The effect of physical aggression (X) on burnout symptoms (Y) is dependent on stress management skills (W) but independent of job stress (M).

The *indirect* (mediation) effect of physical aggression on burnout symptoms through job stress depends on stress management skills. Table 4 shows the estimation of the conditional indirect effect at three values of W. Note that the indirect effect of job stress is positive, with higher levels of job stress being associated with higher levels of burnout on all three values of stress management skills (W). This *indirect* effect increases when people report lower levels of stress management skills (the line depicted with squares in Figure 5). The *direct* effect of physical aggression on burnout symptoms shows an opposite pattern (the line depicted with triangles in Figure 5). In case a staff member reports to have high stress management skills, the effect of physical aggression, if experienced, has a *stronger* influence on burnout symptoms than if the staff member reports to have a lower amount of stress management skills.

3.4. Correlation between Job Related Stress and Skin Conductance

SC was not normally distributed, therefore Spearman rank correlations were used to test the association between burnout symptoms and SC. There were no significant effects between any of the SC parameters (see methods section) and burnout symptoms subscales. After controlling for temperature the results remained non-significant.

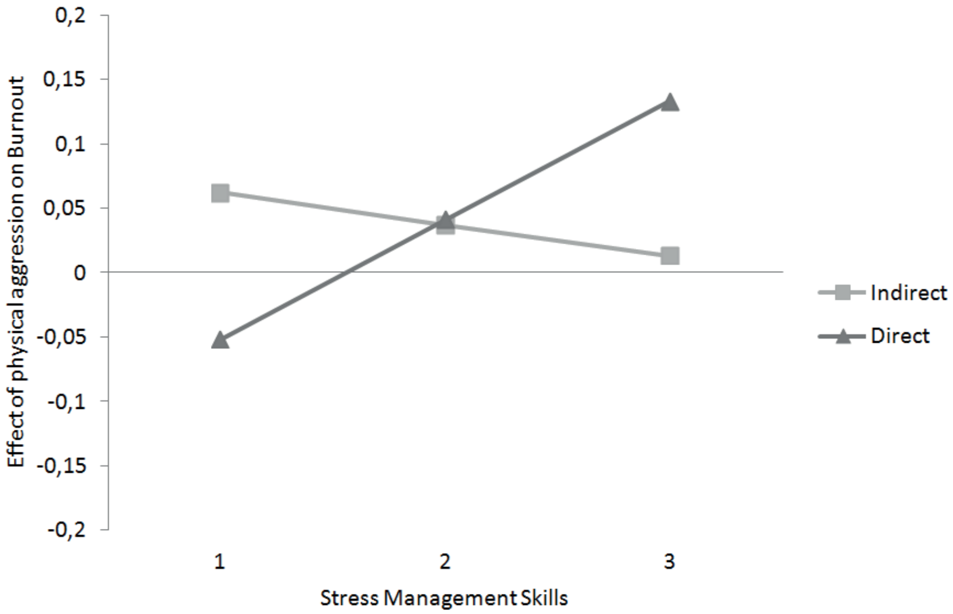

FIGURE 5. A visual representation of the conditional indirect and direct effects of accumulating physical aggression on burnout as a function of stress management skills.

TABLE 4. Model Coefficients for the Conditional Process Model on the Mean and +/- 1 SD level of the moderator Stress Management Skills (W).

	Indirect Effect		**Direct effect**		
W	**ω=(a1+a3W)b**	**95% Bias Corrected Bootstrap CI**	**θx→y = c'1+c'3W**	**SE θx→y**	**p**
-28.148	.06	[.03,.11]	-.05	.04	.23
0	.04	[.02,.07]	.04	.03	.15
28.148	.01	[-.02,.05]	.13	.04	<.001

4. DISCUSSION

The present study investigated the association between patients' aggression as experienced by nursing staff and burnout symptoms in nursing staff caring for patients with intellectual disabilities in forensic psychiatric hospitals. More specific, associations between patient aggression, burnout symptoms and personality, EI, and skin conductance were studied. There are three main findings. First, physical aggression as experienced by nursing staff is the only type of aggressive behaviour that was related to burnout symptoms reported by nursing staff. Second, job stress mediates the relationship between patients' aggressive behaviour and staff's burnout symptoms (i.e. emotional exhaustion and depersonalisation) and only stress management skills acted as a moderator. Third, there was no association between burnout symptoms and SC in nursing staff.

The first research question on the positive association between aggressive behaviour as experienced by nursing staff and burnout symptoms was established only for physical aggression with emotional exhaustion and depersonalisation. Although the correlations are modest, this result suggests that being confronted with physical aggression during work increases the risk of developing burnout symptoms. The expected association between physical aggression and exhaustion was confirmed. However, we expected associations between burnout symptoms with verbal aggression as well (Gascon et al., 2013; Hensel et al., 2012; Evers et al., 2001). The correlations between patient aggression and intensity of aggression were higher than the correlations between patient aggression and frequency of aggression, as was expected (Hensel et al., 2015). A possible reason for the low associations between burnout symptoms and the other types of aggression is that the current sample did not experience some of the other types of patient aggression that often. For instance, sexual aggression has a median frequency and intensity of 3, as opposed to physical aggression with a median of 6 and 7, respectively, which implies that sexual aggression occurs relatively seldom. Another reason might be that physical aggression in particular is a threat to the physical and emotional safety of staff members who experience this behaviour. This does imply that nursing staff who experience physical aggression should be monitored carefully and receive proper social support if necessary, especially if they experienced physical aggression. This could lower the risk of developing burnout as social support is considered a protective factor for burnout (Leiter et al., 2014; Schaufeli et al., 2017).

The second hypothesis, whereby EI and personality would moderate the association between aggressive behaviour and burnout symptoms (i.e. emotional exhaustion and depersonalisation), was only partially confirmed. As expected, the association between patient aggression as experienced by nursing staff and their burnout symptoms was mediated by job stress. Surprisingly, no support was found for the hypothesized moderating effect of personality (Schaufeli et al., 2017; Swider & Zimmerman, 2010). Moreover, in contrast with Chung and Hardy (2009), who reported on an association between burnout and neuroticism, extraversion and conscientiousness, we only found a moderating effect of extraversion on the direct effect between aggression and burnout symptoms. However, this effect was partially accounted for by the amount of stress management skills.

As we expected to replicate the personality-burnout association (Swider & Zimmerman, 2010), two reasons can be given for this deviating finding. First, none of the participants in the current sample were classified with clinical levels of burnout (i.e. exceeding cut-off values on the three subscales of burnout) as used by van Doornen et al. (2009). Forensic nurses with clinical levels of burnout might already be absent or unwilling to participate in this study. Second, the items of challenging behaviour, which were used in an earlier study by Chung and Harding (2009), differ from the items of aggressive behaviour in the current study.

Contrary to our expectations (see e.g., Gerits et al., 2005; Mérida-López & Extremera, 2017), only stress management skills was a significant moderator in the association between aggressive behaviour, job stress, and burnout symptoms. Again, the fact that none of the nurses could be classified with clinical burnout might be a reason for this negative finding. The correlations between aggression and job stress do indicate a significant association with both physical and verbal aggression in contrast to the correlation between verbal aggression and burnout. As expected, the indirect effect indicates that the effect of physical aggression on job stress is highest for people with lower levels of (-1 *SD*) stress management skills. Surprisingly, the direct effect of physical aggression on burnout symptoms is stronger for people with higher levels (+1 *SD*) of self-reported stress management skills. Care must be taken when interpreting these results. First, no causality claim can be made and future research should employ a longitudinal design to replicate this finding. Second, as Maxwell, Cole and Mitchell (2011) point out, potential mediators in cross-sectional research might be lost in longitudinal models. However, it is interesting to note that the impact of physical aggression might be more substantial in cases where people believe their own stress management skills are higher.

Finally, the third research question on the usefulness of SC to detect burnout symptoms (Khanade & Sasangohar, 2017) was not confirmed. This is not in line with the hypothesized association, nor in line with previous findings that (the amount of) non-specific SC responses are a valid indicator of emotional strain (Boucsein & Backs, 2000) or chronic stress or fatigue (Khanade & Sasangohar, 2017) as reflected in burnout symptoms. In the current study, however, SC was assessed during only one shift, which may not be long enough to establish a possible relationship between burnout and skin conductance. Moreover, although the time between assessment of burnout and

SC was 2 days on average, there was variation in the length of the time frame, which could have led to the non-findings. Thus, SC measures might not yet be suited to detect burnout, but further research on this topic is warranted. The questions on the burnout questionnaire describe a larger time frame, and do not represent specific stressful tasks or situations. As the parameters of SC vary considerably between people (Boucsein, 2012), it would be interesting to monitor nursing staff over longer periods of time.

This study has several strengths and limitations. A particular strength is that we managed to monitor SC of nursing staff during a regular working day using ambulatory devices. Although ambulatory monitoring is a promising avenue for future research as naturally occurring stressors might be assessed, it is challenging to distinguish between different emotional states such as anger, happiness, and sadness based on ambulatory psychophysiological recordings (Boucsein, 2012). In addition, another strength is the multi-centre design of the study.

4.1. Limitations

The current study also has several limitations. First, no causality can be claimed considering the cross-sectional, correlational design of the study. Arguably, higher levels of burnout symptoms lead to higher levels of physical aggression as experienced by nursing staff or vice versa. To answer this question, longitudinal data are needed. This point was also made by Winstanley and Whittington (2002). The authors concluded that aggressive encounters were associated with an increase in burnout, most notably on the emotional exhaustion and depersonalisation scales. However, an alternative explanation might be that elevated burnout symptoms might lead to susceptibility of victimisation. Second, the scales from the questionnaires on personality, emotional intelligence, burnout and job related stress have questionable reliability (between .6 and .7) which is reason for concern. However, Aron and Aron (2003) point out that a good questionnaire should have an internal consistency of at least .6 as is the case in this study. Third, the aggression questionnaire might be biased. The amount of time that nurses work on a weekly basis might influence the severity of aggression that is experienced by the nurses, although most nurses work more than 24 hours per week. On the other hand, the fact that staff members who don't work full time may on average experience less patient aggression may not be a problem, as one of the things we want to study is what the impact of the amount of aggression experienced is on burnout symptoms. The differences in the amount of aggression experienced may be associated with various variables, such as the type of patients that are on the ward and also the amount of time spent working on the ward, but it is the absolute difference in aggression experiences between staff members (as expressed in the number and the severity of the aggression experiences) that we are interested in. However, the problem remains that one severe incident (i.e. frequency = 1, intensity = 10, severity = 10) may not have the same impact as 10 incidents with low intensity (i.e. frequency = 10, intensity = 1, severity = 10). Further research is necessary to establish the validity of the aggression questionnaire and the way the overall burden of reported aggression can be calculated. Fourth, the generalizability of the results of the current study are limited as the study was conducted in wards which cared for people with intellectual disabilities and severe challenging behaviours. These are specialist services not representative of other forensic psychiatric units. In addition, the convenience based recruitment strategy might have an effect on the representativeness of the sample. It is conceivable that nurses with heightened levels of burnout symptoms or who experienced much aggression were inclined to participate in the study resulting in a sample bias. As for SC, in future studies we need to monitor nursing staff for a longer period of time as SC does seem to vary quite substantially on a day to day basis. A final limitation is that the ambulatory devices are artifact prone. For instance, when the wristband is not worn tightly enough, contact with the skin can be lost occasionally. A last point of concern is the fact that the wrist may not be the most suitable location for detecting emotion-related data like stress. It was suggested to be more closely related to thermoregulatory indices of the body (Payne, Schell, & Dawson, 2016). Considering the high burnout, sick leaves and attrition rates among psychiatric nursing professionals, we feel that more research on the direct impact of working with aggression-prone forensic psychiatric patients of stress is warranted. As for the physiological measures, the expectations on the use of ambulatory technologies in healthcare are high, and these expectations are warranted according to recent research (Khanade & Sasangohar, 2017). However, we did not find an association between burnout symptoms and SC.

4.2. Implications for Mental Health Nursing

Physical aggression as experienced by nursing staff increases the risk of developing burnout symptoms. This implies that nursing staff who are confronted with physical aggression should be monitored carefully and receive social support which could lower the risk of developing burnout. The effect of patient physical aggression on burnout symptoms is stronger for staff members who report higher levels of stress management skills. The implication is, contrary to intuition, that nursing staff with better stress management skills may be more prone to developing burnout symptoms, if they experience physical aggression.


6

CHAPTER 6

Burnout symptoms in forensic mental health nurses: Results from a longitudinal study

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ABSTRACT

Burnout in nursing staff is a major cause for turnover and absenteeism. Identifying risk and protective factors may be helpful in decreasing burnout symptoms. Moreover, research indicates that ambulatory assessments of the autonomic nervous system might be helpful in detecting chronic stress and burnout symptoms. One hundred and ten forensic nursing staff members completed questionnaires measuring experiences with aggressive behaviour, emotional intelligence, personality, and job stress during four waves of data collection across a 2-year period. Multilevel analyses were used to test the predicted associations and moderation effects with (the development of) burnout symptoms. Burnout was predicted by a combination of emotional intelligence, job stress, aggression, personality factors and skin conductance, but no moderation effects over time were found. Over a period of 2 years, the model approximately predicts a change in 1 burnout category on the Maslach Burnout Inventory**.** The amount of burnout symptoms in nurses might be used as an indicator to predict turnover and absenteeism considering the increase in symptoms over time**.** Nursing staff who experience severe aggression, who have relatively low levels of emotional intelligence and altruism, and high levels of neuroticism and job stress, should be monitored and supported to decrease the risk of burnout. Staff members can be trained to increase their emotional intelligence and relieve stress to decrease their burnout symptoms and turnover and absenteeism on the long term. Ambulatory assessment might be helpful as a nonintrusive way to detect increasing levels of burnout.

1. INTRODUCTION

Several definitions of and causes for burnout have been proposed in recent years. Burnout is often referred to as a psychological syndrome in response to chronic job stressors (Johnson et al., 2018; Leiter et al., 2014; Maslach et al., 2001; Schaufeli et al., 2017). The emotionally demanding interpersonal relationship of professional caregivers with their patients has been identified as a potential cause for burnout (Schaufeli et al., 2017). Also, in the earlier stages of research on burnout, it was noted that burnout is a response to overload, including fairly stable burnout scores over time which indicated a potential influence of chronic job stressors (Maslach et al., 2001). Indeed, recent literature reviews identified three potential causes of burnout that interact with each other: chronic stress, career setbacks and unbearable strain (Neckel, Schaffner, & Wagner, 2017). The most often used questionnaire to measure burnout is the Maslach Burnout Inventory (Grossi, Perski, Osika, & Savic, 2015; Maslach et al., 2001) in which burnout is constructed of three subscales: emotional exhaustion, depersonalization, and lowered personal accomplishment (Day & Leiter, 2014).

One apparent risk factor for burnout in mental health nursing appears to be patient aggression as experienced by nursing staff (Nijman et al., 2005; Winstanley & Whittington, 2002). Evers et al. (2002) found a significant association between interpersonal aggression and burnout. It appears that several types of aggression are associated with burnout symptoms. Indeed, reviews have indicated that both verbal and physical aggression experienced by nurses leads to negative psychological outcomes (Edward et al., 2014, 2016). In general, being confronted with higher levels of aggression during work is associated with higher levels of burnout symptoms, whereby especially physical aggression seems to be relevant (Edward et al., 2014). Winstanley and Whittington (2002), for instance, reported that more frequently victimized nurses have higher levels of emotional exhaustion and depersonalization compared to less frequently victimized nurses. This association between burnout and physical aggression was replicated for emotional exhaustion (Hensel et al., 2015).

Three protective factors seem important in the development of burnout: emotional intelligence (EI), personality and social support. First, the moderating role of EI on burnout has gained attention (Afsar, Cheema, & Masood, 2017; Shead, Scott, & Rose, 2016; Zijlmans, Embregts, Gerits, Bosman, & Derksen, 2011). EI seems to have a major protective influence on burnout (Antoniou & Koronaiou, 2018; Beauvais et al., 2017; Görgens-Ekermans & Brand, 2012; Zysberg et al., 2017). A study in South African nurses found that higher EI is significantly associated with lower levels of job stress and burnout symptoms, and that EI moderated the stress-burnout association (Görgens-Ekermans &

Brand, 2012). However, Shead et al. (2016) investigated the moderating role of EI in the association between violence and burnout in a cross-sectional study, and found that EI did not moderate the association. It seems warranted to investigate if EI is a moderator over time in the development of burnout symptoms.

Second, personality has been an area of interest since the early stages of burnout research. Maslach et al. (2001) already pointed out that individuals with higher neuroticism scores were more vulnerable to burnout. A meta-analysis by Swider and Zimmerman (2010) confirmed this association and several personality characteristics seem to predict burnout. Evidence was presented for a positive association between burnout and neuroticism, and for negative associations between burnout and agreeableness, conscientiousness and extraversion. Although these associations have been established it is unclear if there are moderating effects from personality over time (Schaufeli et al., 2017).

Third, a lack of social support, especially from supervisors, seems to increase the risk of burnout (Maslach et al., 2001). Social support has also been suggested as a moderator (Day & Leiter, 2014; Devereux et al., 2009; Maslach et al., 2001). In a study by Devereux et al. (2009), social support moderated the effect of work demands on personal accomplishment. In the current study, we investigated whether social support also moderates between demands and burnout symptoms.

Day and Leiter (2014) pointed out that numerous suggested associations and interactions with burnout symptoms can only be tested using a longitudinal design. However, much of the available research is cross-sectional in nature. For this reason, several authors (see Day & Leiter, 2014; Gelsema et al., 2006; Hensel et al., 2015) call for longitudinal studies that investigate the mediators and moderators that are associated with burnout symptoms which might aid the development of theory or interventions targeted at burnout symptoms.

Lastly, the use of physiological indicators of burnout and chronic job stress is gaining attention (Grossi et al., 2015; Jarczok et al., 2013). Chronic and acute stress can have detrimental effects on the body (Kamath et al., 2016), and autonomic nervous system activity markers like heart rate and skin conductance (SC) have been suggested as indicators of acute or chronic stress and fatigue (Khanade & Sasangohar, 2017). Traditionally, burnout is measured with questionnaires which are a time-intensive method to establish the level of burnout symptoms. The use of nonintrusive, ambulatory physiological measures might aid in the detection of rising levels of burnout symptoms. In addition, these recordings might be regarded as more objective measures without the option to answer in a socially desirable manner as is the case with questionnaires. Previous studies have linked burnout with heart rate and heart rate variability (Henning et al., 2014; Jönsson et al., 2015; Lennartsson et al., 2016; Moya-Albiol et al., 2010), but no associations with SC have been studied (Boucsein, 2012). This study aims to investigate the association between heart rate, skin conductance and burnout in which the following research questions were investigated:

- Are individual changes in burnout symptoms associated with job stress, EI, personality, and patient aggression over time? And, if so, do these variables moderate this association over time?
- Are individual changes in burnout symptoms associated with SC and heart rate over time?

2. METHOD

2.1. Participants and Setting

Participants were mental health nursing staff members of forensic psychiatric hospitals for patients with intellectual disabilities and severe challenging behaviour. Participants were included in four waves of data collection over a 2-year time period (June 2015 - July 2017). We included 110 participants (59% female) between the ages of 21 to 59 years (mean = 35.5, *SD* = 10.0). On average there were 12 patients residing on each ward (SD = 3.5) and staff members worked with 5 colleagues per shift (SD = 1.6). The mean number of years that staff members were employed on the wards was 4.4 (SD = 3.9). The characteristics of the main study variables can be found in Table 1 where two-tailed Pearson correlations with 95% bias-corrected and accelerated bootstrap confidence intervals are presented. In the first wave, 110 participants participated in the study, 95 participated in the second, 74 in the third, and 68 in the fourth wave. As for the burnout measures, in total 337 burnout questionnaires were obtained during the four waves. It was tested whether dropout from the study was dependent on the time employed in healthcare and nursing. There was no difference in dropout rates for time employed on the unit, time employed with this employer, or time employed in healthcare. The difference in the sum of burnout symptoms for the dropouts is .46 (Figure 1), but this is non-significant (dropout = 9.27 vs. 8.81, $p = .14$). Some noteworthy correlations in Table 1 are those between burnout symptoms and EI ($r = -.49$), neuroticism ($r = .42$), and job stress ($r = .37$). On the basis of the scores of the burn out questionnaire, 12 participants would qualify for a clinical burnout, and 28% reported a larger number of demands than support.

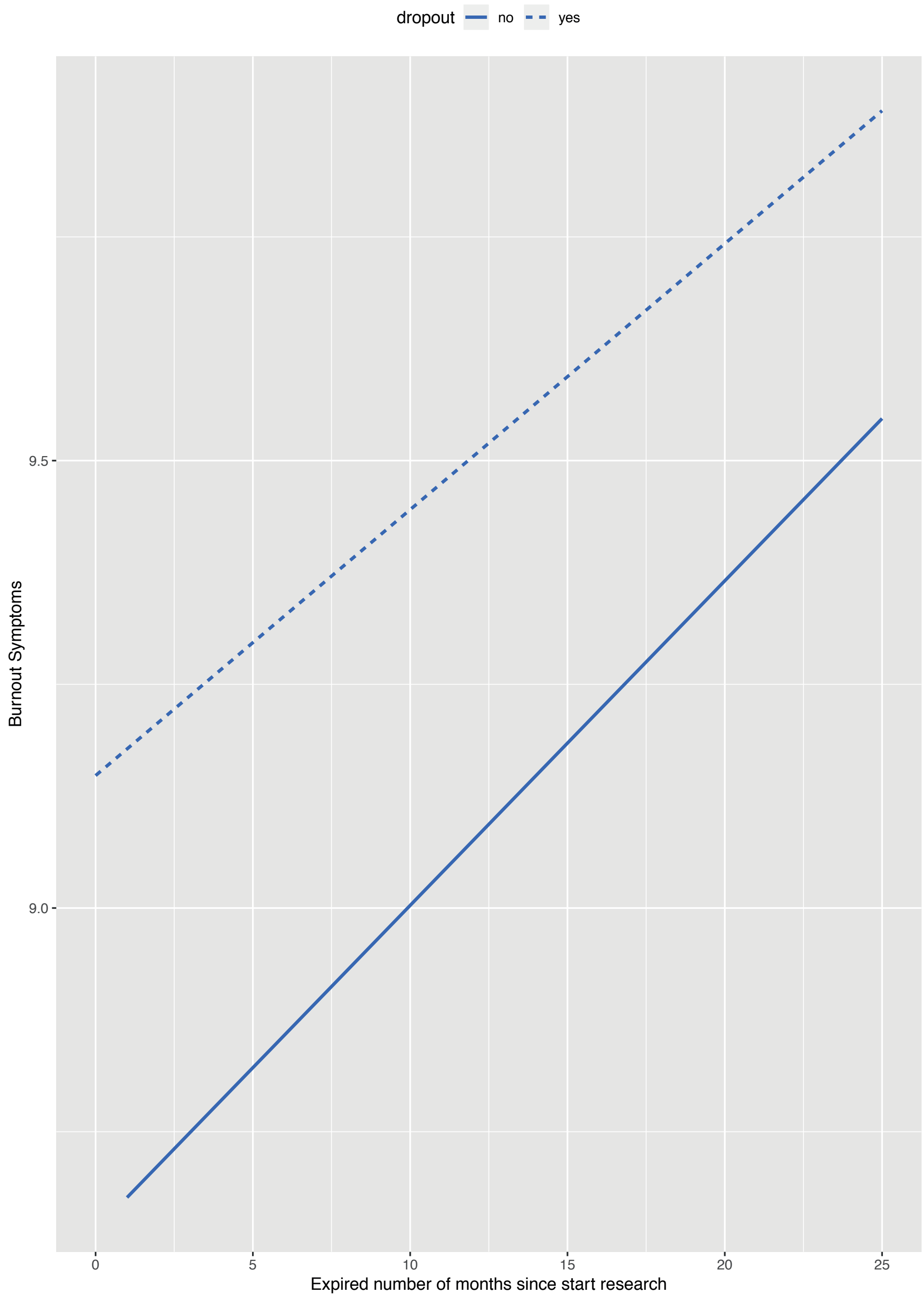

FIGURE 1. Regression slopes on the sum of burnout symptoms for dropouts vs non-dropouts.

2.2. Procedure

The scientific committee and committee of ethics of the Faculty of Social Sciences of the Radboud University at Nijmegen (ECSW2015-1901-282) approved the study. The minimum number of participants necessary for this study was 98. The parameters of the power analysis were set to 95% power, and an effect size of .2 (α = .05) on 4 predictor variables in a repeated measures design with within- and between-subject interaction.

Nursing staff members were initially invited and informed about the aim of the study through email, posters and flyers. First, participants were asked to complete a personality and an EI questionnaire after they gave informed consent. Next, staff wore a wristband called the Empatica E4 which measured SC and heart rate during a full day or evening shift (night shifts were excluded). Following ambulatory assessment, participants were invited to complete questionnaires on burnout symptoms, job stress and frequency and intensity of patient aggression as experienced over the past six months.

2.3. Materials and Measures

The validated Dutch Maslach Burnout Inventory (Maslach et al., 1996) was used to assess burnout symptoms. This 20-item questionnaire has three subscales: Emotional Exhaustion (e.g., "I feel tired when I get up in the morning"), Depersonalisation (e.g., "I can easily empathize with the feelings of patients/clients"), and Personal Accomplishment (e.g., "I have accomplished a lot of valuable things in this job"). The items are rated on a 7-point Likert-type scale ranging from 0 (never) to 6 (every day). Clinical levels of burnout are established based on cut-off values: Emotional Exhaustion $\geq$ 2.2, Depersonalisation $\geq$ 2, and Personal Accomplishment $\leq$ 3.66. The subscales get a value label of very low, low, medium, high or very high based on normative data for mental health nurses (Schaufeli & Dierendonck, 2000). To calculate burnout symptoms, the value label scores on Emotional Exhaustion, Depersonalization and reversely scored Personal accomplishment were summed to indicate the number of burnout symptoms (i.e., a range of 3-15, all 'very low' or all 'very high'). Cronbach's alpha coefficients for the three subscales of the Dutch version are .86, .64 and .81, respectively (Schaufeli et al., 2001).

The Dutch Bar-On Emotional Quotient Inventory (Bar-On, 2006) was used to assess Emotional Intelligence (EI). The Inventory consists of 133 items that are scored on a 5-point Likert scale ranging from 5 (very often true) to 1 (very seldom true). The Inventory results in one general Emotional Quotient-score with a mean of 100 (*SD* = 15) and five subscales: stress management skills, interpersonal skills, amount of adaptability, intrapersonal ability and general mood. The Cronbach's alpha coefficients for the 5 subscales ranged from .69 to .86 (Zijlmans et al., 2013).

TABLE 1. Correlations. intra-class-correlations. and descriptive statistics of study variable.

	Mean	SD	N	ICC	Gender[a]	1[b]	2[c]	3[d]	4[d]	5[d]	6[d]	7[d]	8	9	10[f]	11[f]	12[f]	13[f]	14[f]	15[f]	16[f]	17	18
1. Burnout	9.24	1.67	337	.67	0.05																		
2. Aggression	38.46	17.18	347	.55	-0.04	.17**																	
3. Neuroticism	3.64	1.94	436		.14*	.42**	0.02																
4. Extraversion	6.69	1.70	436		-0.08	-.26**	-0.11	-.34**															
5. Openness	5.54	2.12	436		0.02	0.02	0.04	.14*	-0.01														
6. Altruism	6.23	1.70	436		-0.01	-.34**	-0.02	-.33**	-0.06	-0.09													
7. Conscientiousness	5.83	1.90	436		0.05	-.19**	-0.11	-0.10	.18**	-0.02	.17**												
8. EI	106.22	11.26	432		-0.05	-.49**	-0.03	-.43**	.41**	0.04	.20**	.44**											
9. Job Stress	0.90	0.26	347	.48	.18**	.37**	.17**	.14*	-.21**	.14*	-0.06	-.12*	-.21**										
10. SCR	1.22	0.76	341	.39	-.12*	-0.05	0.00	0.08	-0.06	0.01	0.02	-0.04	-.12*	-0.04									
11. SCL	1.16	1.79	341	.50	-.28**	-0.04	0.05	-0.08	0.05	0.04	.13*	-0.03	-0.02	-0.07	.55**								
12. RIS	1.88	0.15	341	.35	0.02	0.01	.15*	.13*	0.01	0.02	-0.08	-.12*	-0.08	-0.02	.21**	-0.01							
13. AMP	0.08	0.09	341	.48	-.27**	-0.10	0.06	-0.04	0.02	0.03	0.09	-0.09	-0.05	-0.08	.63**	.82**	0.06						
14. DEC	0.87	0.13	341	.15	-0.04	0.02	0.08	0.08	-0.10	0.00	-0.07	-0.08	-0.11	0.04	.36**	0.09	.49**	.24**					
15. WID	2.23	0.18	341	.21	-0.03	0.00	.12*	0.11	-0.07	0.02	-0.07	-.12*	-.13*	0.00	.43**	0.10	.79**	.25**	.90**				
16. AUC	0.21	0.23	341	.51	-.27**	-0.10	0.05	-0.02	0.00	0.03	0.07	-0.09	-0.06	-0.08	.66**	.77**	0.09	.99**	.30**	.31**			
17. Temperature	35.97	3.39	336	.02	-0.04	-0.09	-0.09	-0.02	-0.03	-0.04	-0.05	-0.05	0.01	-0.09	.12*	0.12	-.13*	.16**	0.10	0.02	.16**		
18. Movement	65.22	0.67	341	.20	0.06	0.00	-0.05	0.00	0.04	-0.08	0.07	-0.05	-.13*	0.05	.14*	.19**	-0.03	.21**	0.01	0.00	.20**	.23**	
19. HR	84.12	5.76	319	.61	.27**	-0.06	.13*	0.05	0.03	-0.01	.12*	-0.01	0.00	0.06	.17**	0.10	.19**	.12*	-0.01	0.11	0.11	-0.07	.28**

*. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed); Unless otherwise noted, bootstrap results are based on 1000 bootstrap samples; [a]Gender in numeric variable 0=male; [b]Sum of EE, DP and Reverse scored Personal accomplishment; [c]Mean of the sum of productscores; [d]Personality scores are stanine scores; [e]Demands divided by support above 1 is more demands than support; [f]The Psychophysiological N is based on >2 hours of artifact free data; N=287 for the correlations; EI= Emotional Intelligence; SCR= Skin Conductance Response; SCL= Skin Conductance Level; RIS= Rise time of an SCR; AMP= Amplitude of an SCR; DEC= Decay Time of an SCR; WID= Width of an SCR; AUC= Area Under the Curve of an SCR; HR= Heart Rate.

The NEO Five Factor Inventory (NEO-FFI) was used to assess personality. This 60-item validated Dutch version of the Big Five Personality Inventory (Costa & McCrae, 1992) measures five personality traits: Openness, Conscientiousness, Extraversion, Agreeableness, and Neuroticism. The items are scored on a 5-point Likert-type scale ranging from 1 (strongly disagree) to 5 (strongly agree). Each subscale is standardized to stanines with a mean of 5 (1 *SD* = 2). The Cronbach's alpha coefficients for the 5 subscales of the Dutch version ranged from .64 to .88 (Hoekstra et al., 1996).

The Demands and Support questionnaire was used to measure job stress (Rose, 1999). The questionnaire was specifically designed to identify sources of job stress for people who work with patients with intellectual disabilities. The questions were rated on a 5-point Likert-type scale reflecting low (1) demands (and support) and high (5) levels of demand (and support). The demand questions and support questions were summed and divided by the total number of questions for each scale. The average demand was divided by the average support to obtain a fraction that reflected job stress. Scores above 1 indicate that a person experienced more demands than support. A score below 1 indicates that a participant experienced more support than demand. The score above 1 was used as an index of job stress. The demands over support was used as an index of job stress. Cronbach's alpha's for the scales used in this study were .84 and .62, respectively.

Severity of patients' aggression as experienced by mental health staff was assessed with items on intensity and frequency of aggression. The nursing staff were asked how many times (frequency, ranging from never to very often) and how intense (intensity, ranging from not fierce to very fierce) aggression was experienced at work during the past 6 months resulting in a number between 1 and 10 for 5 types of aggression (see below). The severity of each type of aggression was calculated as the product of frequency and intensity. Severity was then summed into one total aggression score. The items are part of the Modified Overt Aggression Scale+ (Crocker et al., 2006) and the Modified Overt Aggression Scale (Oliver et al., 2007). The items addressed verbal aggression, physical aggression, aggression against objects, auto-aggression, and sexual aggression. In the present study, Cronbach's alpha coefficients for both frequency and intensity scales were .75 and .72, respectively.

2.4. Physiological assessments

The Empatica E4 wristband was used to obtain the physiological data (Garbarino et al., 2014). For all 4 waves of data collection, the participants were instructed to wear the E4 on their non-dominant hand for one eight-hour shift. The E4 measures skin conductance (in µSiemens), temperature (in degrees Celsius), movement (the magnitude of acceleration), and heart rate (in beats per minute, which is based on the blood volume pulse). Boucsein (2012) describes several parameters to extract from the skin conductance signal. The average of the following parameters was extracted: Skin conductance level (SCL), Skin conductance peaks per minute (PPM), Area under the curve of these peaks (AUC), Amplitude of these peaks (AMP), Width of these peaks (WID), Rise time of the peaks (RIS), and Decay time of the peaks (DEC). The threshold for a skin conductance peak was set at 0.005 μSiemens. In addition, we controlled for movement and temperature as these are known to influence both heart rate (Kamath et al., 2016) and SC (Boucsein, 2012).

2.5. Sample attrition

Only recordings with over 2 hours of artifact free data were used in the analyses. The recordings on the wrist are artifact prone as a result of movement or not wearing the wristband tightly enough. As a result, the quality of the recordings might be affected (Boucsein, 2012). Therefore, all recordings were visually inspected and automatically checked with automated recognition software as is standard practice (Kleckner et al., 2017; Taylor et al., 2015) with the use of a batch Python 2.7 script, called 'eda explorer', developed by the Massachusetts Institute of Technology (Taylor et al., 2015). The amount of artifact free data ranged from 4.91% to 99.71% (M = 83.1 SD = 17.8). The physiological data were obtained on a total of 347 recording days. On 341 of those days, at least 2 hours of clean artifact free data were available. The temperature sensor was broken for 5 participants and set to missing.

2.6. Design and statistical analyses

The first research question regarding the individual change in burnout symptoms over time as a function of the 4 predictors (i.e., EI, personality, job stress, and patient aggression) was assessed with a longitudinal multilevel model (Hox, Moerbeek, & Schoot, 2017) where the repeated measures (level 1) were nested within individuals (level 2). The multilevel model is especially useful in case there are missing data (see Table 1 for the main study variables). First, the time-varying predictors aggression and job stress were added to the model followed by the time invariant predictors EI and personality. All predictors were tested as possible moderators over time. The second research question regarding the individual change in burnout symptoms over time as a function of physiological parameters was assessed using a similar multilevel model with physiological parameters as predictors while controlling for possible confounders like movement and temperature. The analyses were performed with SPSS 24 and the nlme package in R (Pinheiro, Bates, DebRoy, Sarkar, & R Core Team, 2018), to check the residuals as they are not given in SPSS. MLwiN version 2.36 was used to check for assumptions of normally distributed residuals on all levels of the model.

3. RESULTS

3.1. Burnout symptoms and moderators

Model 1 (Table 2) shows the empty model for burnout which is estimated with a mean of 9.28 (*SD* = 1.67, range = 5 - 14). The repeated measures variance is estimated at 0.93, with the subject level variance at 1.88, which results in an ICC of .67 indicating that about two thirds of the variance is explained at the subject level and one third at the repeated measures level. Model 2 predicts a value of 8.89 which increases with .035 each month. Considering that each interval of 1 is a category change in Emotional Exhaustion, Depersonalization or Personal Accomplishment, the model approximately predicts a change in category each 2 years. Multiple polynomials for the effect of time were fitted, but none of the higher order polynomial terms were significant. Both the time-varying predictors, job stress and aggression in model 3, have a significant positive effect, meaning that burnout symptoms increase with increasing job stress and aggression. It was also tested whether years working on the unit, with this employer or in healthcare, was a predictor, but neither three had a significant effect. Next, a model with three time-invariant predictors was fitted: EI, personality and sex. Only EI and two personality traits (neuroticism and altruism) had a significant effect and were added to model 4. In line with what could be expected on the basis of earlier research, EI and altruism turned out to have a negative association with burnout symptoms, while neuroticism has a positive association. In model 5 a random slope for time was added, which did not result in a significant improvement compared to model 4 (*Dev* = -4.12, *df* = 3). This conclusion remained after adding an autoregressive covariance structure as burnout is known to have high autoregressive regression coefficients (Maslach et al., 2001). This means that participants do not vary significantly in their rate of change, and therefore model 4 was the model of choice (Figure 2). All predictor variables were also added to the models as interactions with time. However, none of the variables significantly moderated the effect of time within the multilevel model. In addition, it was tested whether the effect of time was moderated by social support, but this turned out not to be the case. The standardized coefficients (model 6) indicate that EI has the largest effect, followed by job stress, and neuroticism. The effects for altruism, time and aggression are approximately equal.

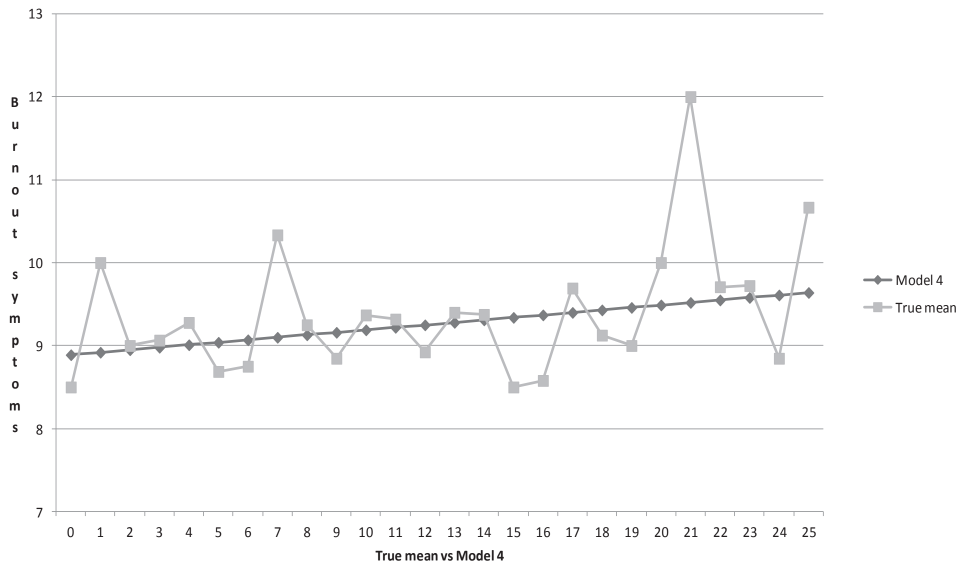

FIGURE 2. Mean sum of burnout scores vs. true and estimated mean burnout scores in Model 4.

3.2. Burnout symptoms and psychophysiology

The empty model 1 and model 2 are identical to those in the previous analyses (Table 3). Adding the time-varying predictors of psychophysiology in model 3 resulted in a significant negative effect for both AMP and AUC of the skin conductance assessments. Only the effects of the AMP are reported as there is a high correlation between AUC and AMP (.988). Movement, temperature and heart rate which are also measured by the Empatica E4 did not have a significant effect in model 4. A random slope for time was added in model 5 as well as an autoregressive covariance structure, but this did not result in a significant improvement compared to model 4. Thus, participants do not vary significantly in their rate of change.

TABLE 2. Multilevel regression models for predictors of burnout.

	Model 1: Random intercept		Model 2: Random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random slope time		Model 6: Standardized model 4
	Parameter	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**
FIXED											
mean/intercept	9.28**	*0.14*	8.89**	*0.17*	6.90**	*0.32*	12.61**	*1.31*	12.69**	*1.32*	
time			0.04**	*0.01*	0.03**	*0.01*	0.03**	*0.01*	0.03**	*0.01*	0.12
Job Stress					1.88**	*0.28*	1.66**	*0.27*	1.70**	*0.27*	0.26
Aggression					0.01*	*0.00*	0.01*	*0.00*	0.01*	*0.00*	0.11
EI							-0.05**	*0.01*	-0.05**	*0.01*	-0.33
Neuroticism							0.16**	*0.06*	0.16*	*0.06*	0.19
Altruism							-0.14*	*0.06*	-0.14*	*0.07*	-0.14
RANDOM											
VAR(e(ij)) [C]	0.93	*0.10*	0.84	*0.08*	0.72	0.07	0.72	0.07	0.62	0.07	
VAR(u(0j)) [C]	1.88	*0.30*	1.94	*0.31*	1.61	0.26	0.89	0.16	1.06	0.26	
VAR(u(1j)) [C]									0.00	0.00	
COVAR									-0.01	0.01	
FIT (par)											
Deviance	1141.11	3.00	1120.80	4.00	1060.87	6.00	990.30	9.00	986.18	11.00	
Diff Dev [A]				1.00	59.92	2.00	130.49	3.00	134.62	3.00	
AIC [B]	1147.11		1128.80		1072.87		1008.30		1008.18		
Explained variance											
R2 level 1					0.14		0.15		0.27		
R2 level 2					0.17		0.54		.46		

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed); [A] cut off value for test with 1 df is 3.84; cut off value for test with 2 df is 5.99; lowest AIC is best model; [C] in test of random parameters (both Wald as well as difference of deviances), p has to be divided by 2.

TABLE 3. Multilevel regression models for physiological predictors of burnout.

	Model 1: Random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 1 control		Model 5: Random slope time	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
FIXED										
mean/intercept	9.28**	*0.14*	8.89**	*0.17*	9.04**	*0.18*	7.91	*6.97*	9.03**	*0.19*
time			0.04**	*0.01*	0.04**	*0.01*	0.03**	*0.01*	0.04**	*0.01*
AMP					-1.86*	*0.88*	-1.82*	*0.91*	-1.79*	*0.88*
Temperature							-0.03	*0.02*		
Movement							0.03	*0.11*		
RANDOM										
VAR(e(ij)) [C]	0.93	*0.09*	0.84	*0.08*	0.87	0.09	0.88	0.09	0.75	0.09
VAR(u(0j)) [C]	1.88	*0.30*	1.94	*0.31*	1.86	0.30	1.86	0.30	2.31	0.45
VAR(u(1j)) [C]									0.00	0.00
AutoCor									-0.45	0.18
FIT (par)										
Deviance	1141.11	3.00	1120.80	4.00	1064.39	5.00	1051.76	7.00	1060.56	7.00
Diff Dev [A]				1.00	56.40	1.00	69.04	3.00	60.24	2.00
AIC [B]	1147.11		1128.80		1074.39		1065.76		1074.56	
Explained variance										
R2 level 1					-0.03		-0.04		0.11	
R2 level 2					0.04		0.04		0.74	

* Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed); [A] cut off value for test with 1 df is 3.84; cut off value for test with 2 df is 5.99; [B] lowest AIC is best model; [C] in test of random parameters (both Wald as well as difference of deviances), p has to be divided by 2.

The models with EI, personality, job stress and aggression might be considered as a psychological model, while the model with AMP of the skin conductance assessments can be considered as a physiological model. To test the relative influence of the physiological part of the model it was checked whether the effect of AMP would still be significant in model 4 of the psychological variables. Indeed, the AMP remained significant in model 4 of the psychological variables (Standardized BETA = -.093). Finally, the residuals at each level were tested for normality and multicollinearity, and all indices were good (i.e. were normally distributed and had a VIF < 10).

4. DISCUSSION

4.1. Main findings

The present study investigated individual changes in, and moderators of, burnout symptoms of mental health nurses as a function of EI, personality, patient aggression as experienced by nursing staff, and job stress. In addition, individual changes in burnout scores as a function of skin conductance and heart rate were investigated which resulted in four main findings. First, the proposed predictors EI, personality, aggression, and job stress are associated with burnout over time. Second, none of these predictors moderated the association over time. Third, the AMP of the SC assessments was associated with burnout symptoms over time and this physiological effect remained after controlling for the psychological predictor variables. Fourth, social support did not moderate the development of burnout symptoms over time.

Considering the first research question, associations were found between burnout and EI, personality, patient aggression, and job stress. However, no moderation effects were found. In line with earlier research (Beauvais et al., 2017; Görgens-Ekermans & Brand, 2012; Zysberg et al., 2017), the results suggest that EI has a protective influence on the development of burnout symptoms. Moreover, standardized parameters suggest it has the largest influence of all four predictors. Training staff members' EI may be helpful to prevent burnout (Zijlmans et al., 2011). As for the moderation, the results suggest no moderation effects of EI which means that the development of burnout is not different at differing levels of EI. These results are in line with the Shead et al. (2016) study. However, a study by Görgens-Ekermans and Brand (2012) found a moderating effect of EI in the job stress-burnout association. The difference with these studies is that in our study moderation was investigated over time while other studies used job stress and violence as moderators with EI. We tested for a moderation effect of EI between job stress and burnout (not reported), but did not find a significant effect. Future research should focus on specific combinations of moderators or mediation effects in the development of burnout symptoms.

For the association between burnout symptoms and personality, the association was significant for neuroticism (Maslach et al., 2001; Winstanley & Whittington, 2002) and altruism (Swider & Zimmerman, 2010). Staff members with a high level of neuroticism experience more burnout symptoms, whereas high altruism scores are associated with lower burnout levels. These findings can be useful in allocating mental health nursing staff to psychiatric wards with high job stress demands. The expected negative association with conscientiousness and extraversion (see Swider & Zimmerman, 2010) was confirmed only for the bivariate correlations. However, the associations were non-significant controlling for the other predictors. In this study, personality factors of neuroticism and altruism seem to play a larger role than the other three personality factors and are the only significant effects when considering the longitudinal multilevel structure of the dataset. The strength of the associations of EI and personality with burnout thus seems to change somewhat when we examine these associations over time and in a multilevel framework. It is therefore essential to take into account both the longitudinal and individual differences in levels of burnout symptoms.

The association between job stress and burnout is the second strongest association and in line with other studies focussing on the influence of chronic job stressors (Leiter et al., 2014; Schaufeli et al., 2017), and the autoregressive nature of burnout (Maslach et al., 2001). Again, no moderation effects over time were found, which also indicates that there are no differences in rate of burnout development at differing levels of job stress. Nevertheless, this result clearly indicates that lowering job stressors and demands may decrease burnout symptoms in mental health staff members. A way to decrease job stress is increasing the number of nurses per shift (Johnson et al., 2018), while larger complements of staff could potentially decrease the amount of aggression (Brandt, Bielitz, & Georgi, 2016).

The association between burnout and patient aggression as experienced by staff is consistent with earlier research. The correlations between aggression and burnout symptoms were not as high as those in the Winstanley and Whittington (2002) investigation, but similar to those reported by Hensel et al. (2015). One reason for this finding might be that we considered the entire burnout scale as well as the entire aggression scale as opposed to using subscales. The use of the entire scales does strengthen our confidence in the association between the constructs. Therefore, what is added in this study is that the association is not only evident with physical aggression

(Hensel et al., 2015) or interpersonal aggression (Evers, Tomic, & Brouwers, 2002), but for a broader construct of aggression as we included several types of aggression. We were unable to test for mediation effects in a structural equation model over time as our the sample was too small. This is an interesting area of research as Winstanley and Whittington (2002) already posed the question if aggression causes burnout or vice versa? Future research on this topic is warranted as there is a growing literature on longitudinal mediation analysis (VanderWeele & Tchetgen, 2017; Zheng & van der Laan, 2017).

The second research question, regarding the association between burnout symptoms and physiology, was partially confirmed as only the effects of AUC and AMP of the skin conductance assessments were significant, but no significant effects of heart rate were found. We found that the AMP and AUC get smaller as burnout symptoms increase. The confidence of this result was strengthened because this association remained significant after controlling for the psychological predictors. However, the relative influence of amplitude is smaller than that of EI, for example, as the standardized beta points out. Nevertheless, early detection of changing levels of AMP could indicate rising levels of burnout symptoms and subsequently help prevent staff turnover and absenteeism, although it remains to be seen if staff members would accept this 'surveillance' were it to be adopted routinely.

Two particular strengths of this study can be identified. First, the nature of this study partially fulfils the need for longitudinal studies (Schaufeli et al., 2017) with which the changes in burnout symptoms can be studied. In addition, specific predictors and moderators can be studied that might aid the development of theory and intervention targeted at burnout. Second, the findings related to particular risk and protective factors identified in earlier research, and their association with burnout symptoms is important as replication of psychological science is not self-evident (Makel, Plucker, & Hegarty, 2012).

However, there are also some limitations. First, we were unable to study causal connections because of the relatively small sample size. Second, the time interval between the physiological measures was large and there is great variation in physiology on a day-to-day basis. Careful 24/7 monitoring is needed to establish the exact nature of the associations. Also, the intervals were 6 months to test whether there were longitudinal changes in burnout symptoms. To increase the likelihood of early detection of increasing levels of burnout symptoms shorter time intervals are needed. The third limitation is the amount of data loss of the physiology sensors. This poses a problem for real time measures, although statistical techniques like the multilevel framework take into account incomplete datasets. The sensors seem useful for the detection of long-term heart rate and skin conductance, but not for more sensitive measures like heart rate variability, as they strongly depend on the correct registration of beats per minute. However, efforts should be made to increase the accuracy of these wrist worn devices.

4.2. Relevance for clinical practice

There are at least four implications for practice, which might also be of interest to employers and organizations. First, it is important to monitor nursing staff regularly, especially nursing staff with relatively higher levels of neuroticism, lower EI and higher levels of job stress as they are at a higher risk of turnover or absenteeism. Although the focus of this study was targeted at psychological variables, there is arguably a balance between considering individual characteristics of staff members and attempting to alter the working conditions as well to increase the person-job fit.

Second, physiological monitoring might be a feasible and objective and unobtrusive monitoring tool to signal rising levels of burnout symptoms. Specifically, AMP and AUC may be useful indicators. Recognizing the variation between and within persons in physiology (Boucsein, 2012; Kamath et al., 2016) underlines the need for more personalized models to predict burnout symptoms. Third, on the short term it is recommendable to monitor nursing staff after they encountered severe aggressive behaviour and provide social support. Fourth, long term interventions focussing on increasing EI in mental health nurses are promising (Zijlmans et al., 2011), which may potentially result in higher levels of resilience against job stress and burnout. Through the advanced knowledge to inform organizational practice, this study might be helpful in keeping that what starts out as pleasant, energetic, meaningful work stays that way and does not change into unpleasant, exhausting and meaningless work (Maslach et al., 2001).


7

CHAPTER 7

Changes in mean heart rate and skin conductance parameters in the thirty minutes preceding aggressive behaviour

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Submitted

ABSTRACT

Introduction. Aggressive behaviour of inpatients threatens the safety and well-being of both mental health staff members and fellow-patients.

Aim. It was investigated whether heart rate and electrodermal activity can be used to signal imminent aggression.

Method. A naturalistic study was conducted in which 100 inpatients wore wearable wristbands during five days to monitor their heart rate and electrodermal activity while staff members recorded patients' aggressive incidents on the ward.

Results. The longitudinal multilevel models indicated that heart rate, skin conductance level and the number of non-specific skin conductance responses per minute, rose significantly in the 20 minutes preceding aggressive incidents controlling for within-subject differences. Although psychopathy was modestly correlated with displaying aggression, it was not a significant predictor of heart rate and skin conductance preceding aggression.

Discussion. This may provide opportunities for the development of individual prediction models to aid acute risk assessment, and to predict aggressive incidents in an earlier stage.

Implications for practice. Combined with new technological advances the current results on the physiological indicators of aggression are promising for reducing aggression and improving both staff as well as patients' safety in psychiatric mental health facilities. People who work with ambulatory devices should carefully consider the amount of artifacts.

1. INTRODUCTION

Aggressive behaviour directed towards staff members and fellow-patients in psychiatric treatment settings is a worldwide problem, as it threatens the safety and well-being of those involved (Hensel, Lunsky, & Dewa, 2013). A meta-analysis revealed that mental health nurses are three times more likely to experience physical aggression in the workplace (Edward et al., 2016) than nurses in other disciplines. Almost all psychiatric nurses experience verbal aggression on a daily basis, and about one out of every six psychiatric nurses also experience physical aggression on an annual basis (Nijman, Bowers, Oud, & Jansen, 2005).

Not surprisingly, researchers have developed questionnaires and risk assessment tools to predict and prevent patient's aggression towards nursing staff or fellow-inpatients. For example, researchers have developed methods for early recognition of potential warning signs of disruptive and aggressive incidents based on observing the patient's behaviour (Fluttert, Van Meijel, Bjørkly, Van Leeuwen, & Grypdonck, 2013). Apart from observing and interpreting patient's behaviours that are assumed to be linked to imminent aggressive incidents, there is a growing interest in the potential of predicting aggression by means of more objective physiological measurements (e.g., arousal measured by electrodermal activity; EDA) on psychiatric wards (Kuijpers, Nijman, Bongers, Lubberding, & Ouwerkerk, 2012), and in facilities caring for people with intellectual disability disorders (Noordzij, Scholten, & Laroy-Noordzij, 2012). Besides EDA, heart rate is an often studied indicator of aggression, and efforts have been made to study these in a more naturalistic setting. For instance, Beauchaine, Gartner and Hagen (2000) used a 10 sec intake electrocardiogram to predict aggressive behaviour based on depression scores and high heart rate variability. However, the majority of these physiological parameters have been studied in experimental and laboratory settings (Lorber, 2004), leaving the question unanswered whether physiological parameters are relevant real-time predictors of actual aggressive behaviour.

As far as we know, four major systematic reviews have been performed on the associations between heart rate, EDA and aggression. The most recent meta-analysis by Portnoy and Farrington (2015) reported a small summary effect size of -.20 (Cohen's *d*) between resting heart rate (HR) and violent behaviour. An earlier meta-analysis by Ortiz and Raine (2004) reported a lower resting HR in samples of antisocial children compared to children without antisocial behaviour. Lorber (2004) reported a small effect size of -.38 (Cohen's *d*) for resting heart rate in adult aggression samples. In addition, a higher HR and EDA reactivity to stimuli was observed in aggressive samples. In these meta-analyses, several categories of externalizing problem behaviours were distinguished:

aggression, psychopathic traits and conduct problems. Lorber (2004) concluded that HR was mostly related to aggression, while EDA was most prominently associated with psychopathy (especially lower rest EDA and reactivity in psychopathy samples). Lastly, the fourth review by Patrick (2008) reported a higher HR and EDA reactivity to stressful events, interpersonal stressors in particular, in samples of hostile-aggressive adults.

As mentioned above, almost all research was done in experimental and laboratory settings, and the most consistent findings were reported for resting heart rate. The aim of the current study was to investigate these associations in a naturalistic setting, namely during day-to-day life on forensic psychiatric treatment facilities for people with mild intellectual disabilities or borderline intellectual functioning (MID-BIF). Recent technological advances allow for the continuous measurement of physiological markers like HR and EDA in real life by means of wearable sensors. In this study it was investigated whether episodes in aggressive behaviour differ from episodes without aggressive behaviour on a physiological level. It is expected that EDA will substantially rise preceding an aggressive incident, such as has been reported in a case study by Kuijpers et al. (2012). In this pilot study, the EDA level of a patient rose significantly in the period preceding aggressive behaviour on the ward, even well before the staff members noted the aggressive behaviour. Another small-scale empirical study with 47 patients also indicated that EDA does seem to rise preceding aggressive behaviour. However, in that study the authors did not control for differences within subjects at baseline (Nijman et al., 2014). In addition, a recent study reported on an increase in EDA following agitation, a concept related to aggression, in patients with dementia (Melander, Martinsson & Gustafsson, 2017). To our knowledge, no studies have been published on heart rate preceding aggressive behaviour in psychiatric MID-BIF patients. It was expected that heart rate would rise preceding aggressive behaviour considering that people get aroused. Furthermore, we also included level of psychopathy as a predictor, as psychopathy is one of the most important predictors of future violence (Hare & Neumann, 2009; Lindsay et al., 2006, Lorber; 2004). A particular problem in ambulatory monitoring is obtaining a noise free signal, which is difficult due to, for instance, movement, tightness of the device that is worn or electrode attachment and placement (Hu et al., 2015; Taylor et al, 2015). As a result, ambulatory measurements may result in artifacts. For the current study it was thus investigated what the influence of different artifact thresholds is on the statistical models that were fitted. The following main research questions are addressed:

- Is aggressive behaviour preceded by a significant rise in HR and EDA compared to baseline levels when the patient is not aggressive? And if so, over what time period do the observed rises in physiological parameters take place before the aggressive behaviour is manifested?
- Is psychopathy a predictor for HR or EDA leading to aggressive behaviour?

2. METHOD

For this observational, naturalistic study, forensic psychiatric patients with MID-BIF and an aptness to engage in aggressive behaviour were asked to wear a wristband that measured their HR and EDA during five consecutive days. The staff members were asked to score the Modified Overt Aggression Scale+ (MOAS+; see below) each time they observed any aggressive behaviour. Approval for the study was granted by the scientific committee and committee of ethics of the Faculty of Social Sciences of the Radboud University at Nijmegen (ECSW2015-1901-282). This study conforms to the declaration of Helsinki for ethical principles involving human participants.

2.1. Participants and Setting

Before the start of data collection, a power analysis was conducted with 95% power, alpha at .05, and an effect size of .25 on the key variables, which indicated that at least 59 participants were needed (Faul et al., 2007). As patients were invited without restrictions on the sample size, 104 patients with MID-BIF were included. Four of the patients withdrew their consent before the end of the study. The remaining 100 participants were admitted in four (forensic) psychiatric hospitals located in different regions of the Netherlands that provide treatment and care to patients with MID-BIF and severe forms of aggressive behaviour.

The age of the 100 participants ranged from 18 to 57 years (mean = 32.01, *SD* = 9.02) and 68% were male. The ethnic background of the sample was 69% native Dutch, 18% non-native Dutch and non-western, and 13% was non-native Dutch, but western. For 36 out of 100 patients the staff members reported one or more aggressive incidents, with a total of 101 aggressive incidents. Several participants were involved in multiple aggressive incidents (range 1 to 9 aggressive incidents per aggressive participant).

2.2. Procedure

Initially, the participants were invited and informed about the aim of the study through email, posters and flyers. Written informed consent was obtained for all patients after they received all necessary information on the study. Participants wore a device in the form of a wristband, called the Empatica E4, during the entire day, for five consecutive days while they were on the ward. Data were collected between May 2015 and august 2017. Staff members monitored aggressive behaviour while wearing watches that allowed them to timestamp the moment they observed any aggressive behaviour, and subsequently documented the nature and severity of the observed aggressive behaviour on the MOAS+ (see below).

2.3. Instruments

Frequency and severity of the patient's aggressive behaviour on the ward was assessed with the Modified Overt Aggression Scale plus (MOAS+; Crocker et al., 2006; Dutch translation by Drieschner, Marrozos, & Regenboog, 2013; Oliver, Crawford, Rao, Reece, & Tyrer, 2007). Subtypes of the MOAS+ are verbal aggression, physical aggression, aggression against objects, sexual aggression, and auto-aggression. The MOAS+ has four subcategories ranging from light to severe for each of the subtypes of aggression. Cohen's Kappa for the MOAS ranges from .65 to .90 (Oliver et al., 2007).

Psychopathy was assessed with the Dutch version of the Psychopathy Checklist-Revised (PCL-R; Hildebrand et al., 2002). The PCL-R consists of 20 items which assess the prototypical characteristics of a psychopath. Each item has to be scored on a 3-point Likert-type scale, ranging from 0 to 2. In Europe, the cut-off score for psychopathy is set at 26 (Hildebrand, de Ruiter & Nijman, 2004). The internal consistency of the PCL-R is high (Cronbach's alpha of 0.87), the two factors have a Cronbach's alpha of 0.83. The PCL-R has two main factors. Factor 1 reflects the affective and interpersonal features of psychopathy. Factor 2 reflects the social deviance found in psychopathy. The PCL-R was scored on the basis of the patients' files by trained professionals who were eligible to score the instrument.

2.4. Physiological assessments

The physiological parameters were obtained with the Empatica E4 (Garbarino, Lai, Bender, Picard, & Tognetti, 2014), a device in the form of a wristband which allows for measuring EDA, blood volume pulse (on which an inter beat interval and HR are based), body temperature and movements. Participants were asked to wear the E4 for five days on their non-dominant hand. HR was expressed in beats per minute. EDA was measured in µSiemens following the parameters described by Boucsein (2012). The parameters that we extracted were skin conductance level (SCL) and number of peaks per minute (PPM). The threshold for the amplitude of peaks was set to a minimum rise of .005

µSiemens. Movement was assessed with a 3-axis accelerometer, and was calculated over the 3-axes as an indication of average movement (Rowlands et al., 2015) using the Euclidean norm which results in:

$$\text{magnitude of acceleration} = \sqrt{x_i^2 + y_i^2 + z_i^2}$$

Temperature was measured in degrees Celsius. As mentioned before, the measurements are somewhat artifact prone, especially when worn on the wrist, possibly because considerable movements during the day can influence the quality of the recordings (Boucsein, 2012). As is standard practice, the physiological signals were both visually inspected as well as automatically checked by automated recognition software (Kleckner et al., 2017; Taylor et al., 2015) with the use of the program 'eda explorer' developed by MIT (Taylor et al., 2015). As mentioned earlier, it was also investigated what the effect of applying different artifact thresholds on the data would be. For this purpose, it was decided a priori to test our two hypotheses with thresholds at a maximum of 25%, 50% and 75% artifact data as artifact thresholds for ambulatory assessment with wristbands are lacking to our knowledge. Artifacts influence the amount of data that can be used to estimate the parameters. For each file and time period the number of artifacts was established as an indicator to retain or discard the time period for analysis.

The physiological data from the half hour periods preceding the aggressive incidents was extracted. Each period was divided into six epochs of five minute intervals. The PPM, SCL and HR were averaged for the six five-minutes periods. To assess whether the physiological parameters in the half hour before aggressive incidents deviate from the regular physiological patterns when there is no aggressive behaviour imminent, we also extracted the PPM, SCL and HR data from the exact same time frames on the other assessment days when the patients had not become aggressive which thus results in difference scores comparing the aggression epochs with the non-aggression control epochs, enabling a within-subject comparison.

2.5. Statistical methods

First, characteristics of the 36 aggressive participants were compared to those of the 64 non-aggressive patients using independent *t*-tests and a chi-square test. Second, it was evaluated if the physiological parameters differed in the half hour period preceding aggressive incidents, compared to the half hour control periods in which the patients did not become aggressive. The statistical model to test this was a multilevel model with repeated measures (level 1) at the incident level (level 2) nested within the person level (level 3). The multilevel model is especially useful to test for predicted effects at multiple levels of the model (Snijders & Bosker, 2012) and when there are missing epochs (Hox, Moerbeek, & Schoot, 2017) as is the case in our data set, especially if we consider different thresholds of artifacts per epoch. The analysis was performed with both SPSS 24 and the nlme package (Pinheiro et al., 2018) in R (to check the residuals as they are not given in SPSS). We also used MLwiN version 2.36 to check for assumptions of normally distributed residuals on all levels of the model. Separate models were considered for each type of parameter (PPM, SCL, and HR), again with the varying amounts of artifacts (< 25%, < 50%, and < 75%) to check whether this would change the associations. The models described in the results section of this paper were the ones fitted on the < 25% artifact data, which constituted the most conservative level of thresholds. The models for the other thresholds (< 50% and < 75%) are also presented in detail in appendix E. Covariates considered in the analyses were movement, temperature, and gender. At first, random intercept models for all three physiological parameters (PPM, SCL and HR) with the repeated measures at level 1, the incidents at level 2 and persons at level 3 were fitted. For the repeated measures we used the final 5 minutes prior to the aggressive incident as the intercept (0). This allowed us to interpret the value of the parameters at the last epoch before aggressive behaviour occurred. The 5-10 minutes epoch before the aggressive incident was given a value of -1, the 10-15 minutes epoch before the aggressive incident was given a value of -2 etc. In addition, multiple polynomials were considered in the analysis, which means that not only linear models were tested but also several higher order associations (e.g., quadratic, cubic etc.). The person level models did not add any explained variance (e.g. the addition of a 3rd level was non-significant for the fitted models) and therefore the incidents were considered as the highest level.

3. RESULTS

3.1. Characteristics of the sample

As mentioned earlier, 36 of the 100 participants displayed one or more aggressive incident during the study, with a total of 101 aggressive incidents. The 36 aggressive participants were significantly younger than the 64 non-aggressive participants [mean ages of 28.7 years and 33.9, respectively; $t(98) = 2.83$, $p < 0.05$; two-tailed]. There were no significant differences between the aggressive and non-aggressive subjects concerning gender or level of psychopathy. The mean psychopathy score of the 100 participants was 15.04 ($SD = 7.59$). As can be seen in the binomial regression in Table 1, lower PPM, SCL, and HR over the 5-day assessment period was associated with a slightly higher probability of an aggressive incident as evidenced by the negative parameter estimates, however the estimates were non-significant. The mean values for the entire sample over the 5-day assessment period on the physiological parameters are presented as well. The mean values for the aggressive participants are only slightly lower for PPM (*M* = 1.14, *SD* = .82), SCL (*M* = 1.46, *SD* = 2.35) and HR (*M* = 86.33, *SD* = 13.09). The Poisson regression in Table 1 shows that increasing levels of PPM, SCL and HR over the 5-day assessment period was associated with an increasing number of aggressive incidents as evidenced by the positive parameter estimates. However, only the estimates for SCL were significant.

TABLE 1. Regression with PPM, SCL and HR as predictors and aggressive incident (binomial) and number of aggressive incidents (Poisson) as outcome variable for the 5-day assessment period.

	b (CI)	SE B	p	Mean	SD
Binomial					
Constant	-1.38 (-1.80; -0.98)	0.21	<.001		
PPM *(μS)*	-0.13 (-0.43; 0.15)	0.15	.38	1.21	0.80
Constant	-1.46 (-1.75; -1.18)	0.15	<.001		
SCL *(μS)*	-0.05 (-0.17; 0.06)	0.06	.40	1.63	2.17
Constant	-0.25 (-2.32; 1.81)	1.05	.81		
HR *(BPM)*	-0.01 (-0.04; 0.01)	0.01	.22	87.47	9.67
Poisson					
Constant	-0.89 (-1.13; -0,67)	0.12	<.001		
PPM *(μS)*	0.15 (-0.00; 0.29)	0.08	.05		
Constant	-0.80 (-0.96; -0.65)	0.08	<.001		
SCL *(μS)*	0.05 (-0.00; 0.10)	0.03	.04		
Constant	-1.49 (-2.62; -0.36)	0.58	<.001		
HR *(BPM)*	0.09 (-0.00; 0.02)	0.01	.17		

Note: N=100; SE = Standard Error.

3.2. Type of aggressive incidents

The 101 aggressive incidents of 36 patients who were involved concerned the following types of aggression (combinations of aggressive behaviour were possible per incident which occurred in 16 cases): For 78 of the 101 incidents (77.2%) staff members reported verbal aggression, in 22 (21.8%) instances the aggression concerned property damage or aggression against objects, 6 incidents (5.9%) concerned acts of sexual aggression, and 5 incidents (4.9%) concerned physical aggression towards people. Finally, 9 incidents (8.9%) concerning auto-aggression were reported by the direct care staff on the MOAS+.

3.3. Sample attrition due to artifacts and missing data

We aimed at measuring 100 participants with the Empatica E4 for 5 consecutive days. However, 2 of the 100 participants completed only 4 days of measurement, one participant completed three days and one completed 2 days of assessment. In addition, HR data were missing for 5 participants on 9 days due to sensor failures. For 13 of the 101 aggressive incidents, the aggression slopes towards aggressive incidents had to be excluded as we did not have a full 30 minutes' physiological data preceding an aggressive incident, leaving us with 88 aggression slopes. Also, of the non-aggression (control) slopes derived from non-aggressive days, 11 slopes were removed because we did not have 30 minutes of physiological comparison data on the same time frame on a non-aggression day. Of the 345 non-aggression slopes, another 66 were excluded due to the absence of EDA data, and one was excluded as a result of an abundance of artifacts. Therefore, there were 88 aggression slopes which could be compared to 278 non-aggression slopes for the within-subject comparison.

3.4. The associations of the physiological parameters with aggression

We chose to analyse the data separately for < 25%, < 50% and < 75% artifacts per epoch. The number of participants, the number of epochs, and the number of slopes for each threshold to be used in the analyses is shown in Table 2. As can be seen in Table 2, the number of artifacts allowed per epoch influences the number of aggression slopes that can be used in the analyses. Underneath, the models based on < 25% are presented, and the other models are submitted as supplementary materials (appendix E).

The bivariate correlations for all variables are given in Table 3. PPM and SCL were significantly positively correlated which indicates that PPM rises as the SCL increases which is expected as a skin conductance response is defined by a sudden increase in SCL (Boucsein, 2012). Temperature was positively correlated to PPM and movement was positively correlated to SCL and HR. Furthermore, aggression that went beyond exclusively verbal aggression was positively correlated to PPM, temperature and the PCL-R score.

In Figures 1 to 3, the grey squared lines represent the means (called 'true means' as opposed to the 'fitted values' in dark diamond lines) in the development of the number of PPMs, SCL and the HR preceding aggressive incidents, compared to the means found for these parameters on non-aggressive control periods. On the x-axis the 5-minute epochs before aggression was observed are depicted. Note that the PPM, the SCL, and the HR show a consistent rise on average preceding the aggressive behaviour from 20 minutes before aggression was reported. The rise (i.e. note that this is a difference score) in the SCL in the 5 minutes before aggressive behaviour became manifest, was 1.15 µSiemens on average (see Figure 2). As the mean SCL of the aggressive patients was 2.21 µSiemens on average during all 30-minute periods included in the current study, this increase in the SCL seems substantial. The HR increased over the 20 minutes preceding aggression with an average total of about 6 beats per minute.

TABLE 2. Number of available participants, incidents and epochs.

Artifact threshold level	**25%**	**50%**	**75%**
Nr of available participants	32	32	33
Nr of available incidents	66	77	78
Nr of available epochs	285	367	421

TABLE 3. Correlations, intra-class-correlations (ICC), and descriptive statistics of study variables (N=285)

	Gender	**PPM**	**SCL**	**HR**	**Temperature**	**Movement**	**PCL-R**	**ICC**	**Mean**	**SD**
PPM	-.05							.48	0.15	1.54
SCL	-.05	.51**						.88	0.45	2.85
HR	.06	.06	-.07					.37	2.17	13.49
Temperature	-.16*	.18**	-.05	-.02				.92	0.11	4.16
Movement	-.10	.07	.14*	.17**	.01			.49	0.15	1.86
PCL-R	-.08	.03	.04	.06	.10	-.10		-	13.61	5.77
Aggression (dummy, 0 = verbal, 1 = other)	-.08	.21**	.05	-.08	.19**	.02	.26**	-	0.37	0.48

Notes. *. Correlation is significant at the 0.05 level (2-tailed); **. Correlation is significant at the 0.01 level (2-tailed).

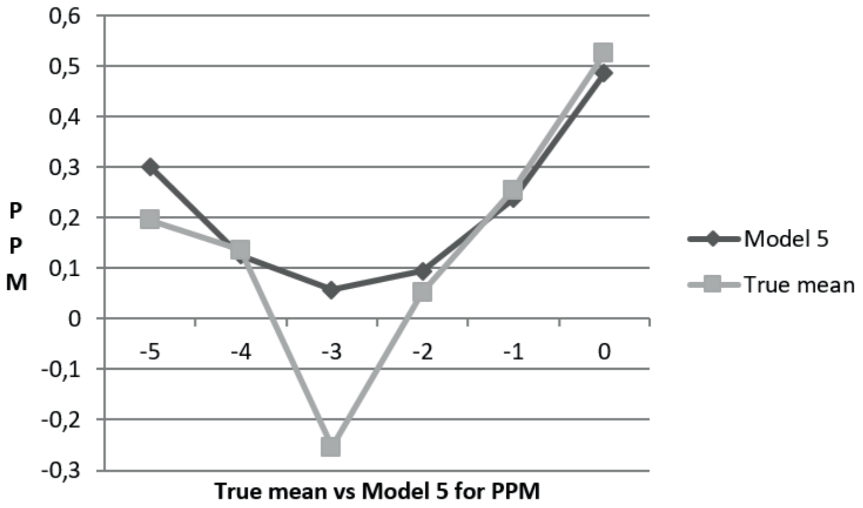

FIGURE 1. True means and best fit models for PPM.

Note. The 5-10 minutes epoch prior to the aggressive incident was given a value of -1, the 10-15 minutes epoch before the aggressive incident was given a value of -2 etc.

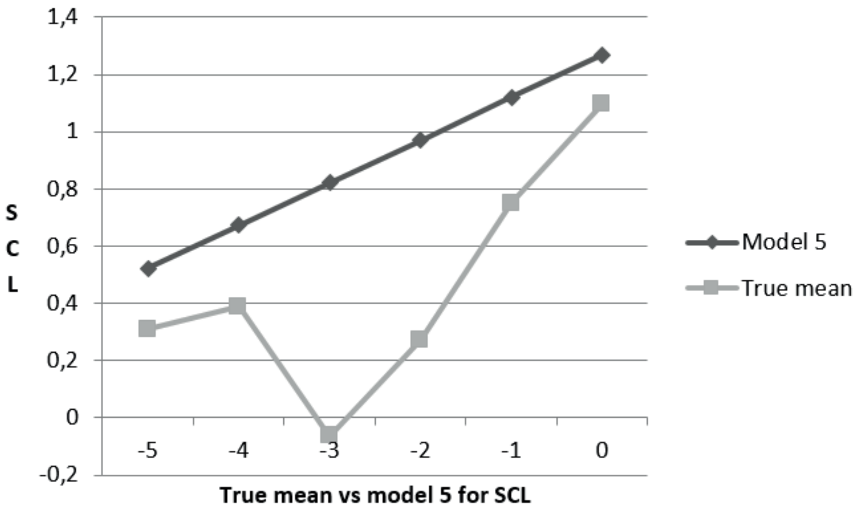

FIGURE 2. True means and best fit models for SCL.

Note. The 5-10 minutes epoch prior to the aggressive incident was given a value of -1, the 10-15 minutes epoch before the aggressive incident was given a value of -2 etc.

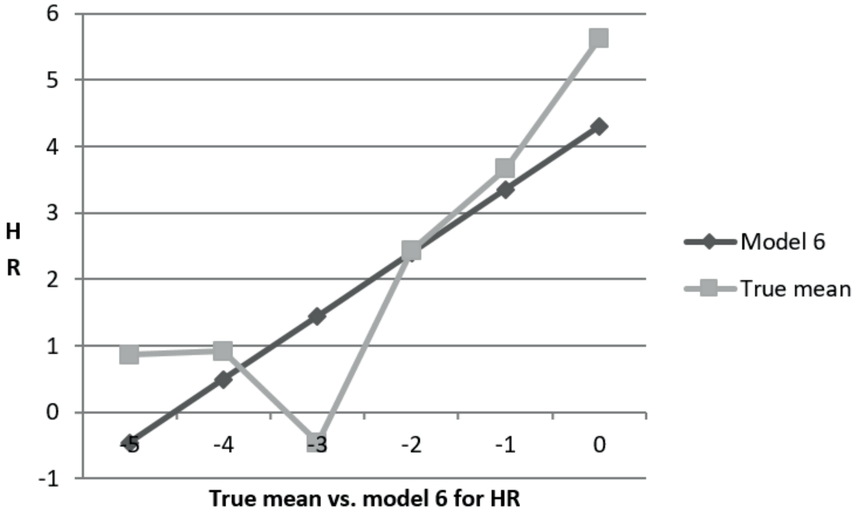

FIGURE 3. True means and best fit models for HR.

Note. The 5-10 minutes epoch prior to the aggressive incident was given a value of -1, the 10-15 minutes epoch before the aggressive incident was given a value of -2 etc.

As mentioned before, in the multilevel analyses, the person level models did not substantially add explained variance and therefore the incidents were considered as the highest level. Separate models for the average PPM, the average SCL, and average heart rate (HR) were fitted. In addition, all models were fitted under different thresholds of artifacts. The best fit models under the < 25% artifact thresholds for PPM, SCL and HR are presented in Table 4. The best fits were based on the Akaike Information Criterion (AIC) indices as not all models were nested. For all three physiological markers we started out by fitting a random intercept model. Next, a linear time variable was added together with multiple polynomials as the shape of the trajectory of change in the physiological parameters towards aggressive incidents was unknown. As can also be seen in Figures 2 and 3 (and Appendix E), the final models for SCL (model 5) and HR (model 6) were best fitted with a linear term, whereas the model for PPM was best fitted with a quadratic term (model 5) for the entire half hour preceding aggressive behaviour.

TABLE 4. Best fit models at the < 25% threshold level for PPM, SCL and HR.

	PPM Model 5: Random Slope time (ARH covariance)		**SCL Model 5: Random Slope time (ARH covariance)**		**HR Model 6: Model 2 and fixed cn.Acc**	
	Parameter	**SE**	**Parameter**	**SE**	**Parameter**	**SE**
FIXED						
mean/intercept	0.49	0.26	1.27*	0.48	4.13*	1.70
time	0.30*	0.14	0.15*	0.06	0.96*	0.43
quadratic time	0.05*	0.03				
temperature						
movement					1.22*	0.51
sex						
pcl						
aggression						
RANDOM						
VAR(e(ij)) [A]	0.97	0.11	1.22	0.14	119.58	12.79
VAR(u(0j)) [A]	2.63	0.70	13.52	2.91	67.54	22.01
VAR(u(1j)) [A]	0.22	0.14	0.11	0.05		
COVAR	0.00	0.00				
ARH var	0.80	0.10	0.60	0.19		

Notes. [A] in test of random parameters (both Wald as well as difference of deviances), p has to be divided by 2; * Correlation is significant at the 0.05 level (2-tailed).; ** Correlation is significant at the 0.01 level (2-tailed).; ARH = Heterogeneous first-order Autoregressive covariance structure.; SCL = Skin Conductance Level; PPM = Peaks per minute; HR = Heart Rate.; cn.Acc = movement variable.

Temperature and movement were expected to have an influence on the physiological measures, and thus these effects were considered as time-varying predictors in the third model. In the fourth model, gender, psychopathy and type of aggression were added as time invariant predictors. The second hypothesis, regarding the predictive value of psychopathy for HR and EDA leading to aggressive behaviour, was not confirmed (see all models 4 in Appendix E). Movement only turned out to be a significant predictor for the HR marker, but not for PPM and SCL. Both a random intercept and random slopes with an autocorrelation covariance structure for all markers was tested (ARH covariance in models 5 in Appendix E) as we expected the points in time that are nearer to each other to be more correlated. For both PPM and SCL this improved the model, but not for HR. Finally, the residuals were tested at each level for normality, only for SCL the residuals were not normally distributed and therefore they have to be interpreted with caution (Maas & Hox, 2004). The best fitting models are presented in Figures 1, 2 and 3 for the three physiological parameters by the dark diamond lines. For PPM, the models under the < 50% and < 75% artifacts changed the significance of the quadratic term (Appendix E). The SCL model was not significant under the < 50% and < 75% artifacts. This indicates that the level of artifact correction is important to consider for the prediction of parameters. For HR, the models remained the same under the < 50% artifact level, which indicates a robust effect for HR.

4. DISCUSSION

Support for our first hypothesis that EDA, both in terms of the PPM and the SCL (Kuijpers et al., 2012; Nijman et al., 2014), as well as HR, would increase preceding aggressive incidents comes from both the fitted multilevel models and visual inspection of the true means. The graphs of the true means indicate that the increases take place from about 20 minutes before aggressive behaviour is observed by staff members. These findings are promising in the sense that methods may be developed with which possible aggressive behaviour may be prevented and succinctly the potential negative consequences of aggressive behaviour be limited. Such prediction methods may give nursing staff a warning signal that a patient is getting more aroused and that the likelihood of aggressive behaviour is increasing. As far as we know, this is the first large scale naturalistic study that shows that increases of EDA and HR precede the overt behavioural manifestations of aggressive behaviour of forensic psychiatric patients controlling for within-subject variation.

No support, however, was found for the hypothesis that psychopathy was a predictor of HR or EDA in any of the fitted models (Hare & Neumann, 2009; Lorber, 2004; Ortiz & Raine, 2004). A possible reason for this non expected finding is the use of patient files. Normally, psychopathy scores are calculated based on an entire interview (Hildebrand et al., 2004), which was not feasible in our study. A second reason for the non-finding is the level of psychopathy in our sample. Only six participants met the European criterion for psychopathy (Hildebrand et al., 2004). Also, adding the person level variables did not explain any variance. This might be due to a low number of incidents within a person or due to a small sample size (Hox et al. 2017).

Based on the reviews by Patrick (2008) and Lorber (2004) we would expect a positive association between HR and EDA reactivity in association with aggressive behaviour. Indeed, HR and EDA were rising preceding an aggressive incident. In the current study we were unable to include a large(r) number of psychopaths. However, the participants who were aggressive tended to have slightly lower levels of PPM, SCL and HR on average over the 5-day assessment period. In addition, there was a positive association between PPM, SCL, HR and number of aggressive incidents. It would be very interesting to study this trait association between physiological phenotypes and probability of aggressive behaviour in a naturalistic study such as the present one, but with a more varied population with regard to the base rate of aggressive tendencies.

One of the strengths of the current study is that we were able to compare the timeframes preceding aggressive incidents with the same time frames on other days of the same subjects when no aggression was displayed as this was a limitation in a recent study (Nijman et al, 2014). This is important as EDA in general tends to increase during the day (e.g., as a result of becoming tired or stressed), and because people have different baseline values for the physiological parameters that were studied (Boucsein, 2012; Kamath et al., 2016). In addition, we were also able to correct our models for movement and temperature which is known to increase HR, and also EDA (Garbarino et al., 2014; Kreibig, 2010). Obviously, random variations in EDA and HR are still unaccounted for in the statistical models as we did not control for the specific type of activities that people undertook during the assessment period.

There are a number of other limitations of the current study that need to be addressed. First, we had some data loss for varying reasons. For instance, of the original 101 aggressive incidents, only 66 were included in the final analysis (< 25%) due to artifacts, lack of comparison slopes or sensor failure. The high number of artifacts in the data poses a threat to the amount of data that can be used (Taylor et al., 2015). Therefore, further methods have to be developed aiming at increasing the reliability and validity of the physiological assessments in real life situations. Second, the form of aggressive behaviour often concerned exclusively verbal aggression, and to a lesser extent, physical aggression as was expected (Nijman et al., 2005). We were unable to investigate the effect of more detrimental and presumably more arousing incidents involving physical aggression due to a lack of enough of such incidents. In the current study, no inclusion criterion on the historical number and type of aggressive behaviour of the included patients was determined. In future studies, it may be preferable to investigate more aggression prone, high risk patients as this might increase the risk for physical aggression. However, it is worth noting that even with a high number of verbal aggressive incidents we found rising levels of physiological parameters towards aggressive behaviour.

Third, the level of aggregation was set a priori. The data were analysed by aggregating 5-minute epochs which already is a more narrow time interval than previous studies (Kuijpers et al., 2012; Melander et al., 2017; Nijman et al., 2014; Noordzij et al., 2012). For future studies it may be interesting to add every minute to the equation. This could be especially important for trying to devise real time aggression monitoring algorithms.

Finally, we are aware that the choices that we made influenced the fitted models. We tried to be as rigorous as possible, but we could have made other choices. Our results, for instance, show that the chosen level of artifact correction influences the fitted models. In this paper we reported the results when no more than 25% of the data were missing (but also see Appendix E for the results when 50% or 75% artifact correction was used).

4.1. Implications for practice

The results of the current study indicate that there are significant rises in the physiological parameters preceding aggressive behaviour, controlling for within-subject variation. The current results are promising for early detection and prevention of aggression and improving both staff as well as patients' safety in psychiatric mental health facilities. The question is whether the differences are pronounced and specific enough to be helpful to signal imminent aggressive behaviour, and will allow for making (personalized) prediction algorithms that are useful to prevent (the negative consequences of) aggressive behaviour in clinical practice. For instance, a review by Kreibig (2010) pointed out that HR increases as a result of anxiety and anger, but also of more positive emotions like happiness and joy. Too strengthen the prediction we might take all three parameters (PPM, SCL and HR) into account as all three parameters tend to rise towards the moment aggressive behaviour is displayed. In addition, there are other statistical techniques to consider like latent class analysis or machine learning (Alberdi, Aztiria, & Basarab, 2016; Jang et al., 2015). However, deploying such techniques requires (much) larger sample sizes. Ideally, with a larger sample we might also describe between-person variances better as far as personalized predictors of aggression are concerned (Rudovich et al., 2018). A viable next step would be to deploy such techniques, added with other biological and personal factors that can predict aggression. With the enormous developments in computer capacities and calculation speed, combined with the improvements that are being made in the development of wearable physiological measurement devices, the options are increasing for developing (and testing) personalized aggression prediction algorithms for (forensic) psychiatric patients. In addition, staff members or researchers that are working with ambulatory monitoring devices should be aware that the artifact threshold will affect the models that are fitted. We recommend to report the statistical models under multiple artifact thresholds.


8

CHAPTER 8

General Discussion

This chapter summarizes the main findings of the research described in this dissertation and the results are discussed in light of the three central questions of this dissertation (see chapter 1). The potential practical implications of the findings are discussed based on the main findings, followed by a discussion of the limitations and strengths of the studies conducted. Lastly, new areas of research that warrant future study are addressed.

1. MAIN FINDINGS OF THE STUDIES AND THEIR POTENTIAL CLINICAL IMPLICATIONS

The current dissertation focused on the associations between ambulatory physiological measurements and both burnout symptoms in nursing staff and aggressive behaviour of patients with MID-BIF (mild intellectual disabilities to borderline intellectual functioning). In chapter 2 an exploratory pilot study was described that investigated the association between skin conductance levels with different shifts and ward activities in forensic nursing staff. The aim of the study was to investigate whether specific working times were associated with higher levels of skin conductance (heart rate measurements were unavailable to us at that time with the devices used in that study), and to gain insight into whether certain ward activities appeared to be associated with higher levels of skin conductance. The study showed that the skin conductance level of 10 psychiatric nurses significantly differed between day, evening, and night shifts. The average skin conductance level turned out to be nearly twice as high during evening shifts when compared to the other shifts (3.2 μS vs 1.8 μS and 1.7 μS). Although arousal levels vary as a consequence of diurnal variation in skin conductance (Hot, Naveteur, Leconte, & Sequeira, 1999; Hot, Leconte, & Sequeira, 2005), the differences found in the study were substantial. This is an indication that an increase (instead of the current decrease) of staffing numbers during the evening shifts on wards caring for patients with MID-BIF may be helpful for the ward staff to meet the demands during the evening shift. Note that during the evening healthcare professionals such as psychiatrists, psychologists, occupational therapists etc. are no longer available, leaving the direct ward staff with the entire patient case load on the ward, while having to perform several demanding (and potentially stressful) tasks. In discussing the results with the nurses, the temporal variations in skin conductance suggest that arousal-increasing tasks or moments may have been handing out (and arguing over) medication, testing the alarm system, hand-over meetings for the next shift, discussing the day and preparing for meals.

However, it should be noted that the study design and the limited sample size do not allow for drawing any firm conclusions. In addition, we hypothesized that specifically neuroticism from the Big Five personality test (Costa & McCrae, 1992; Swider &

Zimmerman, 2010) would be associated with higher skin conductance levels. Despite the small sample, neuroticism was indeed found to be positively associated with the skin conductance level (see chapter 2). In line with this, Boucsein (2012) noted in his standard textbook about electrodermal activity that Eysenck in 1967 already hypothesized that "individuals scoring high on the personality dimension emotional lability should exhibit a higher tonic level as well as hyper reactivity of the limbic system, especially under conditions of stress. In the early 1970s, a high correlation between this trait and EDA had been regarded as being one of the most established results in psychophysiological personality research (……), which was, however, questioned later (…)." (in: Boucsein, 2012, pp. 396-397). A more recent Dutch study from Penterman et al. (2011), however, reported that caregivers working at a psychiatric emergency response unit had lower neuroticism levels in comparison to the general population. Earlier, Bowers et al. (2003) found a negative correlation between neuroticism and how secure staff members felt in working with forensic patients with severe personality disorders. Possibly, high neuroticism levels may make people less suitable for working with patients that have increased risks of becoming aggressive. Note that in the larger-scale longitudinal study on predictors of burnout symptoms in staff described in chapter 6 of this dissertation, the Big Five trait neuroticism was indeed a predictor of an increase of burnout symptoms over time.

During the pilot study described in chapter 2, new devices became available on the market which measured both skin conductance and heart rate (Garbarino et al., 2014). This opened up new opportunities for the inclusion of heart rate measures. This also lead us to first investigate the association between both heart rate and skin conductance with job stress and burnout in a systematic review that was described in chapter 3. An earlier systematic review on workplace stressors and heart rate variability (HRV) had concluded that "stress at work is generally associated with increased risk of disease and worsened health profiles as indicated by decreases in vagally-mediated HRV." (Jarczok et al., 2013, p.1814). This review by Jarczok et al. indicated that workplace stressors were negatively associated with heart rate variability which increased the risk of disease and had negative effects on health. Jarczok et al. investigated both mixed and vagally (parasympathetic) mediated HRV measures in association with job stress measures, while the focus of the systematic review in chapter 3 of this dissertation also included burnout and additionally skin conductance. Besides that, the former review analysed both total as well as subscales of job stress, while the systematic review reported in chapter 3 solely relied on total scales for both job stress and burnout. This is an important distinction with Jarczok et al.'s review which studied the more general 'workplace stressors' as both full and subscales were considered (Jarczok et al., 2013). As the current review compared job stress to burnout, only full scales were considered to compare the job stress-burnout association instead of making comparisons between depersonalization and demands for instance.

Additionally, it was also investigated which guidelines were available for ambulatory assessment and reporting of the results as mobile technological advances enable users to measure heart rate and skin conductance over prolonged periods of time. However, there is little research on the use of parameters over prolonged periods. Providing justification for the extracted parameters in association with job stress or burnout is complex. Moreover, the length of recording varies between studies without apparent justification. There is considerable variability in the timeframes used by researchers ranging from analysis of three minutes of resting time to analysis of workdays, weeks, and leisure time with varying degrees of association between the autonomic nervous system and job stress and/or burnout. This heterogeneity might seriously affect results that were reported, and was therefore addressed in our studies.

Several outcomes of the systematic review are worth noting. First, no studies on skin conductance could be included because there had not yet been any studies performed on the associations between skin conductance and burnout that met the inclusion criteria, and thus no indicator of pure sympathetic arousal was available (i.e. heart rate [variability] measures are either mixed or parasympathetic in nature). Second, in general higher heart rate consistently has been found to be associated with higher levels of job stress. The results on burnout were less conclusive and there were fewer studies that published results on the heart rate-burnout association. Third, lower levels of HRV are associated with higher levels of job stress. Again, fewer studies were reported on the HRV-burnout association, therefore the association between heart rate and burnout is less clear.

Chapter 4 described a study that was aimed at the validation of the Dutch version of the Demands and Support questionnaire (DSQ). This job stress questionnaire was developed by Rose (1999) to estimate levels of job stress in nursing staff who work with people with ID. It is based on the job demands control model (Karasek, 1979), but is specifically designed to monitor the well-being of staff members who work with MID-BIF patients. The questionnaire consists of two scales: a demands and a support scale. The questionnaire was translated into Dutch and the total scales were used as a measure of job stress in the studies described in chapters 5 and 6. The questionnaire had however only been validated in the English language. We were able to reliably validate the factor structure of the demands scale, and we were able to validate two factors for the support scale with configural invariance. However, complete measurement invariance could not be established which limits the utility for comparing means over time. It was concluded that the factors of the demands scale of the Dutch version of the DSQ seem suitable for use in Dutch forensic patients with ID. For the support scale one might consider using a two-factor solution for use in forensic psychiatry. To compare the means over time it is necessary to establish scalar invariance, and more research is necessary on this questionnaire.

In chapters 5 and 6, the results were presented of a study into the associations between physiological indicators and burnout symptoms in nursing staff. Aggressive behaviour of inpatients has been associated with the increased risk of developing a burnout in previous studies (Bossche et al., 2012; Winstanley & Whittington, 2002). Both physical and other forms of aggression are associated with higher levels of both emotional exhaustion (Gascon et al., 2013; Evers, 2001) and depersonalisation (Leiter et al., 2014).

In chapter 5, the first results with the wearable devices were reported that aimed at exploring the association between aggressive behaviour and burnout symptoms. For this study, 110 forensic nursing staff members completed questionnaires measuring experiences with aggressive behaviour, burnout, emotional intelligence, personality, and job stress during four waves of data collection across a 2-year period. The study in chapter 5 reported on the first wave of data collection. In addition, the staff members wore an Empatica E4 to measure heart rate and skin conductance during a workday. The aim of the study was to explore the association of type and severity of aggressive behaviour as experienced by nursing staff and the level of burnout symptoms reported by staff members. In addition, the moderating roles of personality characteristics and emotional intelligence were studied. Earlier research on personality indicated that there may be a positive association between burnout and neuroticism, and negative associations between burnout and extraversion, conscientiousness and agreeableness (Swider & Zimmerman, 2010). Besides personality, recent research indicated that emotional intelligence and burnout dimensions were negatively associated (Beauvais, Andreychik, & Henkel, 2017; Zysberg, Orenshtein, Gimmon, & Robinson, 2017; Gerits, Derksen, Verbruggen, & Katzko, 2005; Mérida-López & Extremera, 2017). The results of the study described in chapter 5 indicated that experiencing physical aggression was positively associated with staff's burnout symptoms (in terms of emotional exhaustion and depersonalization). Although the correlations are modest, the results suggested that being confronted with physical aggression during work increases the risk of burnout symptoms. In addition, it was found that stress management skills, a subscale of emotional intelligence, but not personality, moderated this relationship. Remarkably, the association between experiencing aggression and burnout symptoms was highest for staff reporting a higher number of stress management skills. Surprisingly, skin conductance was not associated with burnout symptoms in the correlational study (chapter 5). This outcome was neither in line with the hypothesized association nor in line with previous findings that (the amount of) non-specific skin conductance responses are a valid indicator of emotional strain (Boucsein, 2012 pp. 460-462) or chronic stress or fatigue (Khanade & Sasangohar, 2017) as reflected in burnout symptoms.

Several authors (see Day & Leiter, 2014; Gelsema et al., 2006; Hensel et al., 2015) called for longitudinal studies that investigate the mediators and moderators that are associated with burnout symptoms. We therefore investigated if individual changes in burnout symptoms were associated with job stress, patient aggression, personality, and emotional intelligence over time. The study described in chapter 5 was extended into a longitudinal, two-year study, which was described in chapter 6. In addition, it was investigated if these variables moderated the associations over time. Lastly, the usefulness of ambulatory measures was investigated further, and heart rate was included in the study described in chapter 6 as well. For this study, we assessed burnout by summing the three subscales of burnout as there is no clear definition of clinical burnout (Bianchi, 2015; Schonfeld et al., 2018). Moreover, with the summation of the three scales, no information is lost and we were able to assess the amount of burnout symptoms of staff members caring for forensic patients with MID-BIF. Job stress (Johnson et al., 2018; Leiter, Bakker, & Maslach, 2014) and aggression (Winstanley & Whittington, 2002) were hypothesized to be risk factors for developing burnout over time, while several personality characteristics (Swider & Zimmerman, 2010), emotional intelligence (Shead et al., 2016) and social support (Schaufeli et al., 2017) were identified as potential protective factors. Most remarkably, the results showed an increase in 1 burnout category over a two-year period. The multilevel models resulted in four main conclusions. First, the predictors of emotional intelligence, neuroticism, altruism, job stress, and patient aggression were associated with burnout over time; The standardized model indicated that emotional intelligence was the strongest predictor, followed by job stress, neuroticism, altruism, and finally aggressive behaviour. Second, the predictors did not moderate the association over time, which indicates that the association is similar at different levels of the included predictors.

Our research showed that experiencing (physical) aggression was a significant predictor of burnout symptoms. An important implication of this finding is that nurses who experience aggression should be monitored and receive social support, especially after severe aggressive behaviour. As social support is considered to be a protective factor for developing burnout symptoms (Schaufeli et al., 2017), this could lower the risk of developing a burnout (Leiter et al., 2014; Schaufeli et al., 2017). The effect of physical aggression on burnout symptoms was stronger for staff members who report higher levels of stress management skills. The implication is, contrary to intuition, that nursing staff with better stress management skills may be more prone to developing burnout symptoms, if they experience physical aggression. Therefore, nursing staff who experience physical aggression should be monitored carefully and receive proper social support if necessary which could lower the risk of developing burnout symptoms. Social support in the current study was measured with the DSQ and comprised of subscales on “External Support”, “Organisation and Management”, and “Social Support and Training”. All these facets should be taken into account when providing staff members with social support. Providing staff with training and support from management might make staff members more resilient in dealing with aggressive behaviour and burnout.

In a general sense, based on the findings described in chapter 6 it is important to monitor nursing staff regularly, especially nursing staff with relatively higher levels of neuroticism, lower EI and higher levels of job stress as they are at a higher risk of turnover or absenteeism. The results of the analysis on the association between burnout with emotional intelligence, personality, patient aggression, and job stress suggested that emotional intelligence, in line with earlier research (Beauvais et al., 2017; Görgens-Ekermans & Brand, 2012; Zysberg et al., 2017), has a significant protective influence on the development of burnout symptoms. Therefore, training staff members’ emotional intelligence may be helpful to prevent the accumulation of burnout symptoms (Zijlmans et al., 2011), which might result in higher levels of resilience against job stress and burnout. Training in emotional intelligence increases insight in dealing with patient behaviour, and subsequently treatment skills and staff behaviour. Moreover, staff members with a high level of neuroticism experience more burnout symptoms, whereas high altruism scores are associated with lower burnout levels. These findings may also be useful in allocating mental health nursing staff to wards with higher or lower job stress demands. It also seems plausible that the amount of burnout symptoms could be useful as an indicator of the risks of (future) absenteeism and turnover. Efforts should be made to influence specific variables to decrease the amount of burnout symptoms that staff members report. The results reported in this dissertation clearly indicate that lowering job stressors and demands may decrease burnout symptoms in mental health staff members. Although the focus of this study was targeted at psychological variables, there is arguably a balance between considering individual characteristics of staff members and attempting to alter the working conditions as well to increase the person-job fit. In sum then, based on the findings in this study, we would suggest that training of emotional intelligence, and providing staff with skills training as well as support from management might make staff members more resilient in dealing with aggressive bahviour and burnout. Recent research indeed indicates that training that is aimed at increasing emotional intelligence and interaction skills is effective (Embregts, Zijlmans, Gerits & Bosman, 2017; Zijlmans, Embregts, Gerits, Bosman & Derksen, 2015). Through the advanced knowledge to inform organizational practice, this study might be helpful in keeping that what starts out as pleasant, energetic, meaningful work stays that way and does not change into unpleasant, exhausting and meaningless work (Maslach et al., 2001).

Third, it should be noted that only the amplitude of the skin conductance assessments was associated with burnout symptoms over time in the study described in chapter 6. Interestingly, this physiological effect was significant after controlling for the other 'psychological' predictor variables. This finding suggests that changes in (the amplitude of) skin conductance is a possible indicator of increasing burnout symptoms, but more research is necessary to investigate this potential association. Several parameters of skin conductance ([i.e., skin conductance level [SCL], skin conductance peaks per minute [PPM], area under the curve of these peaks [AUC], amplitude of these peaks [AMP], width of these peaks [WID], rise time of the peaks [RIS], and decay time of the peaks [DEC]) were tested in association with developing burnout symptoms, it cannot be ruled out that an association of burnout symptoms with a lowered amplitude of the skin conductance peaks was found by chance. However, the power analysis indicated that a sufficient sample size was used. Fourth, social support did not moderate the development of burnout symptoms over time which indicates that the association is similar at different levels of the included predictors. Note that social support, which is a subscale of job stress in our study, was a predictor of burnout symptoms.

Finally, in chapter 7, the results of physiological assessments with the wearable devices in association with aggressive behaviour in patients were presented. Most of the research into the association between physiology and violent and aggressive behaviour was conducted in laboratory and experimental settings (Lorber, 2004). The aim of the study that is reported in chapter 7 was to investigate these associations in a naturalistic setting of (forensic) psychiatric treatment facilities for patients with MID-BIF. It was hypothesized that aggressive behaviour was preceded by a significant rise in heart rate and skin conductance compared to baseline levels when the patient is not aggressive. In addition, the time period before the aggressive behaviour was assessed to investigate the changes in physiological parameters. Moreover, the influence of psychopathy was assessed as this was expected to result in lower levels of skin conductance preceding aggressive behaviour (Lorber, 2004). The multilevel models indicated that rises in both skin conductance and heart rate are visible up to 20 minutes preceding aggressive behaviour controlling for within-subject variation. This indicates that these parameters might be promising for aiding the early detection of imminent aggressive behaviour. Unfortunately, it was not investigated what could have contributed to the rise in heart rate and skin conductance preceding aggressive behaviour which might be an interesting area of study. The participants who showed aggressive behaviour had slightly lower levels of skin conductance levels (SCL), non-specific skin conductance response per minute (PPM) and heart rate (HR) on average. In addition, there was a positive association between PPM, SCL, HR and number of aggressive incidents. These findings show that both skin conductance and heart rate rise significantly preceding aggressive behaviour, and might be used as predictors of imminent aggression. However, more research is necessary to investigate these associations further and to attempt to develop (personalized) models with an increased accuracy of the predictions. Nevertheless, the finding that several of the physiological measures showed significant (and consistent) changes over time before the first behavioural manifestations of aggression became visible to the staff members is a very promising and important result for the prevention of (the consequences of) inpatient aggression that warrants further study (also see paragraph 8.3. "Avenues and practical recommendations for future research" in this chapter).

Contrary to our expectations, in the study described in chapter 7, no support was found for the hypothesis that psychopathy was a covariate in any of the fitted models (Hare & Neumann, 2009; Lorber, 2004; Ortiz and Raine, 2004). However, the mean PCL-R psychopathy score of the patients who participated in the study was 'only' 15.04 (*SD* = 7.59), whereas in Europe a cut-off score of 26 or higher, or even 30 or higher, is often used for diagnosing 'psychopathy' (e.g., see Hildebrand, de Ruiter & Nijman, 2003).

In sum, related to the three central questions of the dissertation, it was found that physiological indicators (i.e. heart rate, SCL, PPM, and the amplitude of the skin conductance response) might be useful in signalling imminent aggressive behaviour in patients, and possibly also to predict changing levels of burnout symptoms in nursing staff. These findings are promising in the sense that methods may be developed with which changing levels of burnout symptoms and aggressive behaviour may be predicted or detected and succinctly develop prevention strategies that are aimed at decreasing the potential negative consequences. Such prediction methods may give nursing staff a warning signal that a patient is getting more aroused and that the likelihood of aggressive behaviour is increasing. In addition, it might also be used to monitor the levels of chronic stress and arousal (Khanade & Sasangohar, 2017). Recognizing the variation between and within persons in physiology (Boucsein, 2012; Kamath et al., 2016) however, underlines the need for more personalized models to predict burnout symptoms. More research is necessary to establish the predictive power of the ambulatory devices when used to arrive at such personalized models.

2. STRENGTHS AND LIMITATIONS

The current dissertation reported interesting findings relating to the use of ambulatory devices in a (forensic) psychiatric setting. A particular strength of the pilot study reported in chapter 2 is the comparison of all three shifts of the nurses, which resulted in an indication of the relative 'weight' of the shifts in terms of skin conductance which, to our knowledge has not been done before. Several limitations on the study in chapter 2 are important to discuss. First, no measures on job stress or burnout symptoms were included which precluded us from formulating statements on the association between skin conductance and job stress. In addition, the sample size was very limited (10 nurses measured during 30 shifts) which decreases the chance of obtaining a true effect and also decreases the likelihood that a significant result is a true effect (Button et al., 2013). Also, the within-subject variability was not modelled, comparisons were made between shifts without considering individual variation within the shifts. Lastly, the study did not control for artifacts in the data which is essential (Kleckner et al., 2017; Taylor et al., 2015).

A strength of the systematic review described in chapter 3 is that the findings from previous reviews were, in part, replicated (Jarczok et al., 2013). In addition, our review only included full scales of job stress, added burnout, and also investigated the literature for studies concerning skin conductance. An obvious, but important limitation however of the review was the inability to conduct a meta-analysis, which limits the confidence we have in the results. Furthermore, there was dependency in the measures, although the independency was higher among studies with larger sample sizes. Also, although the association between job stress and burnout and physiology was investigated, we do not have a sense of the magnitude of the association between heart rate (variability) and skin conductance with both job stress and burnout which a meta-analysis would have solved.

A particular strength of the validation study in chapter 4 was the use of a longitudinal factor analytic technique to validate the questionnaire. A limitation of the validation of the DSQ was that the questionnaire did not include questions on aggressive behaviour by patients. Furthermore, metric invariance was not established in the study described in chapter 4, which will limit the utility of the questionnaire in its current form over time. Metric invariance would mean that the constructs have the same meaning to participants across administrations (Brown, 2015; Putnick & Bornstein, 2016; Vandenberg & Lance, 2000). In addition, establishing scalar invariance would justify the comparison of means over time (Brown, 2015), but this was not established. This will also limit the utility of the questionnaire in repeated measure designs. Also, no back translation of the questionnaire was undertaken, which could have influenced the validity of the translation. As for the use of the questionnaire in the other studies, we did use the fraction of demands/ support to establish a measure of job stress as both scales had acceptable reliability.

A strength of the study that was reported in chapter 5 was that we managed to monitor the SCL and HR of nursing staff during a working day using ambulatory devices. Ambulatory monitoring is a promising technique for future research as naturally occurring stressors and emotions might be assessed. However, it is challenging to distinguish between different emotional states such as anger, happiness, and sadness based on ambulatory psychophysiological recordings (Boucsein, 2012). Another strength of the study was the multi-centre design in which multiple (forensic) mental health facilities for the treatment of MID-BIF patients were included which increases the generalisability in comparison to single centre designs (Tenneij et al., 2009). Lastly, several validated questionnaires (Bar-On, 2006; Costa & McCrae, 1992) were used which was a limitation in the study that was reported in chapter 2. However, the study also had several limitations. First, skin conductance was assessed during only one shift, which may not have been long enough to establish a possible relationship between burnout and skin conductance, which we did find for the amplitude of skin conductance in the longitudinal study. Moreover, although the time between assessment of burnout and skin conductance was 2 days on average, there was variation in the length of the time frame, which could have contributed to the negative findings. In addition, no causality can be claimed considering that the study was cross-sectional in nature (Winstanley & Whittington, 2002). Arguably, higher levels of burnout symptoms may have led to (reporting or experiencing) higher levels of physical aggression of the patients, instead of the other way around. Furthermore, the questionnaires on emotional intelligence, personality, burnout and job stress have moderate reliabilities (between .6 and .7) that were reason for concern. However, Aron and Aron (2003) pointed out that a good questionnaire should have an internal consistency of at least .6 as was the case in this study. Another limitation was the potential bias of the aggression questionnaire that was used. The somewhat varying amount of time that nurses worked on a weekly basis may have influenced the severity of aggression that was experienced by the nurses, although most nurses worked more than 24 hours per week. Furthermore, a problem in the calculation of the severity of aggression score may have been that one severe incident (i.e. frequency = 1, intensity = 10, severity = 10) may not have the same impact as 10 incidents with low intensity (i.e. frequency = 10, intensity = 1, severity = 10). Further research is necessary to establish the validity of the used aggression questionnaire and the way the overall burden of reported aggression can be optimally calculated. In addition, the generalizability of the study that was reported in chapter 5 was limited as the study was conducted in facilities that exclusively treat patients with MID-BIF. These are specialist services that will not be representative of other, more general, forensic psychiatric units. Moreover, it is conceivable that nurses with heightened levels of burnout symptoms or who experienced much aggression were more inclined and interested to participate in the study which would result in a sample bias.

The study that was reported in chapter 6 had three major strengths. First, the study partially satisfied the need for longitudinal studies on (the development of) burnout (Schaufeli et al., 2017). Second, the study replicated findings related to several risk (job stress, neuroticism, and aggression) and protective (emotional intelligence and altruism) factors in the association with burnout which is especially important considering the replication crisis in psychology (Collaboration, 2015; Makel, Plucker, & Hegarty, 2012). Third, the statistical models used allowed for the adjustment of within-subject variation which was a limitation in the study reported in chapter 2. However, several limitations are also worth mentioning. Possibly, existing causal connections between aggression and burnout could not have been studied due to the small sample size (Winstanley & Whittington, 2002) and the relatively small number of measurements over the two-year period. In addition, the time interval between the physiological measures was six months and there is great variation in physiology on a day-to-day basis (Hot et al., 2005). Therefore, careful monitoring on a daily basis may be needed to establish the exact nature of the associations. This also effects the longitudinal changes in burnout symptoms. To increase the likelihood of early detection of increasing levels of burnout symptoms, shorter time intervals between the measurements may be needed and the total follow-up time may need to be longer than two years. Continuous monitoring of physiology increases the chance to study the associations between physiology and burnout. However, it remains to be seen if staff members and patients would accept this more continuous 'surveillance' with wearable devices.

The study that was reported in chapter 7 had two major strengths. First, the statistical models used in the analysis allowed for modelling the within-subject variation of physiology, but, more importantly, the timeframes preceding aggressive incidents were compared with the same time frames on other days that no aggression was displayed by the patients. This was a major limitation in a study that investigated the association between aggression and skin conductance (Nijman et al, 2014), which is important as there is diurnal variation in the skin conductance level (Hot et al., 1999; Hot et al., 2005), and differing baseline levels of heart rate (Kamath et al., 2016) and skin conductance (Boucsein, 2012). Second, the models corrected for movement and temperature which is known to increase heart rate and skin conductance (Garbarino et al., 2014; Kreibig, 2010), and which was an important recommendation of the systematic review reported in chapter 3. Two limitations stand out. First, no expected associations between psychopathy with heart rate and skin conductance were found (Lorber, 2004; Ortiz & Raine, 2004). A possible reason for this negative finding was the use of patient files to complete the PCL-R and, as discussed earlier, the mean PCL-R score may have been relatively low compared to other studies in forensic psychiatric facilities. Normally, an interview (Hildebrand, Ruiter, de Vogel, & van der Wolf, 2002) is used to establish the level of psychopathy which was not possible in our study, and only six participants of the study described in chapter 7, met the criteria for psychopathy in Europe (i.e., a PCL-R score of 26 or higher; Hildebrand, De Ruiter, & Nijman, 2004). Second, verbal aggression was reported most often, and to a lesser extent physical aggression, as was expected (Nijman et al., 2005), but this may have influenced the results as verbal aggression is presumably less arousing and impactful than physical aggression.

Besides the limitations of the separate studies/ chapters that were mentioned above, there are two limitations that transcend the individual chapters. First, there is considerable loss of data if a wearable wristband is used, and this is closely related to the amount of artifacts that are found in the data. For instance, out of 101 aggressive incidents that occurred during the study, only 66 could be included in the final analysis that had less than 25% of artifacts, sensor failure, or lack of comparison slopes. If the wristband is not worn tightly enough, contact with the skin can be lost occasionally. Clearly, the high number of artifacts in the data poses a serious threat to the amount of data that can be used (Taylor et al., 2015). Thus, methods have to be developed aiming at increasing the reliability and validity of the ambulatory physiological assessments in real life situations. Second, the level of aggregation in both studies was set a priori. The analyses in the burnout studies were performed with data aggregated over the day, whereas in the aggression study the data were analysed by aggregating five-min epochs. The time frames of the analyses that are used are likely to have an influence on the results, as our systematic review in chapter 3 indicated. In addition, the study in chapter 7 showed that the chosen level of artifact correction also influences the predicted models. This indeed poses a problem for real time measures, although statistical techniques like the multilevel framework (Hox, Moerbeek, & Schoot, 2017) take into account incomplete datasets. In general, the sensors seem useful for the detection of long-term heart rate and skin conductance, but possibly not for more sensitive measures like heart rate variability, as this is dependent on the correct registration of beats per minute to assess the variability, which is currently not possible with the amount of movement in real life situations in combination with the PPG (photoplethysmography) sensor used. However, it was suggested that the pulse rate variability might be a viable alternative to heart rate variability with a PPG sensor (Gil et al., 2010), although a review showed that movement interferes with the correct registration of the pulse rate (Schäfer & Vagedes, 2013) as well.

3. AVENUES AND SUGGESTIONS FOR FUTURE RESEARCH

To begin with, the limitations mentioned in the preceding paragraph give rise to a number of suggestions for future research on physiological parameters in relation to burnout and aggression. First, it is recommended that guidelines are established and used how to obtain, process and report the physiological data. The systematic review reported in chapter 3 pointed to several guidelines that should be taken into account when obtaining ambulatory measurements and are relevant to clinical practice. It is advised to include a baseline measure to adjust for within-subject variation in heart rate and skin conductance. For instance, there is considerable variation in resting heart (Kamath et al., 2016; Ortiz & Raine, 2004) between human beings which would arguably have an effect on the analyses that are used. It is remarkable that only few articles used rest measures since these seem to be most easily obtained, although some researchers may disagree. However, a rest protocol (Borchini et al., 2014) does assure that there is no movement or psychosocial demand on the participants, which might result in an artifact-free signal, which is especially relevant when ambulatory devices like wristbands are used.

Second, ambulatory measurements are artifact prone because of movement and the tightness of the device. Therefore, artifact correction is necessary to exclude contaminated data and analyse the artifact free signal (Society for Psychophysiological Research Ad Hoc Committee on Electrodermal Measures, 2012; Stapelberg, Neumann, Shum, McConnell, & Hamilton-Craig, 2016). Traditional methods focused on visual screening, but more recently, automated procedures have been suggested which can be used with different thresholds and seriously decrease the time to process the data (Kleckner et al., 2017; Tarvainen, Niskanen, Lipponen, Ranta-aho, & Karjalainen, 2014; Taylor et al., 2015).

Third, in the systematic review that is reported in chapter 3 only time and frequency domain measures were analysed, but Uusitalo et al. (2011) suggested that nonlinear measures of heart rate variability are less movement prone. In comparison with frequency domain measures, the authors (Uusitalo et al., 2011) argue that time domain and non-linear HRV might prove to be more stable and suitable for situations in which a person may show a lot of movement resembling the real-life situations, and therefore more suited for analysis of data which contain a considerable amount of movement.

Fourth, it is advised to carefully consider which heart rate measures and parameters be used for analysis. Parameters obtained in different time intervals are dependent on the time of analysis. For instance, Kamath et al. (2016) suggest that long-term measurements are preferably analysed with time-domain methods, while short-term measures are preferably analysed with frequency domain methods.

Fifth, only few included studies report on adjustments of physical activity, which could seriously affect the quality of the recording (Boucsein, 2012). It is recommended to adjust for these movement artifacts if possible. Moreover, this also applies to breathing and temperature (Kleckner et al., 2017), although devices that control both breathing and measure heart rate and skin conductance in real life settings are currently not on the market to the best of our knowledge.

Sixth, it is strongly recommended to report both bivariate measures and adjusted models as this can seriously alter the effects that are found. Another option would be to publish the raw data with the article so that researchers might be able to do their calculations on the raw data. It is therefore recommended to use the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) (Vandenbroucke et al., 2007) statement to guide reporting for future studies.

Seventh, the use of validated questionnaires is highly recommended, numerous studies used only one job stress question which made it unclear what the construct of the measure was. In addition, if researchers use validated questionnaires, it is recommended to use the same validated cut-offs. A problem with comparability between studies arises when some studies include relatively healthy employees while others include a relatively large number of stressed individuals.

Eighth, it is essential to report on both sex and age as there are few studies that report differences between men and women (Eller, Blønd, Nielsen, Kristiansen, & Netterstrøm, 2011; Hintsanen et al., 2007). The concept of job stress might not be applicable to men and women alike as Riese et al. (2004) already mentioned. The original constructs might hold true more to men than to women and the physiological profile of stress and burnout in women might be different. Lastly, it is also recommended to report exact timeframes, methods of analysis, and transformations and filters applied to compare data more easily, even if mobile devices are not used in laboratories, but in real life situations. The use of ambulatory devices is not really suited for the use of HRV yet, this poses a major problem for future studies. New devices have to be designed that are suited for HRV analysis on the wrist, if possible.

Besides the suggestions concerning the measurement and reporting of physiological parameters with ambulatory devices, several directions for future research aiming at the prevention of burnout symptoms of staff and aggression incidents of patients can be identified. Considering the high burnout, sick leaves and attrition rates among psychiatric nursing professionals (Bossche et al., 2012; Johnson et al., 2018), we feel that more research on the direct impact of working with aggression-prone forensic psychiatric patients on stress levels of nurses is warranted, and these studies should specifically focus on the impact it has on the autonomic nervous system as this is closely associated with cardiovascular disease, metabolic disease, and obesity (Wulsin, Herman, & Thayer, 2018), but also on measures of burnout and stress as became apparent in the current dissertation. Moreover, as mentioned earlier, aggressive patients have a higher risk for coercive treatment or seclusion (Iozzino et al., 2015) which also increases the risk of negative treatment outcomes (Iozzino et al., 2015; Johnson et al., 2018). Therefore, efforts have to be made to detect changing levels of physiology associated with burnout symptoms in nurses or imminent aggressive behaviour of patients.

One of the most important directions for future research would be the need for longitudinal data on the associations between physiological predictors and both burnout symptoms in nursing staff (Johnson et al., 2018) and aggressive behaviour in patients (Winstanley & Whittington, 2002). In accordance, there is a need for larger sample sizes which provides more power to discover a true effect (Button et al., 2013). Longitudinal data with larger sample sizes can be used to study specific causal relationships and distinguish between various mediators and moderators (Wolf, Harrington, Clark, & Miller, 2013). For example, and this point was also made by Winstanley and Whittington (2002), aggressive encounters could be causally related with an increase in burnout, most notably on the emotional exhaustion and depersonalisation scales. However, an alternative explanation might be that elevated burnout symptoms might lead to susceptibility of victimisation. Future research should focus on specific combinations of moderators or mediation effects in the development of burnout symptoms, which is especially relevant considering there is a growing literature on longitudinal mediation analysis (VanderWeele & Tchetgen, 2017; Zheng & van der Laan, 2017) which makes it easier to estimate complex longitudinal growth models. Moreover, it might contribute to the development of theory on the development of burnout symptoms in nurses and aggressive behaviour in patients and their association with the predictive validity of physiological measures. Also, it will contribute to interventions that are targeted at reducing burnout symptoms and aggressive behaviour (Johnson et al., 2018; Zijlmans et al., 2011; Zijlmans, Embregts, & Bosman, 2013). In future studies, it may also be preferable to investigate (even) more aggression prone, high risk, patients as was the case in the studies described in this dissertation, as this might increase the number of physical aggressive incidents which presumably may have more detrimental and more arousing effects. However, it is worth noting that even with a relatively high number of verbal aggressive incidents compared to physical aggressive incidents, we found rising levels of physiological parameters towards aggressive behaviour. Future research should make an effort to include more physical aggression incidents, and potentially also more incidents concerning sexual aggression, auto aggression, and aggression against objects, as these were underrepresented as well.

Future research should also be used to increase the validity and reliability of the predictive models. Studies should be targeted at determining the specificity and sensitivity of these physiological markers in association with burnout and aggressive behaviour which was beyond the scope of the dissertation. The question is whether the differences in physiological markers are pronounced and specific enough to be clinically relevant and helpful to signal changing levels of burnout symptoms or signal imminent aggressive behaviour, and will allow for making (personalized) prediction algorithms that are useful to prevent (the negative consequences of) both burnout and aggressive behaviour in clinical practice. Two points are worth mentioning related to the distinctiveness of the physiological markers. First, a major point of concern is the fact that the wrist may not be the best location for detecting emotion-related data like stress, burnout, or aggression. It was suggested that the wrist is more closely related to thermoregulatory indices of the body (Payne, Schell, & Dawson, 2016) instead of emotion regulatory indices. Further research in this area is necessary. Second, it was pointed out that heart rate increases as a result of anger and anxiety, but also as a result of more positive emotions like happiness and joy (Kreibig, 2010). To strengthen the prediction, we might have to take multiple physiological variables (heart rate, skin conductance, temperature, breathing) and parameters (peaks per minute, SCL and HRV parameters) in combination into account. It seems plausible that combining the scores into one or multiple latent measures may improve the predictive power of the model. Especially, statistical techniques like machine learning (Alberdi, Aztiria, & Basarab, 2016; Jang et al., 2015) seem suited to investigate multiple predictors in large datasets, which is related to the next direction for future research; the aggregation of the data.

In the current study, the aggregated data of the entire day shift was used in the nursing staff sample while we looked at 5-minute aggregated data in the patient sample. In future studies it may be interesting to add every minute to the equation or even every second. However, the cleaning of the data is essential. We used non-obtrusive wristbands (Garbarino et al., 2014) which affected the quality of both the skin conductance and heart rate data, resulting in what are called artifacts. The level of artifacts in a signal is dependent on the tightness of the device on the wrist, and on the movement from both the arm and the wrist. In our studies several artifact thresholds were used to explore the influence of artifacts on the data and the predictive models that were estimated. Further research is necessary to investigate the influence of artifacts and thresholds on the data. However, shorter time frames for the aggregation would allow for trying to devise real time stress and aggression monitoring algorithms.

The within-subject variability of physiological markers is also important to consider in future research. In the development of predictive models, the within-subject variability of the physiological indicators should be modelled in an attempt to create personalized prediction models as the physiological markers tend to vary considerably between subjects (see for instance Feffer, Rudovic, & Picard, 2018). Another viable alternative to personalized prediction models would be the use of latent classes to distinguish between different developmental trajectories in the development of burnout or aggression over time (see for instance van de Schoot et al., 2018). It is essential to take the personal baseline of subjects into account as people differ vastly in their physiology. We noted in the systematic review in chapter 3 that baselines were only included in some of the more recent studies. However, deploying such techniques requires (much) larger sample sizes. Ideally, with a larger sample we might also describe between-person variances better as far as personalized predictors of aggression are concerned (Rudovich et al., 2018). A viable next step would be to deploy such techniques, added with other biological and personal factors that can predict aggression. With the enormous developments in computer capacities and calculation speed, combined with the improvements that are made in the development of wearable physiological measurement devices, the options are increasing for developing (and testing) personalized burnout as well as aggression prediction algorithms.

4. CONCLUSION

Potential risk factors for burnout identified in the current dissertation were job stress, aggressive behaviour of patients, and neuroticism. Potential protective factors consist of emotional intelligence and altruism. Based on the findings on this study, we would suggest that training of emotional intelligence, and providing staff with interaction skills training in addition with support from the organisation might make staff members more resilient in dealing with aggressive behaviour and burnout.

Only evidence was found that a decrease of the amplitude of skin conductance may be associated with burnout symptoms over time, and no association with heart rate was found. As for aggressive behaviour, both rises in skin conductance (the level and peaks per minute) and heart rate seem to be associated with, and precede, imminent aggressive behaviour. These conclusions have to be cautiously interpreted and more large-scale longitudinal research is necessary to investigate the claims that are made in this dissertation. Nevertheless, the use of ambulatory devices in (mental) healthcare yields high expectations, and it is hoped that this dissertation has contributed to the question if these expectations are warranted. On the basis of the reviewed literature and some of the promising empirical results presented in this dissertation, we feel it is plausible that wearable devices can be used to detect changing levels of emotional states and behaviour.


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A

APPENDICES

APPENDIX A

All searches were conducted on the 23rd of December 2016. Here is a link to the databases:

Medline and Pubmed:
https://www.ncbi.nlm.nih.gov/pubmed/

Web of Science:
www.webofknowledge.com/

PsycInfo:
https://www.ebsco.com/products/research-databases/psycinfo

Medline*	
1	Heart Rate/ or (cardiac rate* or heartbeat or heart beat or interbeat or heart rhythm or heart rate* or rate* pulse* or cardiac chronotrop*).mp.
2	galvanic skin response/ or psychophysiology/ or (GSR or electrophysiology or skin potential or galvanic or electrodermal or psychogalvanic or psychophysiology).mp. or ((skin or dermal) adj3 (electric* or conduct* or resistance or physiology)).mp.
3	burnout, professional/ or (((work or job or occupation*) adj3 Stress) or burnout or ((work or job or occupation*) adj3 exhaustion) or ((work or job or occupation*) adj3 strain)).mp.
4	1 or 2
5	3 and 4
6	limit 5 to (english language and yr="2000 -Current")

*the .mp keyword is used to search in multi-purpose (mp) fields. It usually includes fields like Title, Abstract and Subject heading.

Web of Science	
# 6	*(#2 AND #4) AND **LANGUAGE:** (English)* *Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=2000-2016*
# 5	#2 AND #4 Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years
# 4	#1 OR #3 Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years
# 3	TS=((heart rate*) OR (cardiovascular reactivity) OR (psychophysiology) OR (cardiac) OR (heartbeat*) OR (heart beat*) OR (interbeat) OR (heart rhythm) OR (rate* pulse*) OR (physiology)) Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years
# 2	TS= ((((work or job or occupation*) NEAR/3 Stress)) OR (burnout) OR (((job or occupation*) NEAR/3 exhaustion))) Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years

Web of Science	
# 1	TS=(GSR OR Electrophysiology OR galvanic OR Electrodermal OR psychogalvanic OR psychophysiology OR ((skin or dermal) NEAR/3 (galvanic OR electr* OR conduct* OR resist* OR potential OR physiology))) Indexes=SCI-EXPANDED, SSCI, A&HCI, ESCI Timespan=All years

PsycInfo	
1	heart rate/ or cardiovascular reactivity/ or physiological arousal/ or physiological correlates/ or psychophysiology/ or stress reactions/ or (cardiac rate* or heartbeat or heart beat or interbeat or heart rhythm* or heart rate* or rate* pulse* or cardiac chronotrop*).mp.
2	galvanic skin response/ or skin resistance/ or basal skin resistance/ or exp skin electrical properties/ or skin potential/ or psychophysiology/ or (GSR or electrophysiology or skin potential or galvanic or electrodermal or psychogalvanic or psychophysiology). mp. or ((skin or dermal) adj3 (electric* or conduct* or resistance or physiology)).mp.
3	occupational stress/ or (burnout* or burn-out* or ((work or job or occupation*) adj3 stress*) or ((work or job or occupation*) adj3 exhaustion) or ((work or job or occupation*) adj3 strain*)).mp.
4	1 or 2
5	3 and 4
6	limit 5 to (english language and yr="2000 -Current")

Embase	
1	exp "heart rate and rhythm"/ or (cardiac rate* or heartbeat or heart beat or interbeat or heart rhythm or heart rate* or rate* pulse* or pulse rate* or cardiac chronotrop*).mp.
2	electrodermal response/ or (GSR or electrophysiology or skin potential or ((skin or dermal) adj3 (galvanic or electrodermal or electric* or conduct* or psychogalvanic or resistance or psychophysiology or physiology))).mp.
3	burnout, professional/ or job stress/ or (((work or job or occupation*) adj3 Stress) or burnout or ((work or job or occupation*) adj3 exhaustion) or ((work or job or occupation*) adj3 strain)).mp.
4	1 or 2
5	3 and 4
6	limit 5 to (english language and yr="2000 -Current")

APPENDIX B

Association between HR/SDNN/HF/RMSSD/PNN50 and JS/burnout by recording period.

Period	#Positive associations	#Significant effects	#Negative associations	#Significant effects	#No effect/ Mixed
HR					
Rest	8	5	1	0	2
Workday	5	3	0		1
Leisure Time	1	1	1	0	0
Night-time	3	1	2	0	1
Work-Leisure-Night	3	1	0		1
Task	1	0	2	1	0
Total	**21**	**11**	**6**	**1**	**5**
SDNN					
Rest	0		3	2	0
Workday	1	0	3	0	1
Leisure Time	0		0		0
Night-time	1	1	2	0	0
Work-Leisure-Night	2	0	4	1	0
Task	0		0		0
Total	**4**	**1**	**12**	**3**	**1**
HF					
Rest	5	1	6	3	0
Workday	0		5	1	1
Leisure Time	0		3	1	0
Night-time	1	1	3	0	1
Work-Leisure-Night	1	0	4	2	0
Task	3	0	0		
Total	**10**	**2**	**21**	**7**	**2**
RMSSD					
Rest	1	0	2	2	0
Workday	0		4	0/1	2
Leisure Time	0		1	0	2
Night-time	1	1	3	1	4
Work-Leisure-Night	1	0	4	1	2
Task	0		0		0
Total	**3**	**1**	**14**	**5**	**10**
PNN50					
Rest	1	0	1	1	0
Workday	1	0	0		0
Leisure Time	0		1	0	0
Night-time	0		0		0
Work-Leisure-Night	0		2	0	0
Task	0		0		0
Total	**2**	**0**	**4**	**1**	**0**

Example: HR_Workday has 5 positive associations of which 3 are significant. There were 0 negative associations reported and therefore there were no significant effects. 1 association was mixed or had no effect.

APPENDIX C

Summary of the Newcastle-Ottowa Risk of bias scores.

Study	Risk of bias score (Higher means less bias)
Borchini (2015)[40]	7
Clays (2011)[27]	7
Collins (2005)[53]	7
Doornen (2009)[54]	7
Ekstedt (2004)[42]	7
Eller (2011)[46]	7
Eriksson (2016)[55]	7
Fauvel (2001)[56]	7
Hanson (2001)[41]	7
Hernández-Gaytan (2013)[59]	7
Herr (2015)[60]	7
Hintsanen (2007)[28]	7
Jarczok (2016)[61]	7
Johnston (2016)[62]	7
Karhula (2014)[64]	7
Lee (2010)[66]	7
Lennartsson (2016)[67]	7
Loerbroks (2010)[18]	7
Moya-Albiol (2010)[39]	7
Nomura (2005)[68]	7
Riese (2004)[47]	7
Uusitalo (2011)[37]	7
vanAmelsfoort (2000)[71]	7
Vrijkotte (2000)[9]	7
Chandola (2008)[52]	6
Hamer (2006)[57]	6
Jönsson (2015)[3]	6
Kang (2004)[63]	6
Rau (2001)[44]	6
Teisala (2014)[48]	6
Henning (2014)[58]	5
Kotov (2012)[65]	5
Ohira (2011)[69]	5
Poorabdian (2013)[38]	5
Bishop (2003)[50]	4
Morgan (2002)[20]	4
Butterbaugh (2003)[51]	2
Salavecz (2010)[70]	1

The scale can be found at: http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp

The Newcastle-Ottowa Risk of Bias scores are calculated for both cohort or case control studies. The coding manual has 7 questions related to 'Selection', 'Comparability' and 'Exposure'.

APPENDIX D

Modification indices above 10 for the demand scale.

lhs op	rhs	mi	epc	sepc.lv	sepc.all	sepc.nox
3076 D15.2 ~~	D22.2	129.168	0.840	0.840	1.128	1.128
957 SocialRoleT1 =~	D22.1	119.475	0.971	0.801	0.801	0.801
1046 SocialRoleT2 =~	D22.2	109.824	1.150	0.737	0.737	0.737
4395 D22.1 ~~	D18.1	91.655	0.776	0.776	1.591	1.591
964 SocialRoleT1 =~	D22.2	91.294	1.026	0.847	0.847	0.847
1453 ResilnteractT3 =~	D22.1	89.442	-0.870	-0.758	-0.758	-0.758
1615 DomIssueT1 =~	D22.1	89.232	0.997	0.633	0.633	0.633
1210 SocialRoleT4 =~	D22.2	80.079	1.246	0.767	0.767	0.767
1622 DomIssueT1 =~	D22.2	79.337	1.096	0.696	0.696	0.696
1128 SocialRoleT3 =~	D22.2	78.874	0.858	0.785	0.785	0.785
1874 DomIssueT4 =~	D22.2	76.364	1.339	0.893	0.893	0.893
1506 ResilnteractT4 =~	D13.1	67.153	0.418	0.409	0.409	0.409
1534 ResilnteractT4 =~	D22.1	65.376	-0.665	-0.650	-0.650	-0.650
1492 ResilnteractT3 =~	D4.2	64.539	0.556	0.485	0.485	0.485
2464 D13.1 ~~	D21.4	59.967	0.642	0.642	0.849	0.849
2124 WorkPresT3 =~	D22.2	59.335	1.118	0.621	0.621	0.621
1706 DomIssueT2 =~	D22.2	53.389	1.003	0.706	0.706	0.706
2172 WorkPresT4 =~	D13.1	52.620	0.668	0.410	0.410	0.410
1039 SocialRoleT2 =~	D22.1	52.000	0.796	0.510	0.510	0.510
1344 ResilnteractT2 =~	D13.1	50.131	0.348	0.317	0.317	0.317
977 SocialRoleT1 =~	D21.4	47.104	0.527	0.435	0.435	0.435
5340 D22.4 ~~	D18.1	46.589	0.758	0.758	1.603	1.603
1411 ResilnteractT2 =~	D4.2	46.436	0.434	0.395	0.395	0.395
963 SocialRoleT1 =~	D21.2	45.393	0.507	0.418	0.418	0.418
2041 WorkPresT2 =~	D22.2	44.360	0.740	0.490	0.490	0.490
1573 ResilnteractT4 =~	D4.2	43.761	0.429	0.420	0.420	0.420
1425 ResilnteractT3 =~	D13.1	42.468	0.373	0.325	0.325	0.325
1181 SocialRoleT4 =~	D13.1	41.926	0.623	0.384	0.384	0.384
1372 ResilnteractT2 =~	D22.1	41.192	-0.528	-0.481	-0.481	-0.481
1330 ResilnteractT1 =~	D4.2	40.860	0.482	0.371	0.371	0.371
2006 WorkPresT2 =~	D13.1	40.675	0.451	0.298	0.298	0.298
1121 SocialRoleT3 =~	D22.1	40.381	0.558	0.510	0.510	0.510
1223 SocialRoleT4 =~	D21.4	40.143	0.608	0.374	0.374	0.374
1790 DomIssueT3 =~	D22.2	38.591	0.869	0.635	0.635	0.635
2015 WorkPresT2 =~	D20.2	37.909	-0.621	-0.410	-0.410	-0.410
1345 ResilnteractT2 =~	D14.1	37.598	0.349	0.318	0.318	0.318
1003 SocialRoleT1 =~	D4.2	37.569	-0.635	-0.524	-0.524	-0.524
1008 SocialRoleT1 =~	D4.3	37.398	-0.719	-0.593	-0.593	-0.593
1561 ResilnteractT4 =~	D9.4	37.098	0.408	0.399	0.399	0.399
2170 WorkPresT4 =~	D6.1	36.588	-0.739	-0.453	-0.453	-0.453
1924 WorkPresT1 =~	D14.1	36.485	0.694	0.415	0.415	0.415
1844 DomIssueT4 =~	D7.2	36.461	-0.682	-0.455	-0.455	-0.455
1426 ResilnteractT3 =~	D14.1	36.397	0.404	0.352	0.352	0.352
2257 D6.1 ~~	D20.1	36.389	0.553	0.553	1.725	1.725
1509 ResilnteractT4 =~	D20.1	36.214	-0.395	-0.386	-0.386	-0.386
1486 ResilnteractT3 =~	D3.1	35.808	-0.384	-0.335	-0.335	-0.335

lhs op	rhs	mi	epc	sepc.lv	sepc.all	sepc.nox
1264 ResilnteractT1 =~	D14.1	35.799	0.393	0.302	0.302	0.302
1567 ResilnteractT4 =~	D3.1	35.479	-0.351	-0.343	-0.343	-0.343
1342 ResilnteractT2 =~	D6.1	35.061	-0.389	-0.354	-0.354	-0.354
2089 WorkPresT3 =~	D13.1	34.960	0.546	0.303	0.303	0.303
1504 ResilnteractT4 =~	D6.1	34.856	-0.398	-0.389	-0.389	-0.389
1059 SocialRoleT2 =~	D21.4	34.778	0.513	0.329	0.329	0.329
2181 WorkPresT4 =~	D20.2	34.306	-0.785	-0.481	-0.481	-0.481
2234 WorkPresT4 =~	D9.4	34.170	0.675	0.414	0.414	0.414
1263 ResilnteractT1 =~	D13.1	34.051	0.337	0.259	0.259	0.259
2004 WorkPresT2 =~	D6.1	33.749	-0.544	-0.360	-0.360	-0.360
2071 WorkPresT2 =~	D18.4	33.616	-0.706	-0.467	-0.467	-0.467
1399 ResilnteractT2 =~	D9.4	33.568	0.393	0.358	0.358	0.358
1172 SocialRoleT3 =~	D4.3	32.990	-0.520	-0.476	-0.476	-0.476
2207 WorkPresT4 =~	D22.2	32.717	0.946	0.580	0.580	0.580
1760 DomIssueT3 =~	D7.2	32.652	-0.526	-0.385	-0.385	-0.385
2054 WorkPresT2 =~	D21.4	32.466	0.429	0.284	0.284	0.284
1190 SocialRoleT4 =~	D20.2	32.457	-0.786	-0.484	-0.484	-0.484
2068 WorkPresT2 =~	D9.4	32.309	0.530	0.350	0.350	0.350
1988 WorkPresT1 =~	D18.4	32.271	-1.055	-0.631	-0.631	-0.631
1480 ResilnteractT3 =~	D9.4	32.239	0.444	0.387	0.387	0.387
2175 WorkPresT4 =~	D20.1	31.848	-0.665	-0.408	-0.408	-0.408
1507 ResilnteractT4 =~	D14.1	31.598	0.338	0.330	0.330	0.330
1532 ResilnteractT4 =~	D16.1	31.451	0.327	0.320	0.320	0.320
1958 WorkPresT1 =~	D22.2	31.445	0.977	0.584	0.584	0.584
2237 WorkPresT4 =~	D18.4	31.267	-0.845	-0.519	-0.519	-0.519
2173 WorkPresT4 =~	D14.1	30.857	0.582	0.357	0.357	0.357
2094 WorkPresT3 =~	D7.2	30.856	-0.600	-0.333	-0.333	-0.333
1423 ResilnteractT3 =~	D6.1	30.340	-0.422	-0.368	-0.368	-0.368
992 SocialRoleT1 =~	D10.4	30.280	0.603	0.498	0.498	0.498
1932 WorkPresT1 =~	D20.2	30.187	-0.822	-0.491	-0.491	-0.491
2137 WorkPresT3 =~	D21.4	29.658	0.529	0.294	0.294	0.294
2007 WorkPresT2 =~	D14.1	29.541	0.435	0.288	0.288	0.288
1451 ResilnteractT3 =~	D16.1	29.513	0.357	0.311	0.311	0.311
2098 WorkPresT3 =~	D20.2	29.428	-0.688	-0.382	-0.382	-0.382
1347 ResilnteractT2 =~	D20.1	28.924	-0.346	-0.315	-0.315	-0.315
1405 ResilnteractT2 =~	D3.1	28.802	-0.301	-0.274	-0.274	-0.274
2605 D15.1 ~~	D22.1	28.733	0.663	0.663	1.109	1.109
1261 ResilnteractT1 =~	D6.1	28.710	-0.409	-0.314	-0.314	-0.314
1090 SocialRoleT2 =~	D4.3	28.602	-0.642	-0.411	-0.411	-0.411
1318 ResilnteractT1 =~	D9.4	28.390	0.424	0.326	0.326	0.326
1511 ResilnteractT4 =~	D7.2	28.235	-0.324	-0.317	-0.317	-0.317
1635 DomIssueT1 =~	D21.4	28.204	0.520	0.330	0.330	0.330
1349 ResilnteractT2 =~	D7.2	28.169	-0.312	-0.284	-0.284	-0.284
1636 DomIssueT1 =~	D22.4	28.073	0.681	0.433	0.433	0.433
1272 ResilnteractT1 =~	D20.2	27.975	-0.439	-0.338	-0.338	-0.338
1487 ResilnteractT3 =~	D4.1	27.924	0.356	0.311	0.311	0.311
1240 SocialRoleT4 =~	D18.4	27.689	-0.822	-0.506	-0.506	-0.506
4381 D22.1 ~~	D8.3	27.211	-0.902	-0.902	-1.274	-1.274
1676 DomIssueT2 =~	D7.2	27.208	-0.523	-0.368	-0.368	-0.368
978 SocialRoleT1 =~	D22.4	27.143	0.637	0.526	0.526	0.526
1142 SocialRoleT3 =~	D22.4	27.133	0.505	0.462	0.462	0.462

lhs op	rhs	mi	epc	sepc.lv	sepc.all	sepc.nox
1648 DomIssueT1 =~	D18.4	27.070	-0.892	-0.566	-0.566	-0.566
1568 ResiInteractT4 =~	D4.1	27.043	0.325	0.318	0.318	0.318
1428 ResiInteractT3 =~	D20.1	26.908	-0.383	-0.334	-0.334	-0.334
1680 DomIssueT2 =~	D20.2	26.644	-0.597	-0.420	-0.420	-0.420
1430 ResiInteractT3 =~	D7.2	26.131	-0.341	-0.297	-0.297	-0.297
1768 DomIssueT3 =~	D14.3	26.038	-0.545	-0.399	-0.399	-0.399
1006 SocialRoleT1 =~	D2.3	26.017	0.484	0.399	0.399	0.399
1438 ResiInteractT3 =~	D14.3	25.763	-0.369	-0.321	-0.321	-0.321
1179 SocialRoleT4 =~	D6.1	25.590	-0.641	-0.395	-0.395	-0.395
1502 ResiInteractT3 =~	D4.4	25.351	0.374	0.326	0.326	0.326
1672 DomIssueT2 =~	D14.1	25.335	0.473	0.333	0.333	0.333
2443 D13.1 ~~	D21.1	25.276	0.455	0.455	0.592	0.592
1076 SocialRoleT2 =~	D18.4	25.269	-0.732	-0.469	-0.469	-0.469
2177 WorkPresT4 =~	D7.2	24.886	-0.559	-0.343	-0.343	-0.343
2220 WorkPresT4 =~	D21.4	24.830	0.484	0.297	0.297	0.297
1108 SocialRoleT3 =~	D20.2	24.746	-0.441	-0.403	-0.403	-0.403
1370 ResiInteractT2 =~	D16.1	24.683	0.281	0.256	0.256	0.256
1141 SocialRoleT3 =~	D21.4	24.628	0.335	0.307	0.307	0.307
1553 ResiInteractT4 =~	D9.2	24.508	0.311	0.304	0.304	0.304
1556 ResiInteractT4 =~	D18.2	24.249	-0.406	-0.397	-0.397	-0.397
1353 ResiInteractT2 =~	D20.2	24.231	-0.354	-0.323	-0.323	-0.323
1756 DomIssueT3 =~	D14.1	24.055	0.455	0.333	0.333	0.333
1237 SocialRoleT4 =~	D9.4	23.976	0.592	0.365	0.365	0.365
1596 DomIssueT1 =~	D20.2	23.948	-0.652	-0.414	-0.414	-0.414
2087 WorkPresT3 =~	D6.1	23.657	-0.605	-0.336	-0.336	-0.336
994 SocialRoleT1 =~	D18.4	23.582	-0.704	-0.581	-0.581	-0.581
1186 SocialRoleT4 =~	D7.2	23.348	-0.558	-0.344	-0.344	-0.344
1921 WorkPresT1 =~	D6.1	23.008	-0.677	-0.405	-0.405	-0.405
2179 WorkPresT4 =~	D14.2	22.990	0.537	0.329	0.329	0.329
1914 DomIssueT4 =~	D4.3	22.963	-0.619	-0.413	-0.413	-0.413
1060 SocialRoleT2 =~	D22.4	22.900	0.609	0.390	0.390	0.390
1583 ResiInteractT4 =~	D4.4	22.765	0.311	0.304	0.304	0.304
1732 DomIssueT2 =~	D18.4	22.724	-0.716	-0.504	-0.504	-0.504
2154 WorkPresT3 =~	D18.4	22.603	-0.725	-0.403	-0.403	-0.403
1268 ResiInteractT1 =~	D7.2	22.528	-0.321	-0.247	-0.247	-0.247
1324 ResiInteractT1 =~	D3.1	22.447	-0.309	-0.238	-0.238	-0.238
2112 WorkPresT3 =~	D8.1	22.419	-0.470	-0.261	-0.261	-0.261
938 SocialRoleT1 =~	D20.2	22.319	-0.550	-0.454	-0.454	-0.454
1819 DomIssueT3 =~	D3.1	22.307	-0.440	-0.322	-0.322	-0.322
1515 ResiInteractT4 =~	D20.2	22.018	-0.352	-0.344	-0.344	-0.344
1184 SocialRoleT4 =~	D20.1	21.923	-0.574	-0.354	-0.354	-0.354
2092 WorkPresT3 =~	D20.1	21.422	-0.558	-0.310	-0.310	-0.310
1887 DomIssueT4 =~	D21.4	21.234	0.485	0.324	0.324	0.324
2009 WorkPresT2 =~	D20.1	21.178	-0.423	-0.280	-0.280	-0.280
2240 WorkPresT4 =~	D3.1	21.176	-0.490	-0.301	-0.301	-0.301
1662 DomIssueT1 =~	D4.3	21.131	-0.627	-0.398	-0.398	-0.398
998 SocialRoleT1 =~	D4.1	21.085	-0.449	-0.371	-0.371	-0.371
1104 SocialRoleT3 =~	D7.2	20.874	-0.355	-0.324	-0.324	-0.324
1321 ResiInteractT1 =~	D18.4	20.679	-0.473	-0.364	-0.364	-0.364
1266 ResiInteractT1 =~	D20.1	20.669	-0.340	-0.262	-0.262	-0.262
1985 WorkPresT1 =~	D9.4	20.468	0.644	0.385	0.385	0.385

lhs op	rhs	mi	epc	sepc.lv	sepc.all	sepc.nox
1489 ResilnteractT3 =~	D1.2	20.446	-0.300	-0.261	-0.261	-0.261
2090 WorkPresT3 =~	D14.1	20.294	0.486	0.270	0.270	0.270
1971 WorkPresT1 =~	D21.4	20.250	0.509	0.304	0.304	0.304
1570 ResilnteractT4 =~	D1.2	20.093	-0.274	-0.268	-0.268	-0.268
1421 ResilnteractT2 =~	D4.4	20.054	0.296	0.270	0.270	0.270
2151 WorkPresT3 =~	D9.4	19.965	0.537	0.298	0.298	0.298
2029 WorkPresT2 =~	D8.1	19.892	-0.342	-0.226	-0.226	-0.226
1394 ResilnteractT2 =~	D18.2	19.846	-0.359	-0.327	-0.327	-0.327
955 SocialRoleT1 =~	D16.1	19.832	-0.420	-0.346	-0.346	-0.346
1270 ResilnteractT1 =~	D14.2	19.802	0.308	0.237	0.237	0.237
1158 SocialRoleT3 =~	D18.4	19.754	-0.481	-0.440	-0.440	-0.440
4470 D5.2 ~~	D4.2	19.734	0.297	0.297	1.421	1.421
2157 WorkPresT3 =~	D3.1	19.673	-0.463	-0.257	-0.257	-0.257
1198 SocialRoleT4 =~	D8.1	19.648	-0.454	-0.280	-0.280	-0.280
1045 SocialRoleT2 =~	D21.2	19.555	0.371	0.238	0.238	0.238
1391 ResilnteractT2 =~	D9.2	19.481	0.267	0.243	0.243	0.243
1034 SocialRoleT2 =~	D8.1	19.321	-0.399	-0.256	-0.256	-0.256
1848 DomIssueT4 =~	D20.2	19.307	-0.609	-0.406	-0.406	-0.406
2011 WorkPresT2 =~	D7.2	19.136	-0.370	-0.244	-0.244	-0.244
1646 DomIssueT1 =~	D10.4	18.860	0.577	0.366	0.366	0.366
2013 WorkPresT2 =~	D14.2	18.791	0.366	0.242	0.242	0.242
1472 ResilnteractT3 =~	D9.2	18.763	0.306	0.267	0.267	0.267
2415 D7.1 ~~	D1.4	18.489	0.572	0.572	0.739	0.739
1495 ResilnteractT3 =~	D2.3	18.396	-0.283	-0.247	-0.247	-0.247
2938 D13.2 ~~	D21.4	18.216	0.511	0.511	0.606	0.606
632 D20.2 ~*~	D20.2	17.938	-0.447	-0.447	-1.000	-1.000
1475 ResilnteractT3 =~	D18.2	17.830	-0.391	-0.341	-0.341	-0.341
1402 ResilnteractT2 =~	D18.4	17.810	-0.376	-0.343	-0.343	-0.343
1928 WorkPresT1 =~	D7.2	17.589	-0.522	-0.312	-0.312	-0.312
1367 ResilnteractT2 =~	D8.1	17.588	-0.237	-0.216	-0.216	-0.216
1434 ResilnteractT3 =~	D20.2	17.556	-0.346	-0.302	-0.302	-0.302
1357 ResilnteractT2 =~	D14.3	17.523	-0.268	-0.244	-0.244	-0.244
1151 SocialRoleT3 =~	D9.3	16.995	-0.338	-0.309	-0.309	-0.309
1406 ResilnteractT2 =~	D4.1	16.986	0.245	0.223	0.223	0.223
1719 DomIssueT2 =~	D21.4	16.884	0.376	0.265	0.265	0.265
1408 ResilnteractT2 =~	D1.2	16.717	-0.248	-0.226	-0.226	-0.226
956 SocialRoleT1 =~	D21.1	16.611	0.287	0.237	0.237	0.237
1017 SocialRoleT2 =~	D13.1	16.591	0.361	0.231	0.231	0.231
1074 SocialRoleT2 =~	D10.4	16.548	0.463	0.296	0.296	0.296
1839 DomIssueT4 =~	D13.1	16.478	0.416	0.278	0.278	0.278
1116 SocialRoleT3 =~	D8.1	16.399	-0.280	-0.256	-0.256	-0.256
1621 DomIssueT1 =~	D21.2	16.308	0.384	0.244	0.244	0.244
1764 DomIssueT3 =~	D20.2	16.292	-0.446	-0.326	-0.326	-0.326
1930 WorkPresT1 =~	D14.2	16.241	0.494	0.295	0.295	0.295
4386 D22.1 ~~	D5.4	16.199	-0.805	-0.805	-3.993	-3.993
1529 ResilnteractT4 =~	D8.1	16.159	-0.236	-0.231	-0.231	-0.231
1513 ResilnteractT4 =~	D14.2	16.097	0.250	0.245	0.245	0.245
1238 SocialRoleT4 =~	D10.4	16.075	0.488	0.300	0.300	0.300
1903 DomIssueT4 =~	D3.1	15.908	-0.452	-0.301	-0.301	-0.301
1015 SocialRoleT2 =~	D6.1	15.833	-0.460	-0.294	-0.294	-0.294
1830 DomIssueT3 =~	D4.3	15.804	-0.416	-0.304	-0.304	-0.304

lhs op	rhs	mi	epc	sepc.lv	sepc.all	sepc.nox
1840 DomIssueT4 =~	D14.1	15.794	0.449	0.299	0.299	0.299
1842 DomIssueT4 =~	D20.1	15.767	-0.530	-0.354	-0.354	-0.354
708 D19.4 ~*~	D19.4	15.739	-0.524	-0.524	-1.000	-1.000
1459 ResiInteractT3 =~	D21.2	15.721	-0.259	-0.226	-0.226	-0.226
1351 ResiInteractT2 =~	D14.2	15.708	0.237	0.216	0.216	0.216
1519 ResiInteractT4 =~	D14.3	15.539	-0.260	-0.254	-0.254	-0.254
1182 SocialRoleT4 =~	D14.1	15.325	0.431	0.266	0.266	0.266
1018 SocialRoleT2 =~	D14.1	15.267	0.390	0.250	0.250	0.250
1564 ResiInteractT4 =~	D18.4	15.250	-0.348	-0.340	-0.340	-0.340
1097 SocialRoleT3 =~	D6.1	15.171	-0.362	-0.331	-0.331	-0.331
1758 DomIssueT3 =~	D20.1	15.099	-0.419	-0.306	-0.306	-0.306
1341 ResiInteractT1 =~	D19.4	15.088	-0.267	-0.205	-0.205	-0.205
1127 SocialRoleT3 =~	D21.2	14.925	0.255	0.233	0.233	0.233
1010 SocialRoleT1 =~	D1.4	14.890	0.363	0.300	0.300	0.300
1313 ResiInteractT1 =~	D18.2	14.879	-0.365	-0.281	-0.281	-0.281
1746 DomIssueT2 =~	D4.3	14.852	-0.446	-0.314	-0.314	-0.314
999 SocialRoleT1 =~	D19.1	14.736	0.294	0.243	0.243	0.243
1584 ResiInteractT4 =~	D19.4	14.675	-0.231	-0.226	-0.226	-0.226
2195 WorkPresT4 =~	D8.1	14.619	-0.389	-0.238	-0.238	-0.238
2074 WorkPresT2 =~	D3.1	14.408	-0.302	-0.199	-0.199	-0.199
1188 SocialRoleT4 =~	D14.2	14.397	0.443	0.273	0.273	0.273
1669 DomIssueT2 =~	D6.1	14.388	-0.439	-0.309	-0.309	-0.309
1523 ResiInteractT4 =~	D7.4	14.193	0.230	0.225	0.225	0.225
2102 WorkPresT3 =~	D14.3	14.105	-0.470	-0.261	-0.261	-0.261
1340 ResiInteractT1 =~	D4.4	14.022	0.295	0.227	0.227	0.227
1310 ResiInteractT1 =~	D9.2	13.906	0.266	0.204	0.204	0.204
1243 SocialRoleT4 =~	D3.1	13.837	-0.394	-0.243	-0.243	-0.243
5939 D1.4 ~~	D2.4	13.734	0.386	0.386	0.553	0.553
1437 ResiInteractT3 =~	D13.3	13.726	0.255	0.222	0.222	0.222
1753 DomIssueT3 =~	D6.1	13.678	-0.420	-0.307	-0.307	-0.307
1852 DomIssueT4 =~	D14.3	13.590	-0.489	-0.326	-0.326	-0.326
2611 D15.1 ~~	D21.2	13.292	0.631	0.631	1.044	1.044
1156 SocialRoleT3 =~	D10.4	13.292	0.318	0.291	0.291	0.291
1280 ResiInteractT1 =~	D7.4	13.273	0.256	0.197	0.197	0.197
1100 SocialRoleT3 =~	D14.1	13.241	0.290	0.265	0.265	0.265
1574 ResiInteractT4 =~	D19.2	13.184	-0.221	-0.216	-0.216	-0.216
1173 SocialRoleT3 =~	D19.3	13.053	0.239	0.219	0.219	0.219
2069 WorkPresT2 =~	D10.4	13.031	0.348	0.230	0.230	0.230
1986 WorkPresT1 =~	D10.4	13.014	0.533	0.319	0.319	0.319
1422 ResiInteractT2 =~	D19.4	13.001	-0.214	-0.195	-0.195	-0.195
2567 D14.1 ~~	D19.1	12.968	0.406	0.406	0.606	0.606
1500 ResiInteractT3 =~	D2.4	12.925	-0.235	-0.205	-0.205	-0.205
4286 D16.1 ~~	D18.1	12.902	-0.804	-0.804	-1.573	-1.573
646 D8.1 ~*~	D8.1	12.858	-0.302	-0.302	-1.000	-1.000
4006 D20.4 ~~	D10.4	12.852	0.624	0.624	0.946	0.946
1587 DomIssueT1 =~	D13.1	12.818	0.359	0.228	0.228	0.228
1099 SocialRoleT3 =~	D13.1	12.792	0.243	0.222	0.222	0.222
2487 D13.1 ~~	D1.2	12.734	0.343	0.343	0.579	0.579
2086 WorkPresT2 =~	D19.4	12.672	-0.298	-0.197	-0.197	-0.197
2229 WorkPresT4 =~	D18.2	12.668	-0.511	-0.313	-0.313	-0.313
1432 ResiInteractT3 =~	D14.2	12.507	0.243	0.212	0.212	0.212

lhs op	rhs	mi	epc	sepc.lv	sepc.all	sepc.nox
2226 WorkPresT4 =~	D9.2	12.479	0.392	0.241	0.241	0.241
1923 WorkPresT1 =~	D13.1	12.447	0.379	0.227	0.227	0.227
1304 ResilnteractT1 =~	D21.4	12.393	0.231	0.177	0.177	0.177
1518 ResilnteractT4 =~	D13.3	12.325	0.223	0.218	0.218	0.218
2493 D13.1 ~~	D2.3	12.271	0.457	0.457	0.640	0.640
1684 DomIssueT2 =~	D14.3	12.172	-0.393	-0.277	-0.277	-0.277
2875 D7.2 ~~	D9.4	12.055	-0.592	-0.592	-0.804	-0.804
1585 DomIssueT1 =~	D6.1	12.038	-0.446	-0.283	-0.283	-0.283
2096 WorkPresT3 =~	D14.2	12.029	0.389	0.216	0.216	0.216
2294 D6.1 ~~	D5.4	12.010	-0.548	-0.548	-4.597	-4.597
1020 SocialRoleT2 =~	D20.1	11.954	-0.392	-0.251	-0.251	-0.251
3796 D13.4 ~~	D21.4	11.932	0.416	0.416	0.488	0.488
2235 WorkPresT4 =~	D10.4	11.919	0.412	0.253	0.253	0.253
3311 D7.3 ~~	D22.4	11.881	0.806	0.806	0.892	0.892
3706 D7.4 ~~	D12.1	11.869	0.478	0.478	0.501	0.501
1610 DomIssueT1 =~	D8.1	11.812	-0.351	-0.223	-0.223	-0.223
1442 ResilnteractT3 =~	D7.4	11.773	0.239	0.209	0.209	0.209
2746 D6.2 ~~	D20.2	11.764	0.444	0.444	0.752	0.752
1729 DomIssueT2 =~	D9.4	11.763	0.401	0.282	0.282	0.282
1490 ResilnteractT3 =~	D2.2	11.707	-0.219	-0.191	-0.191	-0.191
1208 SocialRoleT4 =~	D16.2	11.696	-0.415	-0.255	-0.255	-0.255
1327 ResilnteractT1 =~	D1.2	11.681	-0.242	-0.186	-0.186	-0.186
970 SocialRoleT1 =~	D21.3	11.647	0.288	0.238	0.238	0.238
707 D4.4 ~*~	D4.4	11.644	0.329	0.329	1.000	1.000
1276 ResilnteractT1 =~	D14.3	11.627	-0.255	-0.197	-0.197	-0.197
1044 SocialRoleT2 =~	D16.2	11.612	-0.373	-0.239	-0.239	-0.239
1862 DomIssueT4 =~	D8.1	11.594	-0.375	-0.250	-0.250	-0.250
4380 D22.1 ~~	D5.3	11.559	-0.720	-0.720	-1.539	-1.539
1704 DomIssueT2 =~	D16.2	11.539	-0.375	-0.264	-0.264	-0.264
1102 SocialRoleT3 =~	D20.1	11.472	-0.298	-0.272	-0.272	-0.272
1816 DomIssueT3 =~	D18.4	11.397	-0.465	-0.340	-0.340	-0.340
1456 ResilnteractT3 =~	D11.2	11.396	0.204	0.177	0.177	0.177
1829 DomIssueT3 =~	D3.3	11.361	0.307	0.224	0.224	0.224
636 D14.3 ~*~	D14.3	11.359	-0.317	-0.317	-1.000	-1.000
1448 ResilnteractT3 =~	D8.1	11.346	-0.222	-0.193	-0.193	-0.193
1126 SocialRoleT3 =~	D16.2	11.328	-0.269	-0.246	-0.246	-0.246
2255 D6.1 ~~	D14.1	11.327	-0.680	-0.680	-1.646	-1.646
2122 WorkPresT3 =~	D16.2	11.286	-0.385	-0.214	-0.214	-0.214
1913 DomIssueT4 =~	D3.3	11.266	0.375	0.250	0.250	0.250
5743 D10.4 ~~	D1.4	11.249	0.438	0.438	0.663	0.663
1788 DomIssueT3 =~	D16.2	11.246	-0.346	-0.253	-0.253	-0.253
4857 D8.3 ~~	D10.4	11.237	-0.537	-0.537	-0.866	-0.866
1161 SocialRoleT3 =~	D3.1	11.187	-0.250	-0.228	-0.228	-0.228
1973 WorkPresT1 =~	D9.1	11.162	0.407	0.243	0.243	0.243
4751 D22.2 ~~	D17.1	11.155	0.465	0.465	0.820	0.820
1134 SocialRoleT3 =~	D21.3	11.154	0.210	0.192	0.192	0.192
688 D18.4 ~*~	D18.4	11.123	-0.345	-0.345	-1.000	-1.000
2450 D13.1 ~~	D21.2	11.075	0.373	0.373	0.490	0.490
5744 D10.4 ~~	D2.4	11.071	0.423	0.423	0.572	0.572
1594 DomIssueT1 =~	D14.2	11.046	0.376	0.238	0.238	0.238
4163 D11.1 ~~	D22.3	11.013	-0.711	-0.711	-0.925	-0.925

lhs op	rhs	mi	epc	sepc.lv	sepc.all	sepc.nox
2690 D20.1 ~~	D21.2	11.001	0.569	0.569	1.039	1.039
987 SocialRoleT1 =~	D9.3	10.999	-0.348	-0.287	-0.287	-0.287
1873 DomIssueT4 =~	D21.2	10.990	0.333	0.222	0.222	0.222
2565 D14.1 ~~	D3.1	10.944	0.345	0.345	0.594	0.594
1361 ResiInteractT2 =~	D7.4	10.927	0.201	0.183	0.183	0.183
1503 ResiInteractT3 =~	D19.4	10.926	-0.223	-0.195	-0.195	-0.195
1467 ResiInteractT3 =~	D22.4	10.920	-0.378	-0.330	-0.330	-0.330
5552 D17.2 ~~	D18.2	10.884	0.355	0.355	2.478	2.478
2967 D13.2 ~~	D2.3	10.757	0.423	0.423	0.532	0.532
1005 SocialRoleT1 =~	D1.3	10.740	0.319	0.263	0.263	0.263
2171 WorkPresT4 =~	D7.1	10.725	0.308	0.189	0.189	0.189
1069 SocialRoleT2 =~	D9.3	10.706	-0.359	-0.230	-0.230	-0.230
4684 D16.2 ~~	D2.4	10.669	-0.533	-0.533	-1.753	-1.753
1837 DomIssueT4 =~	D6.1	10.662	-0.437	-0.292	-0.292	-0.292
1419 ResiInteractT2 =~	D2.4	10.649	-0.188	-0.171	-0.171	-0.171
4606 D12.2 ~~	D9.2	10.565	0.374	0.374	0.554	0.554
671 D21.4 ~*~	D21.4	10.560	0.565	0.565	1.000	1.000
630 D14.2 ~*~	D14.2	10.555	0.339	0.339	1.000	1.000
1499 ResiInteractT3 =~	D1.4	10.494	-0.219	-0.191	-0.191	-0.191
2060 WorkPresT2 =~	D9.2	10.425	0.270	0.179	0.179	0.179
1694 DomIssueT2 =~	D8.1	10.334	-0.302	-0.212	-0.212	-0.212
1385 ResiInteractT2 =~	D21.4	10.288	0.183	0.167	0.167	0.167
2902 D13.2 ~~	D6.3	10.272	0.447	0.447	1.257	1.257
972 SocialRoleT1 =~	D5.4	10.271	-0.337	-0.279	-0.279	-0.279
2044 WorkPresT2 =~	D11.3	10.155	-0.258	-0.171	-0.171	-0.171
1581 ResiInteractT4 =~	D2.4	10.110	-0.183	-0.179	-0.179	-0.179
1641 DomIssueT1 =~	D9.3	10.097	-0.396	-0.252	-0.252	-0.252
1483 ResiInteractT3 =~	D18.4	10.083	-0.325	-0.284	-0.284	-0.284
3799 D13.4 ~~	D10.1	10.081	-0.444	-0.444	-0.586	-0.586
1755 DomIssueT3 =~	D13.1	10.072	0.264	0.193	0.193	0.193
2205 WorkPresT4 =~	D16.2	10.066	-0.377	-0.231	-0.231	-0.231
1961 WorkPresT1 =~	D11.3	10.057	-0.390	-0.233	-0.233	-0.233
1872 DomIssueT4 =~	D16.2	10.034	-0.419	-0.280	-0.280	-0.280
1778 DomIssueT3 =~	D8.1	10.030	-0.284	-0.208	-0.208	-0.208
1879 DomIssueT4 =~	D16.3	10.028	0.406	0.271	0.271	0.271
4467 D5.2 ~~	D1.2	10.022	-0.461	-0.461	-1.490	-1.490

APPENDIX E

Fitted multilevel models with varying artifact thresholds (25%, 50%, 75%) for PPM, SCL, and HR.

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance matrix)		Model 2a: random intercept with time and quadtime	
	Parameter	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**
PPM 25% ARTIFACTS												
FIXED												
mean/intercept	0,226	*0,157*	0,298	*0,188*	0,483*	0,215	0,290	0,417	0,486	0,255	0,487*	0,210
Time			0,030	*0,043*	0,346*	0,151	0,320*	0,148	0,302*	0,144	0,306*	0,146
quadratic time					0,069*	0,029	0,058*	0,028	0,053*	0,025	0,056*	0,028
temperature					0,043	0,036						
movement					0,091	0,051						
sex							-0,101	0,330				
pcl							0,003	0,026				
aggression							0,628	0,324				
RANDOM												
VAR(e(ij)) [C]	1,34	*0,13*	1,34	*0,13*	1,27	0,13	1,34	0,13	0,97	0,11	1,324	0,129
VAR(u(0j)) [C]	1,25	*0,30*	1,24	*0,30*	1,20	0,31	1,09	0,28	2,63	0,70	1,216	0,297
VAR(u(1j)) [C]									0,22	0,14		
COVAR									0,00	0,00		
ARH var									0,80	0,10		
FIT (par)												
Deviance	993,98	3,00	993,50	4,00	900,03	7,00	973,05	8,00	963,83	8,00	989,63	5,00
Diff Dev [A]				1,00	93,47	1,00	20,45	1,00	29,66	3,00	4,35	1,00
AIC [B]	999,98		1001,50		914,03		989,05		979,83		999,63	
Explained variance												
R2 level 1					0,05		0,00		0,28		0,35	
R2 level 2					0,03		0,12		-0,88		0,25	
R2 cross level interaction												
PPM 50% ARTIFACTS												
FIXED												
mean/intercept	0,224	0,143	0,396*	0,170	0,480*	0,197	0,297	0,394	0,587*	0,237	0,536**	0,190

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance matrix)		Model 2a: random intercept with time and quadtime	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
time			0,068	0,037	0,250	0,133	0,269*	0,131	0,304*	0,129	0,27*	0,129
quadratic time					0,040	0,025	0,040	0,025	0,043	0,022	0,040	0,024
temperature					0,005	0,035			Quadtime is almost significant (p=.053)			
movement					0,010	0,040						
sex							0,056	0,315				
pcl							0,014	0,023				
aggression							0,184	0,312				
RANDOM												
VAR(e(ij)) [C]	1,34	0,11	1,33	0,11	1,28	0,11	1,33	0,11	0,91	0,09	1,31	0,11
VAR(u(0j)) [C]	1,24	0,26	1,22	0,25	1,22	0,27	1,21	0,26	2,88	0,67	1,23	0,25
VAR(u(1j)) [C]									0,27	0,13		
COVAR									0,00	0,00		
ARH var									0,81	0,08		
FIT (par)												
Deviance	1273,97	3,00	1270,59	4,00	1149,96	7,00	1238,6	8,0	1227,441	8	1267,94	5,00
Diff Dev [A]			3,38	1,00	120,63	1,00	32,0	1,0	43,152	3	2,66	1,00
AIC [B]	1279,97		1278,59		1163,96		1254,6		1243,441		1277,94	
Explained variance												
R2 level 1					0,03		0,00		0,316		0,01	
R2 level 2					0,01		0,01		-1,350		0,00	
R2 cross level interaction												
PPM 75% ARTIFACTS												
FIXED												
mean/intercept	0,173	0,131	0,268	0,153	0,246	0,180	0,261	0,358	0,292	0,207	0,284	0,170
time			0,039	0,033	0,052	0,120	0,073	0,119	0,066	0,117	0,063	0,116
quadratic time					0,007	0,023	0,007	0,023	0,004	0,021	0,005	0,022
temperature					-0,005	0,031						
movement					-0,061	0,034						
sex							-0,127	0,287				
pcl							0,004	0,021				
aggression							0,136	0,286				

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance matrix)		Model 2a: random intercept with time and quadtime	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
RANDOM												
VAR(e(ij)) [C]	1,33	0,10	1,33	0,10	1,28	0,10	1,35	0,10	0,94	0,09	1,33	0,10
VAR(u(0j)) [C]	1,07	0,22	1,06	0,22	1,12	0,24	1,06	0,22	2,40	0,53	1,06	0,22
VAR(u(1j)) [C]									0,29	0,12		
COVAR									0,00	0,00		
ARH var									0,83	0,07		
FIT (par)												
Deviance	1442,94	3,00	1441,57	4,00	1303,619503	7	1405,63	8,00	1403,26	8,00	1441,52	5,00
Diff Dev [A]			1,37	1,00	138,0	1	35,94	1,00	38,31	3,00	0,05	1,00
AIC [B]	1448,94		1449,57		1317,6		1421,63		1419,26		1451,52	
Explained variance												
R2 level 1					0,03		-0,02		0,290		0,00	
R2 level 2					-0,06		0,00		-1,278		0,00	
R2 cross level interaction												

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance)	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
SCL 25% ARTIFACTS										
FIXED										
mean/intercept	0,909*	0,412	1,232**	0,427	1,255**	0,462	0,726	1,070	1,268*	0,475
time			0,133**	0,046	0,135**	0,050	0,124**	0,045	0,149*	0,063
temperature					0,011	0,068				
movement					-0,007	0,063				
sex							0,036	0,892		
pcl							0,023	0,069		
aggression							0,240	0,890		
RANDOM										
VAR(e(ij)) [C]	1,57	0,15	1,51	0,15	1,63	0,16	1,45	0,14	1,22	0,14
VAR(u(0j)) [C]	10,71	2,00	10,76	2,00	11,60	2,26	10,43	1,96	13,52	2,91

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance)	
	Parameter	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**
VAR(u(1j)) [C]									0,11	0,05
COVAR										
ARH var									0,60	0,19
FIT (par)										
Deviance	1154,36	3,00	1146,23	4,00	1074,88	6,00	1118,89	7,00	1132,81	6,00
Diff Dev [A]			8,127	1,00	71,35	1,00	27,33	1,00	13,42	2,00
AIC [B]	1160,36		1154,23		1086,88		1132,89		1144,81	
Explained variance										
R2 level 1					-0,08		0,04		0,194	
R2 level 2					-0,08		0,03		-0,257	
R2 cross level interaction										
SCL 50% ARTIFACTS										
FIXED										
mean/intercept	0,747	0,379	0,909*	0,400	0,919*	0,435	0,309	1,004	0,969*	0,443
time			0,064	0,050	0,061	0,052	0,085	0,048	0,078	0,081
temperature					-0,034	0,067				
movement					-0,062	0,058				
sex							0,398	0,844		
pcl							0,035	0,062		
aggression							-0,228	0,841		
RANDOM										
VAR(e(ij)) [C]	2,37	0,20	2,35	0,20	2,38	0,21	2,11	0,18	1,54	0,15
VAR(u(0j)) [C]	10,45	1,81	10,46	1,81	11,34	2,06	10,46	1,83	13,39	2,58
VAR(u(1j)) [C]									0,32	0,09
COVAR										
ARH var									0,48	0,13
FIT (par)										
Deviance	1588,99	3,00	1587,34	4,00	1457,16	6,00	1515,85	7,00	1552,57	6,00
Diff Dev [A]			1,65	1,00	130,17	1,00	71,48	1,00	34,77	2,00
AIC [B]	1594,99		1595,34		1469,16		1529,85		1564,57	

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance)	
	Parameter	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**	**Parameter**	**SE**
Explained variance										
R2 level 1					-0,01		0,101		0,344	
R2 level 2					-0,08		0,000		-0,281	
R2 cross level interaction										
SCL 75% ARTIFACTS										
FIXED										
mean/intercept	0,686	0,385	0,948*	0,408	0,903*	0,447	0,38	0,98	0,967*	0,467
time			0,108	0,055	0,083	0,059	0,09	0,05	0,115	0,072
temperature					-0,134*	0,066				
movement					-0,103	0,062				
sex							0,25	0,83		
pcl							0,03	0,06		
aggression							-0,03	0,83		
RANDOM										
VAR(e(ij)) [C]	3,65	0,28	3,61	0,28	3,77	0,30	2,66	0,21	2,958	0,254
VAR(u(0j)) [C]	10,84	1,87	10,81	1,86	11,90	2,16	10,43	1,80	15,088	2,715
VAR(u(1j)) [C]									0,200	0,066
COVAR										
ARH var									0,664	0,104
FIT (par)										
Deviance	1957,85	3,00	1954,04	4,00	1797,67	6,00	1792,08	7,00	1929,97	6,00
Diff Dev [A]			3,81	1,00	156,38	1,00	161,96	1,00	24,08	2,00
AIC [B]	1963,85		1962,04		1809,67		1806,08		1941,97	
Explained variance										
R2 level 1					-0,04		0,26		0,180	
R2 level 2					-0,10		0,04		-0,396	
R2 cross level interaction										

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance)		Model 6 Model 2 and fixed cn.Acc	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
HR 25% ARTIFACTS												
FIXED												
mean/intercept	2,120	1,366	4,546*	1,726	4,522*	1,806	0,143	3,309	4,182*	1,586	4,129*	1,702
time			0,992*	0,432	0,936*	0,454	1,039*	0,428	0,954*	0,439	0,955*	0,429
temperature					0,050	0,333						
movement					1,074*	0,523	1,238*	0,526	1,154*	0,510	1,224*	0,513
sex							4,045	3,037				
pcl							0,332	0,207				
aggression							-3,967	2,722				
RANDOM												
VAR(e(ij)) [C]	124,62	13,32	121,32	12,95	120,76	13,64	118,18	12,62	118,80	14,26	119,58	12,79
VAR(u(0j)) [C]	71,63	23,15	72,26	22,99	70,22	24,16	59,27	19,68	48,51	33,08	67,54	22,01
VAR(u(1j)) [C]									0,43	1,97		
COVAR												
ARH var									-0,69	2,80		
FIT (par)												
Deviance	1952,89	3,00	1947,67	4,00	1763,79	6,00	1903,17	8,00	1941,38	7,00	1942,06	5,00
Diff Dev [A]			5,22	1,00	183,88	1,00	44,50	1,00	6,29	2,00	5,61	1,00
AIC [B]	1958,89		1955,67		1775,79		1919,17		1955,38		1952,06	
Explained variance												
R2 level 1					0,00		0,03		0,02		0,01	
R2 level 2					0,03		0,18		0,33		0,07	
R2 cross level interaction												
HR 50% ARTIFACTS												
FIXED												
mean/intercept	1,115	1,217	3,741*	1,595	3,604*	1,687	0,323	3,096	3,775	1,968	3,392*	1,576
time			1,022*	0,396	1,012*	0,415	1,052*	0,396	1,081	0,587	1,002*	0,391
temperature					0,357	0,329						
movement					1,122*	0,446	1,195*	0,448	1,199*	0,417	1,231**	0,437
sex							3,182	2,755				
pcl							0,215	0,185				

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance)		Model 6 Model 2 and fixed cn.Acc	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
aggression							-2,118	2,553				
RANDOM												
VAR(e(ij)) C	141,286	12,620	137,17	12,26	136,43	12,87	134,97	12,21	96,71	10,20	134,25	12,00
VAR(u(0j)) C	66,481	18,028	68,89	18,32	68,57	19,37	60,67	16,98	171,60	51,96	66,12	17,73
VAR(u(1j)) C									14,10	4,57		
COVAR												
ARH var									0,77	0,08		
FIT (par)												
Deviance	2584,90	3,00	2578,34	4,00	2320,60	6,00	2496,02	8,00	2550,22	7,00	2570,51	5,00
Diff Dev A			6,56	1,00	257,74	1,00	82,32	1,00	28,12	2,00	7,83	1,00
AIC B	2590,90		2586,34		2332,60		2512,02		2564,22		2580,51	
Explained variance												
R2 level 1					0,01		0,02		0,29		0,02	
R2 level 2					0,00		0,12		-1,49		0,04	
R2 cross level interaction												
HR 75% ARTIFACTS												
FIXED												
mean/intercept	1,586	1,214	3,107*	1,506	3,308*	1,608	-0,902	3,062	2,996	1,653	3,080*	1,490
time			0,621	0,366	0,742	0,388	0,790*	0,369	0,666	0,452	0,702	0,361
temperature					0,031	0,318						
movement					1,166*	0,384	1,219**	0,379	1,086**	0,375	1,250**	0,371
sex							2,018	2,730				
pcl							0,267	0,185				
aggression							-0,342	2,572				
RANDOM												
VAR(e(ij)) C	144,08	11,75	142,96	11,65	143,003	12,308	139,26	11,50	116,88	10,71	138,28	11,26
VAR(u(0j)) C	73,17	17,78	72,65	17,61	75,529	19,180	69,11	16,99	116,73	32,90	71,99	17,23
VAR(u(1j)) C									6,13	2,41		
COVAR												
ARH var									0,59	0,14		
FIT (par)												

	Model 1: random intercept		Model 2: random intercept with time		Model 3: Fixed level 1		Model 4: Fixed level 2		Model 5: Random Slope time (ARH covariance)		Model 6 Model 2 and fixed cn.Acc	
	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE	Parameter	SE
Deviance	2994,30	3,00	2991,44	4,00	2687,67	6,00	2884,20	8,00	2969,09	7,00	2980,26	5,00
Diff Dev [A]			2,86	1,00	303,77	1,00	107,24	1,00	22,35	2,00	11,18	1,00
AIC [B]	3000,30		2999,44		2699,67		2900,20		2983,09		2990,26	
Explained variance												
R2 level 1					0,00		0,03		0,18		0,033	
R2 level 2					-0,04		0,05		-0,61		0,009	
R2 cross level interaction												

[A] cut off value for test with 1 df is 3.84; cut off value for test with 2 df is 5.99; [B] lowest AIC is best model; [C] in test of random parameters (both Wald as well as difference of deviances), p has to be divided by 2; * Correlation is significant at the 0.05 level (2-tailed); ** Correlation is significant at the 0.01 level (2-tailed).


8

DUTCH SUMMARY

NEDERLANDSE SAMENVATTING

Het onderzoek in dit proefschrift was gericht op de vraag of het gebruik van draagbare biosensoren kan bijdragen aan het signaleren van agressief gedrag van patiënten en burn-out symptomen van begeleiders die werkzaam zijn binnen de Borg. De Borg is een samenwerking tussen vier instellingen die zorg verlenen aan patiënten met een ernstige stoornis in gedrag en een licht verstandelijke beperking (SGLVG; sterk gedragsgestoord en licht verstandelijk gehandicapt). Tevens worden patiënten vanuit een justitieel kader geplaatst (SGLVG+). Zoals de naam SGLVG doet vermoeden, is een belangrijk onderdeel van de behandeling gericht op het verminderen van agressief gedrag van patiënten, dit is tevens de belangrijkste reden voor verwijzing naar één van de Borg-instellingen. Agressief gedrag heeft een negatieve invloed op het behandeltraject van de patiënt en in sommige gevallen moeten dwangmaatregelen toegepast worden zoals separatie of dwangmedicatie om gevaarlijke situaties te voorkomen. Bovendien beïnvloedt het agressieve gedrag ook de mogelijkheden van de patiënt gedurende de resocialisatie in de maatschappij. Niet in de laatste plaats draagt agressief gedrag bij aan verminderd welzijn van de patiënt, de begeleiders en overige patiënten. Begeleiders die met de deze doelgroep werken lopen een verhoogd risico op het ontwikkelen van burn-out klachten waardoor zij eerder van baan verwisselen, op een andere plek gaan werken of langdurig afwezig zijn.

Onderzoek met biosensoren heeft uitgewezen dat mensen die agressief gedrag vertonen vaker een lagere rusthartslag hebben dan mensen die geen agressief gedrag vertonen. Meer recentelijk bleek uit een pilotstudie dat de huidgeleiding een toename liet zien in aanloop naar agressief gedrag, nog voordat de begeleiders uiterlijke tekenen zoals onrust of irritatie bij de patiënt opmerkten. Mogelijk kunnen biosensoren gebruikt worden bij het signaleren van agressief gedrag en daarmee een bijdrage leveren aan de voorspelling of preventie van agressie. Daarnaast werd in eerder onderzoek gesuggereerd dat fysiologische metingen met biosensoren bruikbaar zijn bij het signaleren van (chronische) stress en vermoeidheidsklachten, twee factoren die sterk samenhangen met burn-out symptomen. Recente technologische ontwikkelingen maken het mogelijk om de biosensoren 24 uur per dag te gebruiken. Bovendien kan de apparatuur aan de pols gedragen worden waardoor er sprake is van een minimale belasting voor zowel de patiënt als de begeleider.

Hoofdstuk 1

In hoofdstuk 1 wordt de algemene introductie voor het proefschrift beschreven. De instellingen van de Borg zijn Trajectum, Ipse de Bruggen, Stevig Dichterbij en Fivoor. De patiënten die bij één van de Borg-instellingen zijn opgenomen behalen doorgaans een

IQ-score tussen 50 en 85 op een intelligentie test. Naast een verstandelijke beperking kan er sprake zijn van ernstige gedrags- en/of psychiatrische problemen. De patiënten ervaren problemen op emotioneel, sociaal of financieel gebied, in relaties met familie en vrienden of bij het gebruik van verslavende middelen. Zoals eerder gezegd is de belangrijkste reden voor een verwijzing naar de Borg-instellingen ernstig agressief gedrag. Het agressieve gedrag vormt een probleem in de maatschappij maar het vergroot ook de kans op dwangmaatregelen tijdens een opname. Bovendien heeft agressie een negatieve invloed op het functioneren van begeleiders en kan resulteren in fysiek letsel, emotionele problemen of langdurig ziekteverzuim. Uit eerder onderzoek blijkt dat chronische stress en burn-out klachten bij begeleiders een belangrijke reden zijn voor langdurige afwezigheid of het verlaten van de gezondheidssector om elders te gaan werken. Ook wordt burn-out in verband gebracht met negatievere behandeluitkomsten voor patiënten, bijvoorbeeld door een langere behandelduur of verminderde resocialisatie uitkomsten. Het verminderen van agressief gedrag van patiënten en het verminderen van chronische stress en burn-out klachten bij begeleiders is daarom van belang om het welzijn van begeleiders en patiënten te vergroten. De meest gebruikte methode om zowel agressie als burn-out te signaleren is het gebruik van vragenlijsten of risico taxatie instrumenten die ingevuld moeten worden door begeleiders of patiënten. Deze vragenlijsten hebben hun nut inmiddels bewezen maar een belangrijk nadeel van vragenlijsten is de tijdsinspanning voor het invullen van de lijsten waardoor er minder aandacht voor de directe zorg overblijft. Er is de Borg veel aan gelegen om de bruikbaarheid van alternatieve voorspellers van agressie en burn-out te onderzoeken waarmee interventies zoals biofeedback kunnen worden ontwikkeld. Signalering van agressie en burn-out middels biosensoren kan bijdragen aan de veiligheid binnen de klinieken maar ook aan de zelfredzaamheid van patiënten en begeleiders, zij monitoren immers zelf.

Gedurende de afgelopen decennia is er meer aandacht gekomen voor de samenhang tussen fysiologische metingen met hartslag of huidgeleiding en agressief gedrag. Er is geen eenduidige definitie van agressief gedrag maar in onderzoeken wordt bijvoorbeeld onderscheid gemaakt tussen psychopathie, antisociale persoonlijkheidsstoornis, gewelddadig gedrag of verbale of fysieke agressie. Het meeste onderzoek naar fysiologie en agressief gedrag is uitgevoerd in laboratoria waarbij een experiment werd uitgevoerd of gebruikt gemaakt werd van testen en rustmetingen. Recente technologische ontwikkelingen maken het mogelijk om op grote schaal data te verzamelen in het dagelijks leven maar er zijn een aantal problemen die de dataverzameling en analyse bemoeilijken. Zo moet de biosensor van goede kwaliteit zijn, mag de biosensor niet te los gedragen worden, kan er veel ruis in het signaal zitten, moet het signaal automatisch gefilterd en visueel gecheckt worden, en zijn er vele berekeningen die je kunt gebruiken om de kenmerken of parameters van de signalen te beschrijven.

Zoals eerder gezegd is de meest voorkomende bevinding dat een lage rusthartslag samenhangt met gewelddadig gedrag. Eén grote literatuurstudie concludeerde dat hartslag samenhangt met agressie en psychopathie met huidgeleiding. Psychopathie is een conditie die wordt gekenmerkt door een gebrek aan empathie en problemen op affectief gebied, in de persoonlijke levenssfeer, met verhoogde scores op antisociaal gedrag en interpersoonlijke problemen. De associaties tussen hartslag, huidgeleiding en verschillende vormen van agressief gedrag zijn vaak gerapporteerd maar er is niet veel onderzoek in het dagelijks leven gedaan. Een reden hiervoor is dat biosensoren waarmee 24 uur per dag gemeten kan worden nog niet beschikbaar waren. Twee recente pilotstudies naar biosensoren en agressie lieten zien dat de huidgeleiding voorafgaand aan agressie stijgt maar hartslagmeters waren voor deze studies nog niet beschikbaar. Bovendien werd geen rekening gehouden met verschillen in huidgeleiding binnen en tussen personen. Zo is er variatie in rusthartslag tussen personen maar varieert de hartslag ook binnen een persoon gedurende de dag. Hiermee is rekening gehouden bij het ontwerp van de studie die wordt beschreven in hoofdstuk 7.

Ook de associatie tussen fysiologische metingen bij chronische stress en vermoeidheid kreeg meer aandacht in de laatste jaren. Chronische stress en vermoeidheid worden als symptomen van burn-out gebruikt. Er is over burn-out enige controverse omdat verscheidene onderzoekers denken dat burn-out een vorm van depressie is en ook zo genoemd zou moeten worden. In dit proefschrift gaan we niet in op deze controverse maar het onderzoek naar burn-out van de afgelopen 45 jaar toont aan dat er klinisch relevante resultaten mee zijn behaald. Inmiddels zijn er zijn meerdere definities van burn-out beschikbaar maar een veel gebruikte definitie bestaat uit 3 factoren; emotionele uitputting, depersonalisatie en verminderde persoonlijke bekwaamheid. Onderzoek naar burn-out heeft uitgewezen dat verschillende beschermende- en risicofactoren een bijdrage leveren aan de ontwikkeling van een burn-out. Beschermende factoren zijn bijvoorbeeld een verhoogde emotionele intelligentie, persoonlijkheidstrekken zoals verhoogde scores op extraversie en nauwgezetheid en de hoeveelheid sociale steun die stafleden ontvangen. Risicofactoren zijn bijvoorbeeld de omgang met moeilijk verstaanbaar gedrag van patiënten, agressief gedrag, chronische werkstress en verhoogde scores op neuroticisme, dat is een maat voor emotionele stabiliteit. Zowel chronische als acute stress heeft een negatieve invloed op het lichaam. Onderzoek heeft uitgewezen dat fysiologische indicatoren zoals hartslag en huidgeleiding samenhangen met de hoeveelheid (chronische) stress en vermoeidheid. Daarom kunnen biosensoren mogelijk gebruikt worden om burn-out klachten in een vroeg stadium te signaleren wat bij kan dragen aan preventie en het verminderen van uitval of ziekte.

Samenvattend werd in dit proefschrift onderzocht wat de samenhang is tussen fysiologische metingen en agressief gedrag bij patiënten. Daarnaast werd onderzocht wat de samenhang is tussen fysiologische metingen en burn-out klachten bij begeleiders. Als laatste werd onderzocht wat belangrijke beschermende en risicofactoren van burn-out op de lange termijn zijn. De fysiologische maten die in dit proefschrift worden bekeken zijn hartslag en huidgeleiding.

Hoofdstuk 2

In hoofdstuk 2 wordt een kleinschalige studie beschreven waarin de samenhang tussen huidgeleiding en het werken in verschillende diensten werd onderzocht. Een tweede vraag was wat de samenhang is tussen huidgeleiding en persoonlijkheidskenmerken. Bij de aanvang van deze studie beschikten we nog niet over polsbanden waarmee hartslag kon worden gemeten, hierdoor kon alleen een huidgeleiding signaal worden gebruikt. Tien begeleiders droegen gedurende een ochtend-, avond- en nachtdienst een polsband waarmee de huidgeleiding voor 30 diensten in kaart kon worden gebracht. Tevens werd een vragenlijst naar persoonlijkheid afgenomen.

De belangrijkste bevinding van deze studie is dat de huidgeleiding tijdens een avonddienst gemiddeld twee keer zo hoog is in vergelijking met een ochtend- of een nachtdienst. Een mogelijke verklaring hiervoor is dat er minder stafleden zoals psychologen, managers en psychiaters aanwezig zijn tijdens de avonddienst, hierdoor komt de zorg voor de patiënten op de schouders van de begeleiders terecht. Daarnaast volgen patiënten gedurende de dag verschillende dagprogramma's en slapen de meeste patiënten 's nachts. Een tweede bevinding was dat hogere neuroticisme scores samenhangen met een hogere huidgeleiding. De bevindingen moeten met voorzichtigheid geïnterpreteerd worden omdat er sprake is van een kleine steekproef.

Hoofdstuk 3

De doelstelling van de literatuurstudie die beschreven wordt in hoofdstuk 3 was tweeledig. Allereerst werd onderzocht of werkstress en burn-out samenhangen met hartslag(variabiliteit) en huidgeleiding. Daarnaast werd onderzocht of er richtlijnen voor dergelijk onderzoek beschikbaar zijn met betrekking tot dataverzameling, analyse en rapportage van hartslag en huidgeleiding.

In de literatuurstudie werden studies opgenomen die uitgevoerd zijn tussen 2000 en 2016. Het onderzoek moest gedaan zijn bij volwassen personen uit de beroepsbevolking met gevalideerde vragenlijsten.

De belangrijkste bevinding uit de literatuurstudie was dat werkstress voornamelijk samenhangt met een verhoogde hartslag en een verlaagde hartritmevariabiliteit. Er werden onvoldoende studies naar burn-out opgenomen om conclusies te trekken.

De studie leverde een overzicht op van diverse methodologische aanbevelingen voor het gebruik van biosensoren in de dagelijkse praktijk waarvan drie bevindingen het meest opvallend zijn. Ten eerste, niet alle artikelen rapporteren over een rustmeting. Dat is opvallend omdat een rustmeting als voordeel heeft dat het signaal niet beïnvloed wordt door beweging. Het kan daarom dienen als baseline of 'ground truth'. Bovendien kan een dergelijke baseline gebruikt worden om te controleren voor variatie tussen en binnen personen, dat is relevant omdat fysiologische maten zoals hartslag en huidgeleiding, variatie vertonen gedurende een dag. Ten tweede, het is aan te bevelen om een afweging te maken aangaande de parameters van hartslag en huidgeleiding die gebruikt worden voor de analyse. Zo is een tijdsanalyse van het hartsignaal bijvoorbeeld minder gevoelig voor beweging dan een frequentie analyse. Ook is het aan te bevelen om altijd voor beweging en ademhaling te controleren indien mogelijk. Ten derde, de tijdsduur van de metingen die worden verzameld met biosensoren beïnvloeden de gebruikte parameters van hartslag (en in mindere mate huidgeleiding). Een veelgebruikte parameter voor tijdanalyse van hartslag is bijvoorbeeld de standaarddeviatie van het NN-interval (ook wel peak-to-peak genoemd, SDNN). Het gebruik van deze parameter wordt alleen aanbevolen bij 24 uurs-metingen maar wordt in de literatuur ook gerapporteerd als de metingen korter zijn. Het is van belang om goed af te wegen over welke parameters gerapporteerd wordt in het onderzoek. Het rapporteren van informatie over de tijdsduur van de metingen, de gebruikte analyses en eventuele transformaties van de data wordt daarom aanbevolen.

Een interessante bevinding die niet direct aan de methodologische dataverzameling ten grondslag lag was dat een grotere steekproef resulteerde in meer verwachte effecten. Een grotere steekproef betekent doorgaans dat een onderzoek meer kans heeft op het vinden van het ware effect, in dit geval een positieve associatie van werkstress met hartslag en een negatieve associatie met hartslagvariatie. Een laatste belangrijke bevinding is dat er meer onderzoek is gedaan naar mannen dan naar vrouwen. In toekomstig onderzoek zal bekeken moeten worden of de associatie tussen werkstress en hartslag (variatie) vergelijkbaar is tussen mannen en vrouwen.

Een sterk punt van de studie was de replicatie van een gedeelte van een eerder literatuuronderzoek naar stressoren op het werk en hartslag (variatie). Dit is met name relevant omdat de psychologie al enige tijd kampt met een replicatiecrisis. Afsluitend worden in het hoofdstuk een aantal aanbevelingen gedaan voor toekomstig onderzoek; volg de richtlijnen voor het rapporteren van observationeel onderzoek, gebruik gevalideerde vragenlijsten, gebruik gevalideerde afkapwaardes om werkstress vast te stellen en rapporteer de leeftijd en sekse van de proefpersonen om de vergelijkbaarheid te vergroten.

Hoofdstuk 4

Hoofdstuk 4 beschrijft een studie waarin een Nederlandse vragenlijst naar werkstress werd gevalideerd. De Engelse vragenlijst werd destijds ontwikkeld voor begeleiders die werken met mensen met een verstandelijke beperking. Dit was de voornaamste reden om de vragenlijst te vertalen en te valideren voor het gebruik voor begeleiders in de SGLVG-sector. Bovendien was de vragenlijst specifiek ontwikkeld om een open dialoog met begeleiders aan te gaan wat zou leiden tot een verhoogd welzijn en verbeterde prestaties op het werk. De vragenlijst is tijdens het onderzoek vier keer afgenomen over een periode van twee jaar. Werkstress wordt in de vragenlijst omschreven als een combinatie van eisen, steun en beperkingen die op het werk ervaren worden. De vragenlijst bestaat uit twee schalen, een 'eisen' schaal en een 'steun' schaal (tot de laatstgenoemde schaal behoren ook de items voor de beperkingen die mensen ervaren).

De resultaten van de confirmatieve factoranalyse lieten zien dat de factorstructuur voor de 'eisen' schaal overeenkomt met de Engelse versie. De 'steun' schaal kwam niet geheel overeen met de Engelse versie en moet aangepast worden naar twee factoren (van de drie) indien de vragenlijst wordt gebruikt binnen de Borg-instellingen. De resultaten wezen er bovendien op dat de scores op de vragenlijst niet vergeleken kunnen worden over de tijd omdat de betekenis van de items voor de participant verandert. Daarnaast wordt in de vragenlijst geen rekening gehouden met agressie, een eis waar begeleiders in SGLVG-instellingen regelmatig mee te maken krijgen. Meer onderzoek en een mogelijke uitbreiding van de vragenlijst is daarom aan te bevelen.

Hoofdstuk 5

In hoofdstuk 5 worden de resultaten gepresenteerd van het onderzoek naar begeleiders. Het doel van de studie was om te bekijken wat de rol van agressief gedrag van patiënten is bij het ontwikkelen van een burn-out. Daarnaast werden beschermende- en risicofactoren onderzocht waarvan verondersteld wordt dat zij de associatie tussen agressie en burn-out beïnvloeden; persoonlijkheid, werkstress en emotionele intelligentie. Niet in de laatste plaats wilden we onderzoeken of huidgeleiding een voorspeller was van burn-out symptomen.

Voor deze studie werden 114 begeleiders bereid gevonden om mee te doen en vulden de vragenlijsten in. Begeleiders droegen de polsband Empatica E4 gedurende een dag- of avonddienst en vulden daarnaast vragenlijsten in naar persoonlijkheid, werkstress, emotionele intelligentie, burn-out en ervaren agressie (Bemerk dat 110 van de 114 begeleiders de E4 hebben gedragen, 114 van hen vulden de vragenlijsten in).

Uit de resultaten bleek dat met name het ervaren van fysieke agressie tot een toename in burn-out symptomen kan leiden. Zoals verwacht hing een toename van de ervaren agressie samen met een toename in de hoeveelheid ervaren werkstress, wat weer samenhing met een toename in de hoeveelheid burn-out symptomen die mensen ervaren. Opvallend wat dat stress managementvaardigheden, dat is een subschaal van emotionele intelligentie, een versterkend effect heeft op deze samenhang, maar niet persoonlijkheid, zoals vooraf werd aangenomen. Bovendien was de associatie tussen fysieke agressie en burn-out het sterkst voor begeleiders met meer zelf gerapporteerde stress managementvaardigheden. In andere woorden, fysieke agressie heeft een hogere impact op begeleiders die denken dat hun stressmanagementvaardigheden relatief hoger zijn. De burn-out symptomen van deze groep mensen zijn relatief hoger dan voor mensen die aangeven dat ze relatief lagere stressmanagementvaardigheden hebben. Verder bleek het aantal burn-out symptomen niet samen te hangen met de huidgeleiding. Een opvallende bevinding omdat we dat vooraf wel verwacht hadden.

Belangrijke implicaties van het onderzoek voor de praktijk zijn met name dat begeleiders die fysieke agressie hebben ervaren goed gevolgd moeten worden door de organisatie en sociale steun moeten ontvangen om de kans op negatieve uitkomsten te verkleinen.

Hoofdstuk 6

In hoofdstuk 6 wordt een longitudinale studie beschreven over de bruikbaarheid van biosensoren bij het signaleren van een toename in burn-out symptomen. Ook wordt beschreven wat de invloed is van beschermende en risicofactoren die een rol spelen in de ontwikkeling van burn-out maar waarvan onduidelijk was wat de invloed van deze factoren over de tijd is. Voor dit onderzoek hebben we 110 begeleiders (42 van hen vielen uit) gedurende een periode van 2 jaar gevolgd en hebben zij viermaal een Empatica E4 polsband gedragen tijdens een ochtend of avonddienst. Tevens hebben zij vragenlijsten ingevuld naar persoonlijkheid, werkstress, emotionele intelligentie, burn-out en ervaren agressie.

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De eerste bevinding was dat de hoogte van de huidgeleidingsrespons een fysiologische voorspeller voor burn-out kan zijn, zelfs nadat gecontroleerd is voor de andere variabelen. Daarnaast is emotionele intelligentie de belangrijkste voorspeller voor burn-out gevolgd door werkstress, neuroticisme, altruïsme en agressie.

Een tweede bevinding van het onderzoek was dat een substantieel deel van de begeleiders uitviel als gevolg van langdurige ziekte, veranderen van baan of enige vorm van verlof. Van de 110 begeleiders die opgenomen zijn in het onderzoek waren er nog 68 over aan het einde van de studie. Opvallend was dat de uitvallers het onderzoek startten met een 1 punt hogere burnoutscore dan de blijvers (op een schaal van 3-15), mogelijk kan deze informatie gebruikt worden voor de dagelijkse praktijk. Op deze manier kunnen we vooraf bepalen of een begeleider een verhoogde kans heeft om op korte termijn uit te vallen.

Een derde bevinding was dat voor alle begeleiders de burnoutscore gemiddeld toenam over de tijd. Begeleiders die mee hebben gedaan aan het onderzoek lieten bovendien een toename van 1 burnoutcategorie zien over een periode van 2 jaar. Dit is nog een voorzichtige schatting omdat de uitvallers later in het onderzoek niet meer meedoen in de analyse en dit kan een verklaring zijn waarom een aantal begeleiders ziek uitviel of een andere baan zocht.

Enkele noemenswaardige implicaties van dit onderzoek zijn dat biosensoren gebruikt kunnen worden als een niet invasieve, redelijk goedkope manier om stafleden te monitoren. Daarnaast zou met name de training in emotionele intelligentie een goede manier zijn om stafleden meer bestendig tegen werkstress en burn-out te maken. Een belangrijke beperking van het onderzoek is dat het tijdsinterval vrij lang is voor (6 maanden) voor fysiologische metingen. Er is veel variatie in fysiologie, zelfs al gedurende de dag. Meerdere metingen met een korter tijdsinterval zijn waarschijnlijk nodig om de voorspellingen te verbeteren.

Hoofdstuk 7

In hoofdstuk 7 wordt de laatste observationele studie van het onderzoek beschreven. Het doel was om te bepalen of biosensoren gebruikt kunnen worden om agressief gedrag te signaleren. Dit zou bij kunnen dragen aan methodes voor preventie en monitoring. Uit literatuuronderzoek en twee eigen pilotstudies werd duidelijk dat de draagbare apparatuur gevoelig is voor artifacten (verstoringen in het signaal). Dit betekent dat er ruis in het signaal kan ontstaan als gevolg van deze artifacten, bovendien was onduidelijk wat voor invloed het aantal artifacten heeft op de statistische modellen die gebruikt worden.

Voor het onderzoek konden 100 patiënten in de studie opgenomen worden die gedurende vijf dagen een Empatica E4 polsband hebben gedragen. De begeleiders van deze patiënten registreerden of de patiënten agressief gedrag vertoonden. De begeleiders droegen een horloge waarmee zij een exacte tijdsregistratie maakten van het tijdstip waarop agressief gedrag en incidenten plaatsvonden. Voor ieder agressief incident werd bekeken wat er een half uur voorafgaand aan het agressieve incident voor fysiologische veranderingen zichtbaar waren. Het halve uur voorafgaand aan het incident werd vergeleken met periodes waarin de patiënt geen agressief gedrag vertoonde.

De eerste bevinding was dat hartslag, huidgeleiding en het aantal huidgeleidingspiekjes per minuut een opmerkelijke stijging vertonen voorafgaand aan agressief gedrag. Deze stijging vindt ongeveer 20 minuten voorafgaand aan het agressieve gedrag plaats. De tweede bevinding was dat de hoeveelheid toegestane artifacten van invloed is op de statistische modellen die gebruikt worden. De belangrijkste implicaties van dit onderzoek zijn dat biosensoren mogelijk gebruikt kunnen worden als een niet invasieve, redelijk goedkope manier om patiënten te monitoren op het ontstaan van agressief gedrag. Verder onderzoek is nodig om te bepalen hoe goed de modellen agressie kunnen voorspellen en of er voorspellingen op individueel niveau mogelijk zijn. Daarnaast is het van belang voor onderzoekers en begeleiders om rekening te houden met de hoeveelheid artifacten in de data omdat deze van invloed zijn op de voorspellende kracht van de modellen.

Hoofdstuk 8

In hoofdstuk 8 van dit proefschrift wordt in de algemene discussie gepoogd om de bevindingen van het huidige proefschrift te synthetiseren. Er wordt een antwoord geformuleerd op de vraag of biosensoren gebruikt kunnen worden om agressief gedrag bij patiënten en burn-out symptomen bij begeleiders te signaleren. Daarnaast wordt besproken welke voorspellers een rol spelen in de ontwikkeling van burn-out symptomen in de tijd. Deze voorspellers zijn emotionele intelligentie, persoonlijkheid, werkstress en agressie. De resultaten van dit onderzoek kunnen belangrijke implicaties hebben voor toekomstig onderzoek, en voor de klinische praktijk. Met name hartslag en huidgeleiding kunnen een bijdrage leveren aan het signaleren van agressief gedrag. Meer onderzoek is nodig om de voorspelling te personaliseren en verbeteren. Onderzoekers die met de biosensoren werken zullen ook een antwoord moeten krijgen op de precieze invloed van artifacten op de predictieve waarde van de voorspelling. Uit ons onderzoek bleek dat het toestaan van een hogere afkapwaarde voor het aantal artifacten van invloed is op de statistische modellen.

Uit het onderzoek bleek dat emotionele intelligentie de belangrijkste voorspeller was van de ontwikkeling van de hoeveelheid burn-out symptomen over tijd. Emotionele intelligentie kan tot op zekere hoogte getraind worden en daarom ingezet worden om een toename in burn-out symptomen te beperken. Een tweede voorspeller voor burn-out was werkstress. Werkstress hoeft niet nadelig te zijn maar bij mensen die hogere scores halen op deze vragenlijst is de kans groter dat zij ook te maken krijgen met een toename in burn-out symptomen. Ook de persoonlijkheidskenmerken neuroticisme en altruïsme zijn van belang in de toename van burn-out symptomen over tijd. Altruïsme is een beschermende factor terwijl neuroticisme een risicofactor vormt. Neuroticisme wordt ook wel beschreven als een neiging tot emotionele stabiliteit. Als laatste was de hoeveelheid agressie die mensen ervaren een voorspeller van burn-out symptomen. Deze factoren kunnen in overweging genomen worden bij het plaatsen van personeel. De resultaten kunnen gebruikt worden om specifieke begeleiders van sociale steun te voorzien. Zo blijkt uit onderzoek dat sociale steun vanuit de organisatie een beschermende werking heeft op het ontwikkelen van een burn-out. In algemene zin, op basis van de bevindingen van deze studie, willen we voorstellen dat training van emotionele intelligentie, en training van interactie vaardigheden gecombineerd met ondersteuning van het management zou kunnen bijdragen aan de veerkracht van personeel in het omgaan met agressie en burn-out. Recent onderzoek heeft laten zien dat training die gericht is op het vergroten van emotionele intelligentie en interactievaardigheden effectief is.

De resultaten van het onderzoek hebben ook implicaties voor het gebruik van draagbare biosensoren. Zo is het van belang om vooraf goed na te denken over de tijdsperiode waarin gemeten wordt en welke parameters geschikt zijn om te analyseren. Het is aan te bevelen om gebruik te maken van een baseline, mogelijk kan hiervoor een rustmeting gebruikt worden. Ook heeft de hoeveelheid beweging en de ademhaling invloed op de metingen, het is een goed idee om hiervoor te controleren. Als het signaal is verkregen dan is het aan te bevelen om gebruik te maken van een filter om de correcte data eruit te halen. Dit kan onder verschillende afkapwaardes, het is van belang om vooraf te bepalen welke afkapwaardes daarvoor gebruikt kunnen worden. Het onderzoek heeft laten zien dat biosensoren gebruikt kunnen worden in de dagelijkse praktijk van de SGLVG-instellingen. Verder onderzoek zal uit moeten wijzen hoe nauwkeurig deze voorspellingen zijn en of de resultaten repliceerbaar zijn, de belangrijkste voorwaarde voor een betrouwbaar resultaat.