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Position Paper: Assessing Stress in UK Operational Police Officers

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ABSTRACT

This paper represents initial research into linking an individual Police Officer's heart rate with the operational activity currently being undertaken to ascertain whether the person may be considered under stress. There is a discussion of heart rate physiology as it relates to stress including health related issues that are caused by stress. For the purpose of this research athletic training zones were used as an indication that an Officer's heart rate had increased to an abnormal level even though they were not undertaking physical activities. The results indicate that, in certain circumstances, Officers' heart rates rise into their training zone indicating that the current activity that is being undertaken may be causing them stress.

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Introduction

Stress is a catch-all term that describes bodily reactions to a range of perceived threats, both physical and psychological. Once essential for survival, the pace of modern life and its myriad demands has turned stress itself into a major threat. Cortisol is secreted into the body by the adrenal glands and is an important hormone involved in a range of functions including being secreted in higher levels during the body's reaction to stress in the "fight or flight" syndrome. Small increases have positive effects such as providing a quick burst of energy, heightened memory functions and lower sensitivity to pain. However, prolonged high levels of cortisol can lead to a range of unhealthy conditions such as heart disease (Seyle, 1950).

If chronic, stress can have serious health consequences, and is a leading risk factor for heart diseases, diabetes, asthma and depression. However short term stress, which is the "fight or flight" syndrome, can affect sleep patterns in the form of insomnia and fatigue and also result in physical pain in the back, shoulders and neck (Reliable resource to ease stress, 2010). It may also affect a person's speech (Wittels et al., 2002).

It has been shown that psychological stress can suppress an immune system's response to infection (Segerstrom & Miller, 2004; Cohen et al, 1991) and slow the rate of wound healing (Kiecolt-Glaser et al., 1995). Lazarus (1995:8) states;

> (…) It should come as no surprise that many conditions of work such as time pressure, noise, work overload,, lack of decisional control, role ambiguity, conflicts with superiors and subordinates and so on are stressful for large numbers of workers (…).

Despite its impact on health, however, it is not unfeasible for physicians to continuously monitor our stress levels, nor is it practical (or objectively possible) for us to keep logs of our internal states throughout the day. Thus, a device that

could monitor stress over extended periods (from weeks or months) would provide individuals and their caretakers with hard data with which to monitor progress and determine the most appropriate interventions. A number of physiological markers of stress have been identified, including electrodermal activity (EDA), heart rate (HR), various indices of heart rate variability (HRV), blood pressure (BP), muscle tension, and respiration. However, in order to gain acceptance as a method of stress management in the workplace, wearable sensors must be minimally obtrusive, so that workers can perform their tasks with complete freedom, and inconspicuous, to avoid anxieties associated with wearing medical devices in public. These usability considerations preclude some of the above measures from being considered as a long-term solution for stress monitoring. As an example, EDA is one of the most robust physiological indices of stress, but electrodes must be placed in the fingers or the palm of the hand, which severely limits dexterity; electrodes can be placed in the feet, but the resulting measurements are then dependent on posture. Another indicator of stress, arterial blood pressure, is equally unsuited for long-term monitoring; accurate measurements are invasive (e.g. a needle must be inserted in an artery), whereas non-invasive methods (e.g. inflatable cuffs) are cumbersome and inaccurate. Fortunately, a wealth of information can be extracted from the heart. Measurements of cardiac activity are robust and, with the advent of consumer-grade heart rate monitors (HRM), relatively unobtrusive and affordable.

To this end, this research explores the feasibility of detecting short term stress in operational Police Officers by using a biometric monitoring/recording device and concentrating mainly on an individual's heart rate.

Monitoring Physiological Conditions

Early research by Darwin (1872: 69) was the first exponent who stated that neural modulation of the heart was a contributor to emotion and stress.

> (…) when the mind is strongly excited, we might expect that it would instantly affect in a direct manner the heart (…) when the heart is affected it reacts on the brain; and the state of the brain again reacts through the pneumo-gastric [vagus] nerve on the heart; so that under

> any excitement there will be much mutual action and reaction between these, the two most important organs of the body.

The vagus nerve has a number of functions including: help to regulate the heart beat, control muscle movement, keep a person breathing and to transmit a variety of chemicals through the body. Recent research relating stress with measures of cardiac vagal tone is focused by the assumed relationship between the central nervous system and the vagal control of the heart (Porges, 1985). Many researchers have expounded that the neurally mediated oscillations in the heart rate pattern reflect a variety of mental states including stress, emotion, consciousness/alertness and attention (Porges and Byrne, 1992).

Stress causes sympathetic responses (such as higher cortisol level, smaller HR variability (HRV), and higher blood pressure). Heart rate variability (HRV) is the variation usually measured as the beat-to-beat interval. The accuracy is dependant on precisely detecting the R-wave peak and the precision of the timing between the RR intervals. Porges and Byrne (1992) recommend that researchers strive to attain 1 ms accuracy as, in certain areas (high risk populations) +/- 1-2 ms can be significant. Movement can produce spikes in the ECG trace which may be falsely assigned as R-waves. One of the more global and simple measures of HRV is the standard deviation of the mean R–R interval (SD_{RR}) (Berntson et al., 1997). When healthy subjects are acutely stressed, HR increases and SD_{RR} decreases transiently (De Geus et al., 1990; Boutcher and Stocker, 1996).

The greater the range of the phasic increases and decreases, the "healthier" the individual. In some situations when measuring HRV it is possible to identify task effects when the average heart rate is static (Lee and Park, 1990). As yet, only a few studies have investigated the impact of acute stressors on various HR complexity measures in healthy individuals. Anishchenko et al. (2001) showed in healthy young subjects that short-term psychological stress was associated with both decreases and increases in HR complexity (i.e., normalized entropy) regardless of the type of stressor (i.e., noise exposure, mental arithmetic, arithmetic against noise, and examination stress). Moreover, Hagerman et al. (1996) demonstrated in ten healthy individuals (33–51 years of age) that the

dominant largest Lyapunov exponent (LLE) of HR significantly decreased during exercise stress.

It has been established that wearing a body sensor to record heart rate (R-R signal) is as accurate as a three lead electro cardiogram (ECG) (Choi & Gutierrez-Osuna, 2009). These authors also show that by using a classifier, they could determine their human subjects were being subjected to mental stress when taking a word and/or mental arithmetic test, by measuring their heart rate.

For the purpose of this paper the authors propose to use an athletic measurement of heart rate (Calvert et.al., 2010) to suggest that an Officer may be subjected to stress. This was decided as, during the time each Officer was monitored, none of them were involved in any overt physical activity which means that to register a heart rate in the training zone the body must undertake a physiological change if not through activity then possibly through stress. Table 1 illustrates the 5 training bands that are currently used by the Concept2 training guide. In this research the training zone refers to the bands UT2 and UT1, aerobic training.

- MaxHeartRate = (208 – (0.7 * age))
- %MaxHeartRate = 50/60/70/80/90%
- ((MaxHeartRate – RestingHeartRate) * %MaxHeartRate / 100) + RestingHearRate

It was not possible to ascertain an Officer's resting heart rate as they were on duty immediately the device was worn so the average heart rate was substituted in the above calculation. The average would be higher than the resting which would have the effect of narrowing the training zone. To suggest that an Officer's body has undergone a substantial physiological change which may indicate a stressful activity has occurred, only readings that were in the training zone for more than ten minutes were accepted.

Band	*Type of Work*	*% MHR*	*What it is good for*	*How you feel*
UT2	Utilisation 2. Light aerobic, low intensity work. Sustainable and fat burning.	55-70	General CV fitness.	Relaxed. Able to carry on a conversation.
UT1	Utilisation 1. Heavy aerobic work using more oxygen.	70-80	Higher level of CV fitness.	Working. Feel warmer. Heart rate and respiration up. May sweat.
AT	Anaerobic Threshold. Harder work. On the aerobic limit. Pushing into anaerobic area.	80-85	High level of CV fitness. Building mental and physical tolerance.	Hard work. Heart rate and respiration up. Carbon dioxide build up. Sweating. Breathing hard.
TR	Oxygen Transportation. Working hard. Unsustainable for long periods.	85-90	Developing oxygen transport to the muscles under stress. Increasing cardiac output.	Stressed. Panting. Sweating freely.
AN	Anaerobic (without oxygen). Short bursts of maximum effort. Unsustainable. Burning carbohydrate.	90-100	Anaerobic work. Increasing speed. Accustoming the body to work without oxygen.	Very stressful. Gasping. Sweating heavily.

Table 1. Heart Rate Training Bands

Methodology

A group of Police Officer volunteers from a UK Police Force Road Policing Department, mainly Police motorcyclists, were used in this preliminary work to establish the feasibility of using a HRM whilst undertaking operational policing duties. The group comprised 2 Sergeants and 7 male Constables all of whom are experienced traffic Officers.

During their tour of duty, Police Officers undertake self generated work, general patrol and are dispatched to recorded incidents. In general terms, a recorded incident is where a member of the public contacts the Police to report something such as a disturbance or a crime. There are 84 incidents categories on the UK Home Office Incident Category List (Home Office, 2008) which have been placed into 39 “super categories” for the purpose of this work. Each Officer completed a spreadsheet which identified the incidents according to a personal preference. Table 2 illustrates a sample of a completed list. The list has a numerical

preference rating of -5 to +5 and the Officer is requested to indicate his preference to each of the incident types.

Incident Set	***-5***	***-4***	***-3***	***-2***	***-1***	***0***	***1***	***2***	***3***	***4***	***5***
Abnormal Load							x				
Alarm Genuine									x		
Alarm Other								x			
Alarm Personal Attack						x					
Animals	x										
Anti Social Behaviour						x					
Bomb Threat								x			
Breath Test										x	
Burglary								x			
C&YP						x					
Car Crime										x	
Crime Other							x				
Criminal Damage						x					
Disorder										x	
Drugs						x					
Fire			x								
Firearms									x		
Fraud	x										
Kidnap	x										
Major Incident									x		
Motorway Incident						x					
Nuisance	x										
Other	x										
RTC-Fatal									x		
RTC-Injury									x		
RTC-Other								x			
Racial						x					
Robbery				x							
Searches				x							
Sexual Offences	x										
Sick & Aged People						x					
Sudden Death						x					
Suspicious Incidents						x					
Theft						x					
Traffic Incident										x	
Traffic Obstruction								x			
Traffic Offences										x	
Violence									x		
Wanted Missing Person			x								

Table 2. Completed Incident Preference List.

Each Officer was invited to wear a monitoring device. Figure 1 illustrates the Equivital monitor (Equivital, Wireless Physiological Monitoring 2010) and demonstrates how it is worn. The shoulder strap (Figure 1a) is particularly useful

as it assists in retaining the actual monitor (Figure 1b) in the correct position on the chest (Figure 1c). The retaining belts are slim and pliable ensuring that the entire device can be worn comfortably for long periods of time. Each Officer wore the device for a working shift of eight hours and maintained an activity log of their work which enabled the physiological readings to be aligned to actual tasks that were undertaken by the Officers. Two Officers wore the device four times each; one, three times; three, twice each and three each wore the device for a single shift. A specified vocabulary was used to ensure that subsequent analysis could be accurately aligned to the relevant tasks. Table 3 lists the activity vocabulary used during this research.

Figure 1. Wearable Body Sensor.

Vocabulary	***Meaning***
Arrest	Taking a member of the public into custody for an offence and processing that person
Bike Safe	Official motor cycle training for members of the public
Blue Light Run	Responding to an emergency call
General Patrol	On duty patrolling the City streets
Incident Attendance	Being despatched to an incident as listed in Table 2
Office Duties	General paperwork and office related duties

Table 3. Activity Vocabulary.

Preliminary Results

The average heart rate for the entire group was 79.48 with a standard deviation (StdDev) of 20.72. There were only two Officers with an average heart rate outside of the group average, Officer 6 and Officer 8. Their readings were:

- Officer 6 – Heart Rate 100.92; StdDev 21.45
- Officer 8 – Heart Rate 116.84; StdDev 37.36

Further analysis was undertaken to ascertain the average heart rate and StdDev for each activity which is illustrated in Table 4 below. All incident attendance was averaged into one figure.

Activity	*Avg. Heart Rate*	*StdDev*
Arrest	86.44	45.7
Bike Safe	102.2	10.42
Blue Light Run	78.12	15.7
General Patrol	79.66	19.35
Incident Attendance	76.46	14.03
Office Duties	68.58	20.56

Table 4. Heart Rate by Activity.

For example; explaining the figures in Table 4 – The "Office Duties" activity; the average heart rate for that task from all Officers is 68.58 and the StdDev was 20.56 meaning that the average range of all Officers' heart rate was between 48.02 and 89.14 beats per minute.

Table 4 raises some interesting issues:

- Officers undertaking Bike Safe activities, which involve the tutoring of members of the public in riding motor cycles, have a higher average heart rate than being involved in a Blue Light Run.
- Office Duties generally cause the heart to beat less than any other activity.

The results in Table 4 were extended to identify individual Officers whose average heart rate was above the activity heart rate when added to the activity StdDev which is an indication that the individual's heart rate is exceeding the normal band for the activity. This could be a stress indicator.

Officer No.	*Activity*	*Avg Heart Rate*	*Activity Avg*	*Activity StdDev*	*Activity + StdDev*
9	Office Duties	99.71	68.58	20.56	89.14
7	General Patrol	100.2	79.66	19.35	99.01

Table 5. Heart Rate Activity by Officer.

However the aim of this preliminary research is to ascertain whether an Officer's heart rate may be an indication of undergoing stress by being in the athletic aerobic training zone when not undertaking any physical activity.

Officer No.	*Activity*	*Mins in Training Zone*	*Time of Day*
5	General Patrol	23	0333 hours to 0356 hours
5	Incident	11	0400 hours to 0411 hours
5	General Patrol	96	0413 hours to 0549 hours
9	Office Duties	30	0719 hours to 0749 hours
1	Office Duties	43	1158 hours to 1241 hours
1	General Patrol	18	1249 hours to 1307 hours

Table 6. Officers Undergoing Possible Stress.

Examining the results in Table 6 raises some questions:

1) Officer 5 – All of his entries occur during the early hours of the morning (during a night shift) could this be due to general fatigue?

2) Officers 9 and 1 are both Sergeants who have a range of compulsory office duties. Could this indicate that these duties are causing the body's physiological change (stress)?

3) Officer 1 – on completing his Office Duties he undertakes General Patrol. Does this indicate that it has taken 18 minutes to relax from the pressures of the office before his physiology returns to within normal boundaries?

4) Generally, Office Duties has the lowest average heart rate but in this table, during the hours mentioned, each Officer's heart rate was in their training zone. Was the work that they were undertaking at that time causing them stress?

Figure 2 illustrates a heart rate trace for a Sergeant who is mainly involved in Office work. It is clear to see that taking breaks away from his desk has a positive affect on his heart rate and it is possible to suggest that his office duties may be causing him some stress.

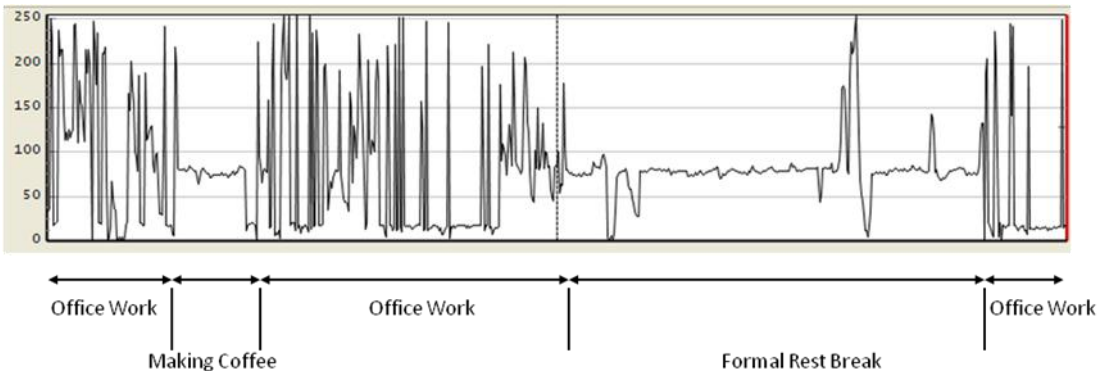

Figure 2. Officer's Heart Rate Trace.

Conclusion

It is accepted by the authors that the number of participants in this research is insufficient to ensure that the results are significantly significant. However, the results that have been obtained may suggest that, under certain circumstances, when not undertaking physical activities, Officer's bodies undergo a physiological change which may be an indication that they are experiencing some form of stress.

Further Research

There is a range of further research that will be undertaken by the authors:

1) Linking biometrics, including heart rate variance, more closely with the Officers' incident preferences to establish whether an Officer's preference can be linked to stress.
2) Assessing an entire department within a Police Force to ascertain departmental norms and stresses.
3) Linking IPIP personality testing with biometric measurements and stress.

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