An experimental study of the job demand–control model with measures of heart rate variability and salivary alpha-amylase: Evidence of increased stress responses to increased break autonomy

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Summary We assessed in an experimental design whether the stress response towards a work task was moderated by the autonomy to choose a break during the assigned time to complete the task. This setting is defined in accordance with the theoretical framework of the job-demand–control (JDC) model of work related stress. The findings from naturalistic investigations of a stress-buffering effect of autonomy (or ‘buffer hypothesis’) are equivocal and the experimental evidence is limited, especially with relation to physiological indices of stress. Our objective was to investigate if increased autonomy in a particular domain (break time control) was related with adaptive physiology using objective physiological markers of stress; heart rate variability (HRV) and salivary alpha amylase (sAA). We used a within-subject design and the 60 female participants were randomly assigned to an autonomy (free timing of break) and standard conditions (fixed timing of break) of a word processing task in a simulated office environment in a random order. Participants reported increased perceptions of autonomy, no difference in demand and performed worse in the task in the break-time autonomy versus the standard condition. The results revealed support for the manipulation of increased autonomy, but in the opposing direction. Increased autonomy was related with dysregulated physiological reactivity, synonymous with typical increased stress responses. Potentially, our findings may indicate that autonomy is not necessary a resource but could become an additional stressor.
1. Introduction

The job demand–control model (JDC; Karasek, 1979) posits that two components of the workplace; job demand and job control, are key influences in determining stress and ill-health in employees. In particular, it is proposed that jobs with low control, and high demands (strain hypothesis) place employees at the greatest risk of subsequent poor health. The JDC, as assessed by its sub-components of skill discretion and job autonomy, is said to moderate the experience of work demands. This notion is regarded as the ‘buffer hypothesis’ (Van der Doef and Maes, 1999; Vanroelen et al., 2009) and it has received mixed support from hundreds of cross sectional and prospective epidemiological studies, whereas the strain hypothesis has been largely supported in studies assessing psychological well-being (for reviews see, van der Doef and Maes, 1999; Häusser et al., 2010). The purpose of the present investigation however, was to assess the buffer hypothesis using an experimental design with physiological indices of heart rate variability (HRV) and salivary alpha amylase (sAA); a first in this area of research.

Only a handful of studies have used experimental designs to manipulate the JDC constructs (Perrewe and Ganster, 1989; Parkes et al., 1990; Hutt and Weidner, 1993; Rau, 1996; Jimmieson and Terry, 1997, 1998, 1999; Searle et al., 1999, 2001; Hockey and Earle, 2006; O’Brien et al., 2008; Flynn and James, 2009; Parker et al., 2009; Häusser et al., 2011, 2014), and this is not surprising as the JDC is contextualised in work settings. However, issues surrounding causality in cross-sectional naturalistic designs are well known, and further, even prospective designs in naturalistic settings have their flaws. Zapf et al. (1996) outlines a number of these but we will point only to common method variance, selective attrition of participants and error estimation in time lags (i.e., identifying the best distance between assessments). Experimental techniques also have their flaws including low ecological validity, but they remain the best design to infer causality between variables.

The experimental designs used to test the JDC are not exempt from methodological problems, most are based on experimental tasks of less than 30 min, which impacts their ability to elicit alterations in well-being or physiological states (Häusser et al., 2011) and only five of these fifteen studies assessed physiology. These included heart rate and blood pressure (Perrewe and Ganster, 1989; Hutt and Weidner, 1993; Rau, 1996; Flynn and James, 2009), and cortisol (Häusser et al., 2011). While these investigations are useful, they are problematic as they employ between-group designs to assess differences in physiological reactivity. Given individual variations in diurnal rhythms and physiology, where possible, within-group designs are the preferred option.

The JDC investigations that used experimental designs with physiological assessments reveal inconsistent support for the JDC. For instance, Perrewe and Ganster (1989) utilised a mail sorting task and measured heart rate and skin temperature of their participants but report no differences in physiological arousal evoked by manipulations of task demand or control. Two decades later, Flynn and James (2009) used differing versions of a computerised mental arithmetic task, measured heart rate and blood pressure, and found participants in the high demand group exhibited greater baseline-to-task increases in heart rate and systolic blood pressure relative to low-demand participants.

The most comprehensive assessment of the JDC using an experimental design with physiological indices was conducted by Häusser et al. (2011). Participants were tested in a simulated office environment. Job demands were operationalised in terms of time pressure (participants in low demand condition only had to process 70% as many customer requests as those in high demand condition) and job autonomy was operationalised in terms of pacing control (machine paced versus self-paced). The findings support the strain hypotheses of the JDC model; with participants in the high strain condition (high demand and low control) showing significantly higher cortisol responses compared to the other three lower-strain conditions. However, neither main nor interaction effects of control or demands were found with regard to the subjective measures of intrinsic motivation, mood and mental fatigue; suggesting support for the JDC model regarding endocrinological but not psychological measures (Häusser et al., 2011). These findings of stronger associations of task manipulation with objective physiological evidence are important and may be furthered by a consideration of sAA responses.

As acute stressors tend to elicit sympathetic responses and direct observation of salivary adrenaline and noradrenaline do not reflect sympatho-adrenal medullar (SAM) responses (Schwab et al., 1992), the present investigation sought to capture sAA as an indirect marker of SAA activity (Nater and Rohleder, 2009; Filaire et al., 2010). Further, in acute stress testing, sAA is often preferred to the hormone cortisol for its shorter time lag between stress exposure and salivary secretion and for its ability to return to basal states quickly post-exposure (Takai et al., 2004; Gerdts et al., 2006). It has been proposed that sAA may be differentially related to stressors than cortisol (given the lack of correlation between cortisol and sAA), and that a multifaceted approach to physiological stress assessment may
elucidate our understanding of biological systems (Nater et al., 2006a).

HRV indices offer an opportunity to monitor the push—pull relationships between the para-sympathetic and sympathetic arms of the autonomic nervous system. Generally the two divisions are complementary, with increases in sympathetic activity associated with increases in heart rate, whereas increased parasympathetic nervous activity decreases heart rate (Aubert et al., 2003). Increased HRV is a result of increased parasympathetic activity. A ‘normal’ response to perceived stress involves the sympathetic nerves producing increased adrenaline and reduced vagal tone, whereas the parasympathetic nerves attempt to ‘regulate’ the arousal (Sharpley, 2002). Low heart rate variability has been observed in response to acute stressors (Nater et al., 2006a; Filaire et al., 2010) and further, low heart rate variability has been associated with increased rates of morbidity and mortality (Thayer and Lane, 2007; Thayer et al., 2010).

We used a within-group experimental design to assess the buffer hypothesis by manipulating autonomy while holding demands constant. Our outcome variables included sAA and HRV. In addition to these physiological variables, we assessed and controlled for self-reported neuroticism, work locus of control and chronic stress. In the interest of brevity, these variables and their relationship with physiology and the JDC are detailed in the Methods section.

2. Method

2.1. Participants

Female university students (N = 60, M age = 25.82, SD = 9.99) were recruited via posters placed on university noticeboards alerting potential participants to contact the researchers, and via face to face invitation using a script. As prior research suggests that sex differences may exist in relation to sAA reactivity, the study targeted only one gender (Nater et al., 2006b; van Stegeren et al., 2008). Eligibility for the study included being female, aged between 18 and 60, and being proficient in English. Participants voluntarily excluded themselves from participating if they were taking any medication (other than the contraceptive pill); were presently suffering from ill-health; were considered to be physically frail; or had a chronic health, thyroidal, heart or mental health problem, as these things can potentially confound the physiological assessments used (Nater et al., 2005). Participants were asked to refrain from alcoholic beverages, meals, soft drinks, coffee, smoking, and engaging in physical exercise 1 h prior to the experiment, as these activities have all been found to impact on salivary α-amylase activity (Mackie and Pangborn, 1990; Nater et al., 2007; Weiner et al., 2008; Klein et al., 2010). Eligibility was confirmed via participants’ self-report and again just prior to the experiment by asking ‘Do any of the exclusion criteria apply to you?’ No participants were excluded due to violation of the testing protocol. Participants were told that they would be compensated $60 for their time if they successfully completed 80% of the assigned tasks, with pilot testing (N = 6) suggesting that this was readily achievable.

2.2. Materials

2.2.1. Neuroticism

The neuroticism sub-scale of the short form Revised Eysenck Personality Questionnaire (Eysenck et al., 1985) was used to measure trait neuroticism. Neuroticism is frequently used as a measure in stress research as persons higher in neuroticism may perceive environments to be more stressful than those lower in the trait (Suls, 2001; Schneider, 2004) and may be related to HPA axis dysregulation (McCleery and Goodwin, 2001; Roberti, 2003) and suggests personality may capture some of the variability seen in stress responses. The neuroticism sub-scale comprises 12 items and each item has a binary response, ‘Yes’ or ‘No’ to questions such as ‘Are you an irritable person?’ Scores range between 12 and 24, with higher scores indicative of trait neuroticism.

2.2.2. Work locus of control

Work locus of control was measured with the Work Locus of Control (WLOC) scale which assesses the degree that an individual perceives control in the workplace to be internally or externally attributed. Externally attributed people believe they are at the will of powerful others or chance (Calnan et al., 2004). High levels of external attribute have been linked to burnout and higher levels of cortisol secretion (Pruessner et al., 1999), and may be linked to poor health. WLOC may be a useful tool in the current investigation as this can assess the degree that individual differences in cognitive styles explain the impact of manipulating autonomy in the conditions. That is, some individuals may be more distressed by a lack of autonomy than others. The WLOC consists of 16 items such as ‘Making money is primarily a matter of good fortune’ which participants are instructed to indicate between ‘1’ disagree very much and ‘6’ agree very much (Spector, 1988). High scores relate to higher external attributions (Spector, 1988).

2.2.3. Perceived Stress Scale

The 10-item Perceived Stress Scale (PSS; Cohen et al., 1983) measured chronic stress as these states have the potential to blunt acute physiological indices (McGonagle and Kessler, 1990) and consequently confound interpretation of the acute stress testing. Stress loads in non-working hours should be considered as equally important as those in working hours as they contribute to the overall load which may lead to adverse health (Sjörs et al., 2014). The items are designed to gauge how stressful respondents perceive their lives over the previous 30 days (Cohen and Janicki-Deverts, 2012). Using a 5-point Likert scale ranging from 0 = never to 4 = very often, respondents answer ten items, such as ‘In the last month, how often have you felt nervous and “stressed”?’ with scores theoretically ranging from 0 to 40, with higher scores indicating higher levels of perceived psychological stress.

2.2.4. Perceived demands, and autonomy scale

Three items assessed perceived demands (‘I found this task required a lot of effort’, ‘I found the task was easy to complete in the time given’, ‘I found the task taxed my abilities’) and three items assessed the subjective perception of autonomy (‘I would have preferred to have more control in
completing the task’, ‘I was happy with the amount of control I had in completing the task’, ‘I found the timing of the break frustrating’ during the experiment. Responses for perceived demands and autonomy were rated on a 5-point Likert scale ranging from 1 = strongly agree to 5 = strongly disagree. Scores can theoretically range between 3 and 15 for the subscales with higher scores indicative of higher perceived demand and autonomy during the task.

2.2.5. Condition performance score
Participants were required to complete two computer-based word processing tasks requiring them to alphabetically re-sort a numbered ‘Vancouver style’ 40-item reference list. Scores from the task could range from 0 to 40 correctly ordered references. These scores were used to assess condition efficacy.

2.2.6. Demographic and other information
Participants were also asked to provide their age, time of awakening on the day of testing, and if they had adhered to the requirements required to participate in the study (e.g., refrain from eating, drinking and exercise).

2.3. Procedure
Institutional ethics approval was granted for this study (FSTE13/R16) and all participants provided informed consent. When participants arrived for their testing, they were asked to adopt the role of a research assistant and to complete the test sessions in one of the three identically matched rooms that were arranged to simulate a typical office environment, with a desk, laptop computer and filing cabinet. Twenty participants completed testing in each of the three rooms. Prior to the experiment commencing, participants were given access to a private room with instructions on how to fit the heart rate variability equipment. Experimenters then checked it was correctly fitted and operational. Although our design included a within-subject comparison of conditions, testing was conducted between 12pm and 6pm to control for the diurnal pattern of salivary α-amylase (Nater et al., 2006b). The instructions for the practice and experimental conditions were provided at the beginning of each document as they were opened on the laptop. Experimenters ensured that conditions were equally counter balanced by observing that each participant performed the condition in their own pre-determined unique sequence. Testing took place in a temperature controlled environment (~22°C) and experimenters wore white laboratory coats and stood silently observing participants perform the task. The experimental sequence is outlined in Table 1. Please note that a ‘reward’ phase was also completed but it is not reported in this discussion of the investigation.

2.3.1. Baseline
Participants were asked to take a seat at their work station and to open each practice and experimental task when prompted by the experimenter. Heart rate was continuously recorded from this point. Immediately after sitting, participants provided their first saliva sample by placing the cotton salivette in their mouth and moving it around in a circular pattern for 60s to collect saliva from all three glands in the mouth. This technique is used by the majority of studies sampling stimulated saliva for amylase activity (Rohleder and Nater, 2009). Participants were then requested to complete the WLOC, Neuroticism and PSS questionnaires to assess disposition and current life stress. Eight minutes into baseline monitoring, participants completed the practice condition of alphabetically re-ordering five references, and to ask any questions regarding the task. Tasks were completed on a laptop computer with a 14-inch screen.

2.3.2. Condition 1 (standard)
Participants were instructed to open Condition 1 (‘standard’ task), read the instructions and start the task. Participants were given 12 min to alphabetically re-order 40 references and were told that they would receive $5 if they correctly ordered 80% of the references. In reality, participants were paid $5 as long as they successfully completed 40% of all conditions (participants were given a debriefing leaflet at

<table>
<thead>
<tr>
<th>Phase</th>
<th>Duration</th>
<th>Content</th>
<th>Break</th>
<th>Pay</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>12 min</td>
<td>Instructions/saliva sample/questionnaires(^a)</td>
<td>Randomly enforced 90s break</td>
<td>$5</td>
</tr>
<tr>
<td>Standard (Condition 1)</td>
<td>12 min</td>
<td>Re-order reference list</td>
<td>$5</td>
<td></td>
</tr>
<tr>
<td>Break</td>
<td>5 min</td>
<td>Saliva sample/6 task perception questions(^b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Autonomy (Condition 2)</td>
<td>12 min</td>
<td>Re-order reference list</td>
<td>Choose own 90s break</td>
<td>$5</td>
</tr>
<tr>
<td>Break</td>
<td>5 min</td>
<td>Saliva sample/6 task perception questions(^b)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reward (Condition 3)</td>
<td>12 min</td>
<td>Re-order reference list</td>
<td>Randomly enforced 90s break</td>
<td>$10</td>
</tr>
<tr>
<td>Break</td>
<td>5 min</td>
<td>Saliva sample/6 task perception questions(^b)</td>
<td>Debriefing</td>
<td></td>
</tr>
</tbody>
</table>

Note: The ‘Reward’ condition is not analysed in this article. Total duration of experimental session = 63 min.
\(^a\) WLOC, Neuroticism and Perceived Stress Scales.
\(^b\) Questions relating to perceived demands and autonomy. Heart rate variability was continuously monitored from the beginning of the baseline until the end of the final break.

Table 1: Experiment timeline.
the end of the experiment detailing this deception). Ninety seconds into the task participants were told to take a 90-s break during which time they had to remain seated and could not touch the keyboard. At the end of the 12 min session, participants were requested to provide their second saliva sample and complete the six items regarding their perceived demands and autonomy for the condition they just completed.

2.3.3. Condition 2 (autonomy)
Break autonomy was increased in this condition as unlike in the standard condition where they were forced to take a break after 90 s, participants were able to choose when to take their 90 s break during the condition. If participants did not remember or elect to take a break during the condition, then they were asked to stop at 10 min and 30 s. Participants were informed that they would receive $5 if they accurately completed 80% of the task, but in reality were paid if they completed 40% (16 correctly ordered references). Conditions were counterbalanced to control the influence of order and practice effects.

2.3.4. Breaks
After the standard and autonomy conditions, participants had a 5 min break where they provided another saliva sample during the first minute of the break. Participants used this period to complete 6 questions on their perception of demand and autonomy of the condition.

2.4. Physiological observations
Salivary α-amylase activity was assayed using a Salimetrics® 98 Well Kinetic Enzyme Assay Kit (No. 1-1902; State College, PA, USA). Prior to analysis, saliva samples were thawed and centrifuged at 3000 rpm for 15 min to obtain clear saliva. Saliva samples were diluted with α-amylase diluent following the manufacturer’s protocol to achieve a final dilution of 1:200. The α-amylase substrate solution was then heated to 37 °C and 320 μL was pipetted simultaneously into 8 wells containing 8 μL of diluted saliva using a multichannel pipette. Test strips were tested one at a time. Optical density measurements were performed at 450 nm with a Synergy™ HT Multi-Detection Micro-Plate Reader (Bio-Tek Instruments Inc., Winooski, VT). Concentrations of the select compounds were calculated using KC4 v3.4 Software (Bio-Tek Instruments). The assay has a lower detection limit of 0.1 nmol/L with intra- and interassay coefficients of variations <8%.

Heart-rate variability was measured continuously throughout the experiment using the Polar RS800CX wireless heart rate monitor and chest belt (Polar, Finland) at 1000 Hz and subsequently analysed using Polar Pro Trainer 5 software. Graphical observation was used to manually edit and exclude artefacts. Previous research has shown the Polar RS800CX to be a reliable instrument, producing ECG-comparable measures of HRV, especially for time domain analyses (Nater et al., 2006b; Weippept et al., 2010; Vieira et al., 2012).

The mean heart rate (HR) for each time period was calculated as well as three temporal indices of HRV. These being; the standard deviation of all RR intervals (SDNN), the square root of the mean of the sum of the squared differences between adjacent normal RR intervals (RMSSD), and the percentage of heart beats where the difference between the new RR interval and the previous RR interval is greater than 50 ms (pNN50).

Both pNN50 and RMSSD data represent parasympathetic activity of the ANS, whereas SDNN reflects sympathetic activity (Task Force of the European Society of Cardiology and North American Society of Pacing and Electrophysiology, 1996).

2.5. Data analysis
IBM SPSS statistics computer software package (Version 21.0) was used for all analyses performed. Manipulation checks were performed using paired t-tests, and 5 repeated-measures ANOVA’s were conducted to investigate if scores for the five physiological indices (i.e., sAA, RMSSD, pNN50, HR, and RR) differed across the three conditions (i.e., baseline, standard and autonomy). Hierarchical regressions were used to determine the contributions of disposition, mean task performance, and perceived efforts and rewards on changes to physiological difference scores (standard-autonomy), after controlling for age, hours awake and chronic stress. All statistical tests were conducted using a criterion value of 0.05 unless otherwise specified.

3. Results
3.1. Testing of assumptions
The sAA, SDNN, and RMSSD distributions were found to be positively skewed (<0.001) and were transformed via the natural logarithmic method. The pNN50 variable was corrected using a square root transformation. Transformed variables were used in all analyses but not in calculations of descriptive statistics. Assumptions of normality, linearity, homoscedasticity, and independence of residuals were assessed through examination of the scatterplots of predicted dependant variable scores and errors of predictions, with no assumptions violated. Data was also checked for the absence of multicollinearity, singularity and outliers, with no cases identified. All participants completed all questions and provided data/saliva for all phases of the experiment.

3.2. Psychological stress indices
Using 3 paired t-tests, we assessed if the ‘standard’ and ‘autonomy’ conditions differed in relation to self-perceived autonomy, demand and task performance. The primary purpose was to ascertain if the manipulation of autonomy was successful. The manipulation appeared successful with conditions differing on perceived autonomy t(60) = 2.11, p = 0.023, and task performance t(60) = 2.33, p = 0.039, but not on perceived task demand t(60) = 0.74, p = 0.464 (see Fig. 1).

As Fig. 1 highlights, the direction of change for autonomy was as expected with lower perceived autonomy in the ‘standard’ condition. However, task performance was
lower in the autonomy condition and this was not anticipated (Fig. 1).

### 3.3. Physiological stress indices

The means and standard deviations for sAA, HR and HRV indices (i.e., RMSSD, pNN50 and RR) are presented in Table 2.

We conducted a repeated-measures ANOVA (Baseline, Standard, Autonomy) for each of the 5 dependent variables (HR, SDNN, RMSSD, pNN50, sAA) to determine if the physiological indices differed between the testing phases. We used Bonferroni correction (0.05/5) to establish a 0.01 alpha criterion. The analyses revealed that HR, $F(1.86, 109.96) = 243.65$, $p < 0.001$, partial $\eta^2 = 0.81$; SDNN, $F(1.71, 100.99) = 17.34$, $p < 0.001$, partial $\eta^2 = 0.227$; RMSSD, $F(1.99, 117.20) = 6.79$, $p = 0.02$, partial $\eta^2 = 0.10$; and sAA, $F(1.42, 83.07) = 34.60$, $p < 0.001$, partial $\eta^2 = 0.37$, had significant variation between the means for each phase whereas pNN50 did not, $F(2.85, 85.57) = 2.85$, $p = 0.08$, partial $\eta^2 = 0.05$. Pairwise comparisons were then used to identify which means were significantly different from each other (Table 3). The pNN50 data was not assessed further due to the non-significant ANOVA finding.

The comparisons revealed that sAA and HR data differed in each of the comparisons and that all physiological indices differed between the ‘standard’ and ‘autonomy’ conditions. The change in physiology across phases was anticipated, the direction was not. Consistent with heightened stress reactions, HR and sAA were elevated and SDNN and RMSSD were reduced in the ‘autonomy’ phase (Fig. 2).

### 3.4. Hierarchical regressions

The next phase of analysis involved assessing if the physiological indices were significantly associated with the difference scores (standard-control) from each of the 5 physiological indices after controlling for the influence of covariates (Step 1: Age, hours awake, and chronic stress). Additionally we assessed the contribution of trait cognitive and personality influences (Step 2: Neuroticism, WLOC) and skill and potentially self-efficacy for the condition (Step 3: mean performance score).

The variables assigned to the first 3 steps did not produce significant Beta scores with any of the physiological indices and further, the $\Delta R^2$ scores for combined variables at each step were also nonsignificant. Two of the five hierarchical...
subjective conditions, autonomy and models perceived with data stress). Increased regressions however, did produce significant associations with the physiological indices; these being the HR and SDNN models (Table 4).

The regression findings (Table 4) suggest that increased perceived demand difference scores were associated with increased HR, (direction associated with increased stress), and increased SDNN (direction associated with reduced stress). The inconsistent findings with the subjective stress data are in concert with our analyses that assessed if the autonomy manipulation was successful. These showed no subjective differences in perception of demand across conditions, whereas all objective physiological data indicated an increase in stress.

4. Discussion

The JDC model has received considerable attention in the occupational health psychology literature with the 'job-strain' hypothesis receiving support in many epidemiological investigations. The 'buffer hypothesis'; the moderating effect of autonomy upon job demands, has received less support, and we proposed to assess this hypothesis in an experimental investigation using sAA and HR as outcome measures. Our findings reveal strong support for the association between the break-autonomy manipulation and physiological arousal, but not in the direction anticipated.

### Table 2 Comparison of physiological indices across conditions.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Standard</th>
<th>Autonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>HR (bpm)</td>
<td>74.85</td>
<td>1.50</td>
<td>81.07</td>
</tr>
<tr>
<td>SDNN</td>
<td>65.74</td>
<td>6.71</td>
<td>59.11</td>
</tr>
<tr>
<td>RMSSD</td>
<td>37.22</td>
<td>3.98</td>
<td>33.14</td>
</tr>
<tr>
<td>pNN50 (%)</td>
<td>6.99</td>
<td>0.99</td>
<td>6.66</td>
</tr>
<tr>
<td>sAA (U/mL)</td>
<td>190.96</td>
<td>19.48</td>
<td>220.33</td>
</tr>
</tbody>
</table>

Note: U/mL – units per millilitre; ms – millisecond; bpm – beats per minute.

### Table 3 Mean scores for sAA, HR and heart rate variability indices across conditions (N = 60).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline-standard</th>
<th>Baseline-autonomy</th>
<th>Standard-autonomy</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>SDNN</td>
<td>$p = 0.211$</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.001$</td>
</tr>
<tr>
<td>RMSSD</td>
<td>$p = 0.566$</td>
<td>$p &lt; 0.001$</td>
<td>$p = 0.004$</td>
</tr>
<tr>
<td>sAA</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.001$</td>
<td>$p &lt; 0.001$</td>
</tr>
</tbody>
</table>

### Table 4 Hierarchical regression results with HR and SDNN difference scores (standard-autonomy) as dependant variables (N = 60).

<table>
<thead>
<tr>
<th>Predictor</th>
<th>HR</th>
<th>SDNN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Final summary</td>
<td>Step summary</td>
</tr>
<tr>
<td></td>
<td>Beta</td>
<td>$r$</td>
</tr>
<tr>
<td>Step 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age</td>
<td>0.18</td>
<td>0.15</td>
</tr>
<tr>
<td>Hours awake</td>
<td>$-0.04$</td>
<td>$0.10$</td>
</tr>
<tr>
<td>Chronic stress</td>
<td>$-0.10$</td>
<td>$-0.17$</td>
</tr>
<tr>
<td>Step 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neuroticism</td>
<td>$0.24$</td>
<td>$0.05$</td>
</tr>
<tr>
<td>WLOC</td>
<td>$-0.10$</td>
<td>$-0.17$</td>
</tr>
<tr>
<td>Step 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task performance</td>
<td>$0.04$</td>
<td>$-0.05$</td>
</tr>
<tr>
<td>Step 4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Demand difference</td>
<td>$0.38^{**}$</td>
<td>$0.40$</td>
</tr>
<tr>
<td>Autonomy difference</td>
<td>$0.03$</td>
<td>$-0.09$</td>
</tr>
</tbody>
</table>

* $p < 0.05$.  
** $p < 0.01$.  

4.1. Increased autonomy invokes physiological stress responses

Our break-autonomy manipulation involved giving participants the freedom to choose when they were to have their break during the cognitive task. We had assumed that this increased autonomy would elicit decreased stress responses and that participants’ task performance would improve due to lack of task-interruption. Participants may have viewed the increased autonomy differently. Participants may have responded to their increased autonomy negatively as this presented them with an additional decision, or increased their cognitive load. In the ‘standard’ condition, participants were simply told when to take a break, they did not need to formulate a strategy. Our manipulation check revealed that participants perceived more autonomy, but they did not report more demand in the break autonomy condition. The physiological indices present a case for increased stress in the autonomy condition with increased SAA and HR and reduced HRV commensurate with ‘normal’ increased stress responses. However, the repeated measures ANOVA showed the pNN50 variable was not significantly different between phases and an explanation may be that this index was not as sensitive to the moderate acute stressor that participants were exposed to. The significant decrease in task performance between ‘standard’ and ‘autonomy’ conditions provides further evidence that participants responded negatively to increased autonomy.

4.2. Self-reported task demands and autonomy are inconsistently related to SAA and HRV

Similar to the experimental findings of Häusser et al. (2011) we can report that our physiological indices appeared more sensitive than self-reported demands and control to the objective manipulation of autonomy. The hierarchical regression results showed no relationships with chronic stress, neuroticism, task efficacy (as measured by task performance) and WLOC with any of the physiological indices and disparate associations with HR (in the anticipated direction) and SDNN (in the alternate direction). No relationships emerged between the self-report data with SAA, pNN50 or RMSSD. Our experimental findings are at odds with much of the epidemiological job stress-physiology literature (e.g., Hansen et al., 2006; Wright, 2011; Bathman et al., 2013) which report strong relations between chronic work stress and physiological arousal. This discrepancy is not limited to experimental investigations however (e.g., Jönsson et al., 2010; Perroni et al., 2009; Häusser et al., 2011), with several epidemiological investigations also highlighting stronger associations between stressor exposure with objective indices of stress and health compared to self-perceptions of stress (e.g., Wellens and Smith, 2006; Hansson et al., 2008).

For instance, a longitudinal study by Hansson et al. (2008) found that organisational changes usually correlated with increased stress (such as downsizing, streamlining and changes in role expectations) did not affect employees’ self-reported work satisfaction, health and exhaustion. However, decreased levels of dehydroepiandrosterone sulphate which is thought to be inversely related to stress, was noted. Perroni et al. (2009) created a simulated fire-fighting intervention and found that the highly intense situation produced significant increases in the physiological stress responses of free cortisol, alpha amylase and heart rate; however no changes in self-reported mood and anxiety were reported. These findings when considered with the results of the present study indicate that multi-methodological approaches should be considered when assessing stress.

Potential explanations for the incongruous self-report-physiology findings include self-report biases, which may include self-protective or image enhancing responses as well as others such as a non-conscious awareness of perceived stress. Häusser et al. (2011) postulated that their mixed findings may be attributable to a time-lag. We concur with this point and suggest that physiological alterations may precede perceptions of affective or cognitive alterations. This is especially the case in experimental designs when exposure to the stressor is minimal compared with natural stressors in work environments.

4.3. Implications

The buffer hypothesis was not supported in the present investigation. This finding is not at odds with the majority of the correlational field studies with most not supporting the hypothesis (Häusser et al., 2010). However, the significant association in the opposing direction is unusual. Limited evidence exists that assesses the JDC with employees new to their occupations such as trainees or apprentices. Potentially in these cases, and in accordance with our findings with novel tasks (participants may have performed the task before, but not in an experimental setting with financial and time constraints), in the present investigation these employees may prefer more instruction as it decreases the likelihood of anxiety associated with error. We assessed WLOC to determine if individual differences in control loci impacted the successful manipulation of increased task autonomy; and, they did not.

4.4. Limitations

Like most previous experimental studies of the JDC, we did not assess the participants’ ‘desire for control’. Parker et al. (2009) proposed that an individual’s desire for control (DFC) may predict the stress-buffering effects of autonomy. In their study, it was found that the proposed stress-buffering effects of control were only observed for those high in DFC and a stress-exacerbating effect of increased autonomy was apparent for those low in DFC on task efficacy perceptions as well as performance (Parker et al., 2009). Potentially, there may be individual trait differences in whether participants find more autonomy a positive or negative experience. This notion has been minimally researched in the JDC literature. Unlike previous experimental studies, we did however, assess a related concept in work locus of control which measures individual preferences for internal or external control. Our hierarchical regression analyses suggested no relationship between WLOC with any of the physiological indices.

Another limitation is that we tested the “buffer hypothesis” in this investigation by manipulating only one component of the JDC model (i.e., autonomy). We did not assess or
manipulate skill-discretion. Future research of this element of the JDC may elucidate our understanding of the links between pre-clinical physiological indices of ill-health with the JDC hypotheses. Additionally, the generalizability of our findings to the workforce may be limited given our young all female student sample, and further, while participants were asked to self-exclude from the experiment if they did not meet the inclusion criteria, we cannot guarantee that this occurred in all cases.

A final limitation is related to the experimental design. We used a single baseline design (AB) but ideally, to infer causality, multiple baselines designs (e.g., ABAB) are considered superior (Kazdin, 1982). We would argue however, that the within-group design employed in the present investigation is an improvement on the between-group designs used previously in the vast majority of experimental investigations of the JDC with only two investigations incorporating within-group designs (Rau, 1996; Searle et al., 2001). The within-subject comparisons in our design minimise the impact of body mass index (BMI) on HRV indices, but we acknowledge that controlling for the effects of BMI on HRV would have been a preferable strategy.

4.5. General conclusion

Our findings may add a further layer of complexity to the JDC model. Potentially, our findings suggest that further enquiry into individual preferences for workplace control may be required to determine if this construct needs be considered and statistically controlled in future investigations. Further, employees may benefit from increased direction and guidance when they are beginning new tasks or occupations, or, if they are working in unfamiliar environments. While this assertion would intuitively seem logical, it is at odds with the ‘buffer hypothesis’ so future research is required in both experimental and naturalistic settings to test this hypothesis further. Additionally, the findings provide further support for the use of HRV indices and SAA to assess acute stress responses in experimental settings and for the use of objective physiological assessments of stress in general, alongside subjective self-reports of stress. Self-report biases may partially explain the inconsistent findings in investigations of the ‘buffer hypothesis’. The challenge for future researchers will be to determine how the alterations in acute physiology seen in the present study may be specifically related to stress-related illness.

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Conflict of interest

None declared.

References


