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Is the link between depressed mood and heart rate variability explained by disinhibited eating and diet?

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ABSTRACT

Consistently it has been reported that a depressed mood and low heart rate variability (HRV) are linked. However, studies have not considered that the association might be explained by dietary behaviour. The resting inter-beat interval data of 266 adults (Study 1: 156 (51 M), Study 2: 112 (38 M)) were recorded for six minutes and quantified using linear (HF power: 0.15–0.4 Hz) and nonlinear indices (Sample entropy). Participants also completed the Profile of Mood States and the Three Factor Eating questionnaires. The Alternative Healthy Eating Index was used to quantify diet quality. In study 1 mood was associated with HRV; an effect partially mediated by diet. Study 2 replicated the finding: disinhibited eating (the tendency to lose control over one's eating) and diet sequentially mediated the association between mood and HRV. Diet plays a role in the link between mood and HRV and studies should consider the influence of this factor.

1. Introduction

Depression and cardiovascular disease (CVD) are two of the most frequently occurring diseases in the developed world (Mathers & Loncar, 2006; Murray & Lopez, 1996) and are often comorbid (Celano & Huffman, 2011; Grippo & Johnson, 2009). Not surprisingly attention has been directed towards understanding the factors that connect the two disorders (Celano & Huffman, 2011; Grippo & Johnson, 2009; Hare et al., 2013; Kemp et al., 2010; Raison, Capuron and Miller, 2006) with low heart rate variability (HRV) suggested as a mediating pathway. Indeed there is evidence that HRV indices are reduced in disorders characterised by emotional dysregulation (Chalmers et al., 2014; Kemp et al., 2010) and are associated with an increased risk of CVD (Tsuji et al., 1996). However, whilst it is assumed that HRV (usually HF power: 0.15–0.4 Hz) directly reflects the capacity for self-regulated emotional responding (Appelhans & Luecken, 2006), an alternative view is that individuals who have difficulty regulating emotions are at risk of adopting emotion regulation strategies such as the consumption of 'comfort' foods, with a resulting decrease in the quality of the diet (Luppino et al., 2010). As the vast majority of studies examining the association between HRV indices and mood have not systematically controlled for the influence of diet, two studies assessed this unexplored indirect pathway. It is reported for the first time that the mood/HRV association might be explained, at least in part, by changes in dietary behaviour.

Worldwide an unhealthy diet is a leading cause of premature mortality (Forouzanfar et al., 2015) and is increasingly linked to the development of affective disorders (Dash, O'Neil and Jacka, 2016). For instance, consuming a 'western' style diet of refined carbohydrates, processed or fried foods, sugary products and alcohol was associated with a higher rate of depression and anxiety (Jacka et al., 2010). On the other hand a Mediterranean dietary pattern (high in fruits, vegetables and fish) may confer protection against the development of depression (Sánchez-Villegas et al., 2009). However, such associations are likely to be bidirectional – whilst diet might influence mood and wellbeing, mood will also influence dietary behaviour. It is well recognised that negative affect influences the total amount of food consumed, as well as food choice (Gibson, 2006). For example, naturalistic studies that have examined mood related food behaviour during times of increased workload (such as the examination period) found increases in the intake of total energy and fat (McCann, Warnick and Knopp, 1990). In addition, experimental induction of negative mood increased the intake of high calorie foods (i.e foods containing a high amount of sugar and fat) in individuals who were depressed (Privitera et al., 2016). In those suffering from affective disorders a lack of adherence to self-care regimens (e.g diet and exercise) exacerbates the associated adverse physiological effects; including reductions in HRV indices (Katon, 2003). Taken together a plausible hypothesis is that

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Table 1
Participant characteristics for study 1 and study 2.

Characteristic	Study 1	Study 2
	Mean (SD or range)	Mean (SD or range)
Age (years)	21.86 (18–34)	21.93(18–30)
Body mass index (kg/m^2)	23.44 (16.82–37.28)	23.16 (17.51–35.81)
Gender		
Females	105	74
Males	51	38
Current smoker		
Yes	27	0
No	129	112
Alcohol (units per week)	5.05 (0–38)	9.20(2–21)
R–R interval (milliseconds)	785.58(136.29)	754.84(110.19)
HF power	820.47(718.24)	722.26(696.88)
HR entropy	1.42 (0.26)	1.32 (0.25)
Mean RR interval	793.75(107.97)	749.57(100.29)
Depressed mood (POMS)	4.80(7.04)	6.88 (5.47)
Diet (AHEI)	33.22(17.63)	35.96(20.67)
Disinhibited eating (TFEQ)	NA	12.17(3.39)

R–R – Interbeat interval, HF – High frequency, HR – Heart rate, POMS – Profile of Mood States, AHEI – Alternative Healthy Eating Index, TFEQ – Three Factor Eating Questionnaire.

a depressed mood might induce poor dietary choice behaviour which in turn may have consequences for HRV.

Indeed there is sporadic evidence that diet might influence HRV. For example, a Mediterranean dietary pattern was found to be associated with higher HRV including HF power (0.15–0.4 Hz) and the length of the R–R interval (Dai et al., 2010). In addition, supplementation of omega 3 fatty acids for four weeks improved HRV (LF/HF ratio and R–R interval length) in patients with coronary disease (Villa et al., 2002). Previously we reported that a supplement high in the antioxidant carnosine influenced the HRV (HF/LF ratio) of young adults (Young, Benton and Carter, 2015). Given this emerging evidence it is surprising that little consideration has been given to the fact that dietary behaviour might mediate the association between depressed mood and HRV. Therefore two studies were designed to consider this possibility.

2. Study 1

2.1. Methods

2.1.1. Participants

One hundred and fifty six medication free young adults (51 male) between 18 and 34 years of age participated in this study (Table 1). Participants were excluded if they reported a cardiovascular or metabolic disorder, gastrointestinal problems, were pregnant, had a current diagnosis of a mood or eating disorder, and/or were taking medications or herbal supplements to manage body weight or control appetite.

2.1.2. Procedure

Participants were instructed to refrain from drinking alcohol and taking part in any physical activity twenty four hours prior to the start of the study. All data were collected between the hours of 9am and 12noon – participants were asked to abstain from consuming any food and drink (including caffeinated beverages) before attending the laboratory. Upon entry into the laboratory, after providing written informed consent, the participants completed the European Prospective Investigation into Cancer and Nutrition Norfolk Food Frequency Questionnaire (FFQ) (Mulligan et al., 2014) and the Profile of Mood States (POMS) (Lorr, McNair and Fisher, 1982). Participants then had their height and weight measured before being fitted with a RS800 Polar heart rate monitor electrode transmitter belt (T61) using conductive gel (Polar Electro, Kempele, Finland). Finally participants rested quietly in a semi – supine position for six minutes while R–R interval data were recorded. The procedure was approved by Swansea University ethics committee (reference number: 08.25.2015.2) and carried out in accordance with the principles laid down by the declaration of Helsinki 2013. All participants completed the study.

2.1.3. Measures

2.1.3.1. Heart rate variability (HRV). Interbeat interval measurements were collected using a Polar RS800 HR monitor set to R–R interval mode (Polar Electro, Kempele, Finland) at a sampling rate of 1000 Hz. This instrument has been previously validated for the accurate measurement of R–R intervals and analysing HRV (Nunan et al., 2009).

2.1.3.2. Body mass index (BMI). Body mass was measured using an electronic scale (Kern KMS-TM, Kenr and Sohn GmbH, Germany) that, to avoid problems associated with movement, took 50 assessments over a 5 s period and produced an average value. Height was measured using a portable stadiometer.

2.1.3.3. Habitual diet. Dietary data were collected using the European Prospective Investigation into Cancer and Nutrition Norfolk Food Frequency Questionnaire (EPIC-Norfolk FFQ) (Mulligan et al., 2014). A common unit or portion size for each food was specified and subjects were asked to indicate on a 9 point scale ranging from 'never' to '6+ per day', how often they tend to consume specific foods. This FFQ has been previously validated by comparing it with a 16-day weighed food record (Bingham et al., 1994) and nutrient biomarkers (Bingham et al., 2001). Data were further analysed using FETA software that uses UK based food composition databases to produce nutrient data as well as basic food groups (Mulligan et al., 2014). Importantly this gives rise to food groups that are captured cleanly. For example, for 'fruit juice' a fraction of the juice drink – which may be only 10% of the total product – counts toward total fruit, but the rest of the beverage counts towards added sugars. Likewise, the skim milk fraction of whole milk counts toward the dairy constituent, but the butterfat in whole milk counts toward calories from solid fat. From these food groups a modified version of the Alternate Healthy Eating Index (AHEI) score (McCullough et al., 2002) was created (Supplementary information Table S1) by taking the sum of 7 component scores [1: fruit; 2: vegetable; 3: ratio of white meat (seafood and poultry) to red meat; 4: ratio of polyunsaturated fatty acids (PUFA) to saturated fatty acids SFA); 5: total fibre; 6: nuts and seeds; and 7: multivitamin use]. The score ranged between 2.5 and 67.5 with higher values corresponding to a healthier diet – one that is high in fruit, vegetables, white meat and fish, PUFA, fibre and nuts and seeds and low in SFA and red meat. This approach was chosen to maintain consistency with other large UK based cohort studies that have examined the influence of dietary patterns on mental and physical health (Akbaraly et al., 2013). Alcohol was not included in our modified AHEI but was considered a covariant in the main analysis.

2.1.3.4. Physical activity. Participants were asked how often they took part in moderate and vigorous exercise such as walking, cycling, sports, gardening, housework and home maintenance and for how long. They were then classified according to whether they did or did not meet the World Health Organization recommended levels of physical activity. This metric has been used in previous studies examining the association between mood and HRV (Jandackova et al., 2016).

2.1.3.5. Depressed mood. Depressed mood was measured using the 12 item Elated – Depressed subscale of the Profile of Mood States Bi-Polar questionnaire (POMS) (Lorr et al., 1982). Participants were