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Neuroendocrine and cardiovascular correlates of positive affect measured by ecological momentary assessment and by questionnaire

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Summary
The relationships between positive affect, salivary cortisol over the day, and cardiovascular responses to laboratory mental stress tests, were assessed in 72 healthy non-smoking men (mean age 33.6±8.8 years). Positive affect was measured by aggregating ecological momentary assessments (EMA) of happiness obtained at four times on each of 2 working days, and by questionnaire using the Positive and Negative Affect Schedule (PANAS). Saliva was sampled on 2 days, on waking, 30 and 60 min later, and four other times over the day. Blood pressure and heart rate responses to speech and mirror tracing tasks were measured over two sessions 4 weeks apart. Data were analysed using regression of positive affect on biology adjusting for age, body mass and negative affect, with additional adjustment for time of waking in cortisol analyses and for work stress in cardiovascular analyses. EMA positive affect was inversely associated with cortisol early in the day and with the cortisol increase after waking, controlling for age, body mass index, and negative affect ($P = 0.012$). There was no relationship between PANAS positive affect and cortisol, or between EMA positive affect and cortisol later in the day. Diastolic pressure recovery post-stress was more rapid among participants with high positive affect ($P = 0.022$) and with lower systolic pressure throughout the stress sessions, after controlling for covariates including negative affect. PANAS positive affect was also inversely associated with systolic pressure, but not with diastolic stress or heart rate. We conclude that positive affect is related to biological responses in the laboratory and everyday life that may be health protective. Effects were substantially stronger when positive affect was assessed by aggregating EMA samples than with questionnaire measures.

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1. Introduction

There is growing evidence that positive affect is associated with a longer healthy life expectancy and reduced risk of physical disease (Huppert et al., 2004; Pressman and Cohen, 2005). Studies with older adults have shown associations between positive affect and reduced risk of mortality, onset of disability, and stroke, independently of risk factors and negative affect (Ostir et al., 2000, 2001; Blazer and Hybels, 2004). Positive affect also predicted reduced risk of upper respiratory infectious illness following experimentally administered virus (Cohen et al., 2003), and greater antibody responses to hepatitis B vaccination (Marsland et al., 2006).

These findings have stimulated interest in the biological factors that might correlate with positive affect and contribute to health-protective effects. We carried out a study involving 216 men and women from the Whitehall II epidemiological cohort, assessing positive affect by aggregating ecological momentary assessments (EMA) of happiness throughout a working day and evening (Steptoe et al., 2005a). Positive affect was associated with lower salivary cortisol averaged from eight samples over the working day, with a similar pattern for the weekend day. These effects were independent of age, gender, socioeconomic status, smoking, and body mass index (BMI), and were replicated at 3-year follow up (Steptoe and Wardle, 2005a). Positive affect was also associated with lower ambulatory heart rate in men, and reduced fibrinogen responses to standardised mental stress tests. Crucially, the effects were independent of negative affect. Negative affective states have been associated with elevated cortisol (van Eck et al., 1996; Polk et al., 2005) and psychophysiological stress reactivity (Kibler and Ma, 2004), but these findings indicated that associations between biological responses and positive affect were not merely due to low levels of negative affect.

Associations between lower cortisol and positive affect have also been reported in a community sample in the USA (Smyth et al., 1998), and in a sample of Hong Kong Chinese (Lai et al., 2005). Polk et al. (2005) reported a more complex pattern in a large sample of healthy adults in which positive affect was either estimated as a trait characteristics by averaging seven sets of affect ratings obtained in the evenings over a 6-week period, or as a state characteristics from affect ratings taken on the day of cortisol assessment. Trait positive affect was associated with lower cortisol on waking in women and not men, but with lower cortisol later in the day in men. However, these data were collected while participants were living in a hotel before carrying out a virus challenge study, so may not reflect cortisol output in normal life. In view of these varied results, the first aim of this study was to discover whether we could replicate our finding associating EMA-derived positive affect with cortisol independently of negative affect in a young male adult sample. We paid particular attention to the cortisol awakening response (CAR) as a marker of neuroendocrine dysregulation (Clow et al., 2004).

It is possible that in addition to biological correlates in everyday life, positive affect is related to attenuated physiological stress reactivity (Pressman and Cohen, 2005). In our previous study, we did not show any association between positive affect and blood pressure (BP) or heart rate reactions to behavioural stress tasks. However, Tugade and Fredrickson (2004) found that undergraduates reporting higher levels of positive affect showed faster post-stress cardiovascular recovery following challenging tasks. In contrast, Maier et al. (2003) reported that positive affect was associated with heightened systolic and diastolic BP reactivity to mental arithmetic.

One reason for the inconsistency in the results may be lack of representativeness of results from single laboratory stress sessions. It has been argued that psychophysiological stress profiles should be aggregated across two or more sessions to identify robust individual differences (Kamarck et al., 1994, 2000). In the same vein, salivary cortisol measures over a single day may not accurately reflect 'typical' cortisol profiles for the individual (Kirschbaum et al., 1990; Smyth et al., 1998). In the present study, psychophysiological stress testing and saliva sampling over the day were repeated at a 4-week interval, and we aggregated data across the two time points for EMA measures of positive affect, salivary cortisol and cardiovascular stress responsivity. We tested the hypothesis that positive affect would be associated with reduced BP and heart rate stress reactivity and accelerated post-stress recovery.

The third issue addressed in this study was the method of assessing positive affect. The most common technique is to use positive affect scales from instruments such as the Positive and Negative Affect Schedule (PANAS, Watson et al., 1988), or the positively worded items from standard depression scales (e.g. Ostir et al., 2001). The respondent is typically average mood over a specified time period (such as 1 week). These methods have been criticised for being influenced by recall bias, memory distortion, the dominant influence of current mood state, and focusing illusions (Stone and Shiffman, 2002; Kahneman et al., 2006). The alternative is to assess affect with EMA techniques, in which people are prompted to rate how they feel 'at the moment' on several occasions during a day or across days. Aggregation of these measures is thought to provide more valid estimates of typical affective states (Schwarz, 1999). However, EMA approaches involve a heavy participant burden, and of course the day or days over which ratings are obtained may not be typical for that individual. In the present study, we assessed positive affect both by aggregating EMA measures and by administering the PANAS at the time of each laboratory session. The third aim of this study was therefore to discover whether the biological correlates of EMA-derived and questionnaire-based measures of positive affect are the same.

2. Methods

2.1. Participants

Participants were 73 non-smoking men who were all in full-time employment. They were aged 33.6 ± 8.8 years, were predominantly white European (81.7%) and well-educated, with 73.4% having a university degree. Participants reported being healthy, and were recruited for a study of the effect of tea consumption on health. All the data presented here were collected before any experimental manipulation of tea consumption. Results for the stability of laboratory stress