Humor attenuates the cortisol awakening response in healthy older men

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Brief report

Cortisol secretory activity because the HPA axis is highly adaptive and is characterized by marked inter- and intra-individual variability. Recent evidence suggests that the cortisol awakening response (CAR), which is marked by an increase from 50% to 150% within the first 30 min after waking up in the morning, can be used as a reliable marker of HPA axis functioning. This indicator has been considered to comprise two elements: the overall level of cortisol and the increase in cortisol in response to waking.

The CAR has been shown to be relatively stable within individuals over time and has weak correlations with cortisol secretion over the course of the day. This indicator has also been shown to have a salient genetic component because CAR concordance in MZ twins is statistically greater than that observed in DZ twins. In addition, recent studies have indicated significantly altered CAR in various conditions related to psychopathology. It is positively associated with chronic stress (e.g., Schlotz et al., 2004; Schulz et al., 2005). This indicator has also been shown to have a salient genetic component because CAR concordance in MZ twins is statistically greater than that observed in DZ twins. This indicator has also been shown to have a salient genetic component because CAR concordance in MZ twins is statistically greater than that observed in DZ twins. This indicator has also been shown to have a salient genetic component because CAR concordance in MZ twins is statistically greater than that observed in DZ twins.
1998; Wüst et al., 2000), neuroticism (Portella et al., 2005) as well as with depressive symptomatology (Pruessner et al., 2003a). However, blunted post-awakening cortisol was found to be related to the stress of military training (Clow et al., 2006) and burnout symptomatology (Pruessner et al., 1999). In addition to stress and clinical conditions, positive psychological dispositions or states have also been reported to affect post-awakening cortisol levels. For instance, higher optimism (Lai et al., 2005) and higher positive affect (Steptoe et al., 2007) have been found to be related to a lower level of cortisol in the awakening period.

The aforementioned characteristics of the CAR have been shown to be consistently observed across different studies by two recent quantitative reviews (Chida and Steptoe, 2009; Fries et al., 2009). In particular, it has been pointed out that the CAR is not simply an extension of the circadian rhythm of cortisol secretion and is an imposition reflecting psychological processes closely associated with awakening (Wilhelm et al., 2007). Moreover, although a number of studies have shown an association between CAR and personality traits or trait-like factors (e.g., Kudielka et al., 2006; Polk et al., 2005; Portella et al., 2005), variance of this particular index of HPA functioning has been suggested to be attributed to the influence of both state and trait factors in a recent study (Hellhammer et al., 2007).

Despite the demonstrated sensitivity of the CAR to psychological factors and clinical conditions, it has not attracted due attention in geriatric research until recently. The existing handful of studies has demonstrated the influence of socioeconomic status (Wright and Steptoe, 2005), well-being (Evans et al., 2007) and prior-day psychological states (Adam et al., 2006) on post-awakening cortisol in the elderly. In particular, older people having higher well-being or socioeconomic status have been found to exhibit a lower CAR. Moreover, prior-day feelings of loneliness, sadness, or threat are associated with a higher CAR. Gender has been reported to affect post-awakening cortisol in a recent study with a middle-aged British sample (N=6335) (Li et al., 2007) such that women had higher levels of cortisol in the morning but a greater decline in cortisol from 45 min to 3 h post-awakening. In another study, the magnitude and intra-individual variability of the CAR have been found to increase with age in men but not women (Almeida et al., 2009). As the causes and implications of the aforementioned gender differences in CAR have not been fully understood, a number of recent studies have focused exclusively on one of the two sexes in examining the CAR (e.g., Lieb et al., 2004; Rademaker et al., 2009).

As mentioned earlier, one of the most fundamental assumptions of stress theories of aging is that the aging process is marked by a gradual dysregulation of the HPA axis and a reduced capacity to adapt to stress in life (McEwen, 2002). On the other hand, the concept of successful aging (e.g., Rowe and Kahn, 1997) implies that there are individuals who do not show an increased risk of disease and disability (i.e., good physical health) associated with aging and exhibit high cognitive function and social engagement. Since a properly functioning HPA axis is a central characteristic of low risk of disease during old age (McEwen, 2002), psychosocial factors that contribute to good physical health, one of the three markers of successful aging, may express their effects via the HPA axis. In other words, the concept of successful aging may be useful for capturing the hitherto elusive individual differences that confound psychobiological research on aging in humans. More recent research has expanded the aforementioned model of successful aging by including positive psychological constructs such as optimism (e.g., Ko et al., 2007) or positive spirituality (e.g., Crowther et al., 2002) as additional markers of successful aging.

Keeping the aforementioned issues in mind, we designed the present study to examine the impact of the construct of humor on CAR on the basis of the following considerations. Firstly, humor has been shown to have positive effects on well-being in a number of recent studies with western samples (e.g., Kuiper and Borowicz-Sibenikas, 2005; Lefcourt et al., 1997; Martin et al., 2003) although a recent review (Martin, 2001) claimed that findings regarding the humor–health relationship are mixed. This may be attributed to the multifaceted nature of the concept and the resulting heterogeneity in operationalization (Martin et al., 2003). Different instruments have been developed to measure selective aspects of humor such as the use of humor as a coping mechanism (e.g., the Coping Humor Scale, Martin and Lefcourt, 1983), the frequency of displaying mirth (e.g., the Situational Humor Response Questionnaire, Martin and Lefcourt, 1984), and the ability to notice and enjoy humor (e.g., the Sense of Humor Questionnaire, Svebak, 1996). With respect to the relative impact of the aforementioned aspects of humor on well-being, the coping aspect has been found to be able to moderate the impact of life stresses on mood disturbances and other outcome measures (e.g., Martin, 1996; Martin and Lefcourt, 1983). This beneficial effect of humor has been suggested to stem from its adaptive influences on the appraisal and restructuring of stressful situations (Abel, 2002).

Secondly, humor operationalized as coping had been shown to contribute to successful aging in a recent study with a large community Chinese sample (N=2970) in Hong Kong (Chong et al., 2006; Ng et al., 2005, 2006; Woo et al., 2008). A three-factor model of successful aging was adopted in the study which operationalized the construct as avoidance of disability, high physical and cognitive functioning, and high engagement with life.

Thirdly, there is evidence pointing to the impact of coping on salivary cortisol response to laboratory stressors (Gaab et al., 2005; Lam et al., 2009) as well as diurnal cortisol levels (e.g., O’Donnell et al., 2008; Sjögren et al., 2006). As self-esteem (Pruessner et al., 2005) has been shown to play an independent key role in modulating cortisol response to stressors in prior research, it was included in the present study to evaluate the incremental utility of humor in predicting post-awakening cortisol. It was hypothesized that humor operationalized as coping, would be able to explain additional variance in post-awakening cortisol levels after the effect of self-esteem had been controlled. In addition, this hypothesis was tested in a sample of older men because of documented gender differences in the magnitude and variability of CAR (Almeida et al., 2009) and higher likelihood for older men to age successfully than their female peers as revealed by a recent study with Hong Kong Chinese (Chou and Chi, 2002). This selective focus on one sex was expected to reduce variability and thus optimize statistical efficiency.

1. Methods

1.1. Participants and procedures

Forty-five Chinese community dwelling older men took part voluntarily in the study. Each of them was given HKD100 (in the form of a shopping coupon) in return for participation. Their ages ranged from 64 years to 86 years (mean age = 73.6 years). They were recruited from a number of senior or community centers with which one of the authors had contact. Participants were free of heart diseases, cancer and psychiatric illnesses, and were not on medication such as estrogen, synthetic glucocorticoids, anti-steroid drugs and anti-seizure drugs that would potentially affect cortisol concentrations. In addition, all participants reported that they had not been smoking habitually. Ethical approval was obtained from the relevant approving body of the City University of Hong Kong for conducting the study.

All participants were briefed by the experimenter in the first home visit during which they were given a study pack containing fully standardized written instructions, questionnaires, saliva sampling tubes (Salivettes), a comprehensive description of the procedure of the study including instructions for using the Salivettes and an electronic timer used to control the timing of saliva collection. The electronic timer is a simple device that can be used to alert participants with an auditory alarm immediately after the countdown of a pre-determined period of time, which was 15 min in the present study. Participants were asked to provide saliva samples according to a specific protocol for two consecutive days. They were instructed to collect one saliva sample using the Salivette (Sarstedt AG & Co, Nümbrecht, Germany) on each day at each of the four collection times: immediately after awakening, 15, 30 and 45 min post-awakening. Moreover, participants were asked not to eat and drink anything other than water and refrain from smoking and brush-
ing of teeth. The correct use of the timer was also explained to ensure that saliva samples would be collected on time. Saliva samples were stored in the participants’ home freezers until the second home visit during which the saliva samples were collected and participants were asked to complete a questionnaire assessing humor and self-esteem, and provide demographic information. The saliva samples were stored at −20°C in the laboratory until they were thawed for biochemical analysis. Data collection was completed within 3 months to minimize seasonal impact on cortisol concentrations.

1.2. Cortisol assay

The biochemical assay was conducted at the laboratory of the Center on Behavioral Health of the University of Hong Kong, using a procedure adopted in prior studies (Chan et al., 2006a,b; Lai et al., 2005). Saliva samples were thawed and centrifuged at 1000 rpm for 15 min at room temperature. Clear supernatant was used for analysis. Cortisol levels were determined by an enzyme-linked immunosorbent assay kit (ELISA) developed for use in saliva (Salimetrics, LLC, State College, PA, USA). The assay sensitivity for the kit was 0.2 nmol/l. Intra-assay and inter-assay coefficients of variation were 3% and 10%, respectively.

1.3. Measures

1.3.1. Humor

Humor was assessed using a Chinese adaptation of the Coping Humor Scale (CHS) originally developed by Martin and Lefcourt (1983). The original English version consists of seven items showing acceptable internal consistency (Cronbach’s α in the 0.60–0.70 range) (Lefcourt and Martin, 1986). This scalar measure of humor focuses on the intentional use of humor to cope with difficult circumstances. The adaptation used in the current study consisted of five of the original seven items and was internally consistent (Cronbach’s α = 0.60). Two items from the original scale were removed to improve the internal consistency of the adapted Chinese scale when administered to an elderly sample of Hong Kong Chinese in a prior study (Ng et al., 2005, 2006). The adapted Chinese version consists of translations of the following five items from the original scale: “I have often found that my problems have been greatly reduced when I tried to find something funny in them”; “I usually look for something comical to say when I am in tense situations”, “I have often felt that if I am in a situation where I have to either cry or laugh, it’s better to laugh”, “I can usually find something to laugh or joke about even in trying situations”, and “It has been my experience that humor is often a very effective way of coping with problems”.

1.3.2. Self-esteem

Self-esteem was assessed with a Chinese version of the Rosenberg Self-Esteem Scale (Rosenberg, 1965) adapted by Cheng and Hamid (1995). The adapted version consists of 9 of the original 10 items. One of the negatively worded items in Rosenberg Self-esteem Scale, “I wish I could have more respect for myself”, was syntactically problematic in Chinese and the actual meaning was lost due to differences in syntax after the item was back-translated (Cheng and Hamid, 1995). Moreover, the problematic item was the only one that, when omitted from the calculation, raised the alpha coefficient. This specific item was thus excluded. The internal consistency of the scale was high, with Cronbach’s α = 0.85, comparable to that reported in a recent study with Chinese coronary heart disease patients (Chan et al., 2006a; Cronbach’s α = 0.82). The scale was shown to be internally consistent in the present sample of older men (Cronbach’s α = 0.82).

1.3.3. SES

Socioeconomic status (SES) was assessed with an adaptation of a subjective measure used in a recent study (Wright and Steptoe, 2005). Subjective measures of SES have a number of advantages in assessing SES in the aging populations over conventional measures tapping absolute levels of SES, which have been summarized in Wright and Steptoe. To complete the measure, participants were asked to indicate on a drawing of a ladder of ten rungs where they stood in society. They were told that the top rung represents people who are the best off and the bottom one those who are the most worst off. The mean of this measure was 5.38 (SD = 2.46) for the present sample.

2. Results

As in prior studies, the cortisol data of the current sample are also highly skewed. Extreme values were winsorized in order to reduce the impact of outliers: large values were winsorized at two standard deviations and at the lower end, 0.2 nmol/l for values small than 0.2 nmol/l (Lai et al., 2005). Square-root transformation, which has been one of the most reliable methods to reduce data skewness, was applied before subjecting the data to further analysis. All analyses carried out on cortisol concentrations were based on the square-root transformed data. Three participants were forced out of analysis due to substantial amount of missing data, meaning that the final sample consisted of 42 participants having sufficient data for inclusion. These 42 participants all adhered to the protocol on the basis of the records of sampling times that they returned. The median waking times of the 2 days were similar, 5:30 am on the first and 6:00 am on the second day, respectively, and were also highly correlated, r = 0.87, p < 0.001.

2.1. Cortisol level in the awakening period

The mean cortisol concentrations observed in the current sample of older men are comparable to those reported in previous studies with Chinese participants (Table 1) (Lai et al., 2005). The product–moment correlations of cortisol concentration at each of the four sampling times across the 2 days were significant: immediate post-awakening, r = 0.39, p < 0.01; 15 min post-awakening, r = 0.59, p < 0.01; 30 min post-awakening, r = 0.49, p < 0.01; 45 min post-awakening, r = 0.56, p < 0.01. These moderate correlations imply acceptable intra-individual stability across the 2 days, which is similar to that reported in prior studies (Lai et al., 2005; Pruessner et al., 1997). The mean morning cortisol levels at the four sampling times on the first day were 8.63 nmol/l (SE = 1.00), 9.09 (SE = 0.89), 9.58 nmol/l (SE = 0.94), and 9.32 nmol/l (SE = 1.08). These were 7.17 (SE = 0.66), 9.00 (SE = 0.94), 9.35 (SE = 0.87), and 7.22 (SE = 0.73) on the second day.

A two-way ANOVA with repeated measures was run to examine the change in morning cortisol levels across the 2 days. Results show that cortisol concentrations did not vary across the 2 days, F(1, 41) = 2.58, p > 0.05. Contrast analysis revealed a significant change in cortisol levels in a quadratic manner, F(1, 41) = 7.60, p < 0.01. However, the change of cortisol levels within the post-awakening period did not differ across the 2 days in a quadratic way, as indicated by a nonsignificant interaction, F(1, 41) = 3.88, p > 0.05.

Two indices relevant to cortisol response to awakening, namely the area under the curve with respect to ground (AUCG) and the area under the curve with respect to increase (AUCI) (Pruessner et al., 2003b) were computed separately for each day. These indices are able to capture the two major aspects of the CAR: overall concentrations are estimated by AUCG, and increase from after post-awakening is assessed by AUCI. These two indices exhibited moderate temporal stability over 2 days: AUCG, r = 0.60, p < 0.05; AUCI, r = 0.34, p < 0.05. In view of this and the moderate temporal stability of the CAR that have been indicated in the foregoing analyses, data from the 2 days were aggregated for all subsequent analyses as adopted by Lai et al. (2005).

2.2. Correlations between AUC indices and psychological variables

Product–moment correlation coefficients were used to examine the linear relationships among subjective economic positions, age, self-esteem, coping humor and the two CAR indices mentioned earlier. Results summarized in Table 1 indicate that only coping humor is significantly related to AUCI in that a higher coping humor is associated with a lower AUCI, i.e., the overall level of cortisol in the post-awakening period. Moreover, although self-esteem is significantly associated with humor, its relationship with the two CAR indices is not significant.

Hierarchical multiple regression analysis was used to examine the independent effect of humor on AUCG. Specifically, age and socioeconomic status were entered in the first step, followed by self-esteem. Humor was entered in the last step. Results indicated that coping humor was able to explain a significant portion of variance in AUCG, ΔR² = 0.101, F(1, 37) = 4.39, p < 0.05, after the effects of self-esteem and demographic variables had been statistically controlled. Self-esteem did not exert an independent and significant effect on AUCG in the present sample. The result was similar
when the effect of the mean waking time of the 2 days were controlled in addition to the aforementioned variables, \( \Delta R^2 = 0.107, F(1, 34) = 4.39, p < 0.05 \).

To examine the possibility that the aforementioned approach might mask the impact of waking time, analyses were run separately for each day. Results were generally consistent with the aggregated analyses. Specifically, when the effects of age, socioeconomic status, waking time and self-esteem were controlled, humor explained similar portions of variance in AUCG to that obtained above for measures aggregated over the 2 days. Thus estimates of \( \Delta R^2 \) were for day one 0.05 and for day two 0.09. For both days, none of the control variables including waking time which explained less than 1% of variance in AUCG, significantly affected post-awakening levels of cortisol. Levels of post-awakening cortisol across the 2 days in participants scoring high versus low in coping humor are summarized in Table 2.

3. Discussion

Findings of the present study show that humor, when operationalized as a coping mechanism has a significant effect on the overall level of cortisol in the awakening period in older men. Those who had higher scores of coping humor exhibited lower levels of cortisol in the awakening period than those having lower scores of coping humor. On the other hand, coping humor did not have any effects on the rise of cortisol in response to awakening. Although humor has been shown to have significant health effect (e.g., Kuiper, 2004; Martin et al., 2003) and predict successful aging (e.g., Ng et al., 2005), the present study is the first reporting a significant neuroendocrine impact attributable to this concept. Present findings may be taken to suggest that the health benefits of humor documented in the literature may be mediated by the HPA axis.

As indicated earlier, the CHS measures a stable use of humor as a coping method, its effect on post-awakening cortisol levels should be very similar to that of personality traits or trait-like factors. Recent evidence suggests that the impact of traits versus states on morning cortisol is different. Specifically, the effect of personality traits tend to manifest in the overall level of post-awakening cortisol (Rademaker et al., 2009) whereas state factors are more likely to affect rise in response to awakening (Stalder et al., 2010). Present findings show a selective effect of humor on overall cortisol level, and are thus in line with what prior data suggest.

It is also interesting to note that the effect of humor on the CAR as observed in the present study is similar to the effect of other positive psychological constructs reported in prior studies (Evans et al., 2007; Lai et al., 2005; Steptoe et al., 2007). With regard to the impact of well-being on the CAR, Evans et al. have found an interactive effect between positive and negative well-being in a group of older people such that those who are high in positive well-being and low on negative well-being exhibit a lower level of cortisol in the post-awakening period in comparison with other participants. In a similar vein, Steptoe et al. have found an attenuating effect of positive affect on cortisol level in the first hour post-awakening. A similar attenuating effect of optimism on the CAR has also been reported by Lai et al. (2005).

When taken together, the aforementioned findings point clearly to the modulating effect of positive psychological constructs on cortisol levels in the post-awakening period. Although all these constructs are able to confer resilience to stressful encounters of life and thus highly related to health (Seligman, 2005), some of them like humor and a synergetic combination of positive and negative well-being may be more relevant to older people. Further research is warranted to systematically examine the independent and interactive effects of various positive psychological constructs on cortisol response in the elderly.

<table>
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<tr>
<th>Table 1</th>
<th>Pearson correlation coefficients between indices of the cortisol awakening response and demographic and psychological variables.</th>
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<td>SES</td>
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<td>SES</td>
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<td>Age</td>
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<td>Humor</td>
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<td>AUCG</td>
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SES = socioeconomic status; AUCG = area under the curve with reference to ground; AUCI = area under the curve with reference to increase.

* \( p < 0.05 \).
** \( p < 0.01 \).

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<tr>
<th>Table 2</th>
<th>Means and standard errors of morning salivary cortisol concentrations (nmol/l) across 2 days in older men having low versus high coping humor.</th>
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<tr>
<td>Minutes post-awakening</td>
<td>0</td>
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<tr>
<td>Day one</td>
<td>9.77 (1.67)</td>
</tr>
<tr>
<td></td>
<td>7.71 (1.20)</td>
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<tr>
<td>Day two</td>
<td>9.11 (1.12)</td>
</tr>
<tr>
<td></td>
<td>5.69 (0.67)</td>
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</table>

Standard errors are in parentheses. Data for participants having high coping humor are in bold type. Low versus high coping humor was created by a median split of the scores on the Coping Humor Scale.
Present findings also allude to the potential impact of contextual factors in modulating the potential health effects of positive psychological constructs such as humor in the elderly. Self-esteem has been shown in prior research to be one of the most important factors contributing to the well-being of the elderly and able to modulate cortisol response to psychosocial stressors (Pruessner et al., 2005), but did not exhibit any significant effect on morning cortisol in the present sample of older Chinese men. On the other hand, humor, which has not been shown to be most reliably predict longevity or well-being in the western literature (Martin, 2001), turned out to be the significant predictor of the awakening cortisol response in the present sample of Chinese older men. Increased attention should also be paid to this important issue in future research.

Despite the significance of findings reported in the above, they should be interpreted with cautions because of a number of limitations. The small sample size may curtail the generality and replicability of present findings. Exclusive focus on one sex may enhance statistical efficiency but overlooks factors that potentially affect both sexes. Inclusion of both sexes in the sample will enable the researcher to directly address gender differences which have been observed consistently in older people’s cortisol reactivity to stressful challenges (e.g., Seeman et al., 2001; Traustadóttir et al., 2003). Future studies should pay more attention to this issue acquiring increasing importance in psychobiological research on aging.

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