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Positive Affect, Social Connectedness, and Healthy Biomarkers in Japan and the U.S.

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Abstract

Previous studies have shown that positive affect and social connectedness predict better health in the U.S. However, the relevance of such findings for other cultural contexts has been largely ignored. The present study investigated the interplay of positive affect, social connectedness, and health using large probability samples of Japanese and U.S. adults. Health was measured objectively with biomarkers that represent restorative functioning: HDL (high-density lipid) and DHEA-S (dehydroepiandrosterone-sulfate). Lower levels of both biomarkers (i.e., less healthy biomarker profile) were found among those in Japan who reported high positive affect in combination with low social connectedness. In the U.S, the general pattern was that those with greater positive affect showed healthier HDL levels regardless of social connectedness. The findings highlight cultural variations in the health implications of how positive affect and social connectedness come together.

Keywords

positive affect; culture; social connectedness; HDL; DHEA-S

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Previous studies have shown that positive affect has numerous health benefits in Western cultures (Boehm & Kubzansky, 2012; Boehm, Peterson, Kivimaki, & Kubzansky, 2011; Ong, Mroczek, & Riffin, 2011; Pressman & Cohen, 2005; Steptoe, Dockray, & Wardle, 2009; Steptoe, Wardle, & Marmot, 2005). However, cross-cultural studies offer a more nuanced perspective following from the idea that positive affect varies with cultural scripts and norms (Kitayama, Markus, & Kurokawa, 2000; Kitayama, Mesquita, & Karasawa, 2006; Tsai, 2007; Tsai, Knutson, & Fung, 2006). As such, it is unclear whether the positive affect is equally beneficial for health across different cultural contexts. Particularly, in East Asian cultures, positive affect may complicate relational concerns (e.g. creating jealousy, overshadowing others) (Kitayama et al., 2000; Miyamoto, Uchida, & Ellsworth, 2010;

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Uchida & Kitayama, 2009). Such relational concerns may, in turn, undermine the health benefits of positive affect. Alternatively, in the U.S., both positive affect and social connectedness have been suggested to improve health (Cohen, 2004; Pressman & Cohen, 2005). The present study investigated the interplay between positive affect, social connectedness, and health in different cultural contexts, specifically Japan and the U.S. The overarching question was whether positive affect would be beneficial for health, measured objectively with healthy biomarkers, but in ways that possibly vary by cultural context and its relationship with social connectedness.

Positive Affect, Health, and Culture

Building from research on the health concomitants of negative affect, the effects of positive affect (PA) on health have increasingly been studied (Pressman & Cohen, 2005). Higher PA is associated with fewer chronic symptoms, higher self-rated health, and better health-related behaviors. Objective health outcomes, such as morbidity and longevity, are also predicted from positive affect (Koivumaa-Honkanen et al., 2000; Maier & Smith, 1999). Other studies have focused on biological pathways, finding that PA is associated with better immune system and cardiovascular functioning (Cohen, 1988; Marsland, Pressman, & Cohen, 2007; Steptoe et al., 2005). The inverse relationships between stress hormones and PA have been supported by both correlational and experimental studies (Berk et al., 1989; Codispoti et al., 2003).

Most prior research has been conducted with Western samples. Thus, little is known as to whether cultural context plays a role in the PA-health link, Emotional experiences are embedded within culture-specific definitions of " resources," drawing on lay theories, schemas, behavioral routines, etc. (Kitayama & Markus, 2000). For example, in East Asian cultures, the middle way between positive and negative affect is valued, whereas the maximization of positive affect and the minimization of negative affect (NA) is an ideal in North America (Bagozzi, Wong, & Yi, 1999; Schimmack, Oishi, & Diener, 2002; Sims et al., 2015; Spencer-Rodgers, Williams, & Peng, 2010). Since cultural norms shape views of adaptive coping strategies, the health correlates of emotion must incorporate information about which emotional styles are culturally dominant (Miyamoto & Ryff, 2011). Following this reasoning, consideration of cultural scripts about NA led to differential predictions on how NA is associated with health. As predicted, in the U.S., high levels of NA were positively linked with an inflammatory marker (interleukin-6, IL-6) involved etiologically in pathways to multiple disease outcomes, while in Japan, NA showed a weaker, nonsignificant association with IL-6 (Miyamoto et al., 2013; see also Curhan et al., 2014). To date, no study has examined whether the cultural differences in PA might be reflected in objective health outcomes.

Cultural Differences in PA: The Key Role of Social Connectedness

Although positive affect is generally considered good and valued, perhaps due to its rewarding nature (Sommers, 1984), cultural scripts related to positive affect are not universal (Kitayama & Markus, 2000; Kitayama et al., 2000). In a country like the U.S., which is dominantly individualistic, PA is pursued not only as an individual prerogative, but also as an encouraged social norm that elevates positives linked to individuals' goals. However, in

East Asian cultures, social norms regarding PA are more complicated. Individuals with high positive affect risk undermining social relationships (Kitayama et al., 2006; Mesquita & Karasawa, 2002; Miyamoto et al., 2010; Uchida & Kitayama, 2009) given that in collectivistic societies like East Asia the primary rule of social scripts is to act in ways that do not hurt relationships with close others or harmony of the group to which one belongs.[1] Maximizing personal happiness may thus go against this rule in that it may create jealousy among other people, or make one insensitive to the feelings of others who are less fortunate. In fact, such concern for troubling others, in extreme cases, can manifest as a culturally specific form of social anxiety called "Taijin Kyofusho", fear of embarrassing others rather than the self (Kleinknecht, Dinnel, Kleinknecht, Hiruma, & Harada, 1997). Thus, individuals in these cultures tend be cautious about being happy, given overarching relationship concerns (Diener, Oishi, & Lucas, 2003; Kitayama et al., 2006; Mesquita & Karasawa, 2002; Miyamoto et al., 2010; Oishi & Diener, 2001; Uchida & Kitayama, 2009).

That East Asian cultures put less emphasis on the maximizing personal goods and more emphasis on being attuned to social norms, compared to North Americans, is also evident in the literature on psychological well-being (Diener et al., 2003; Oishi & Diener, 2001). For example, life satisfaction–an index of subjective well-being – was predicted mainly by the valence of individuals' emotions in individualistic cultures: the higher the frequency of PA, the higher life satisfaction people reported. However, life satisfaction in collectivistic cultures was less strongly predicted by individuals' emotions and more strongly predicted by normative value of life satisfaction (Suh, Diener, Oishi, & Triandis, 1998). Therefore, the meanings of PA that are assigned differently across culture may also lead to differences in the effect of PA on physical well-being. Particularly, high PA combined with social uneasiness could prevent East Asians from enjoying full benefits of PA on health.

Social Connectedness and PA in Each Cultural Context

East Asian Context—Since PA in East Asian cultures has complex layers of meanings, it is necessary to formulate links between PA and health with consideration of cultural influences. In East Asian contexts, individuals' social connectedness may be a key moderator of the link between PA and health. This idea emerges from observations that PA may conflict with social relations (Kitayama et al., 2006; Mesquita & Karasawa, 2002; Miyamoto et al., 2010). However, individuals in East Asia who are high on social connectedness, that is those who have good social relationships or have personal traits that promote social connection, may be licensed to experience high level PA without creating social unease. On the other hand, for those with weak social ties or lacking psychological characteristics that facilitate social relationships, having high PA may cause social unease, which can undermine health benefits of PA.

The primary sources of PA may also vary depending on one's level of social connectedness. People with both high social connectedness and high PA may derive more of their PA from social relationships, whereas people with low social connectedness and high PA may draw their PA more from individual achievement (Kitayama et al., 2000; Kitayama et al., 2006).

[1]It should be noted that the relations between social concerns and PA may be specific to East Asian collectivistic cultures, and may not be generalized to other collectivist contexts (e.g. Mexico) (Ruby, Falk, Heine, & Villa, 2012).

Such a focus on personal happiness over social connectedness among people with low social connectedness and high PA may contribute to social disruption, which could account for why East Asian cultures are cautious about maximizing PA. It is not adaptive to prioritize PA at a cost of relational concerns in such cultures; thus, health benefits of PA may not result for those with low social connectedness. For these reasons, the relationship between PA and health may be importantly contingent on social relationships in East Asian countries.

Western Context—In the U.S., both PA and social relationships have been studied as influences on health. Studies with North American and Western European samples have shown that PA robustly predicts better health outcomes (e.g. better cardiovascular function and immune system, decreased pain and disease) (Pressman, Gallagher, & Lopez, 2013). Measures of social relationships vary across studies (e.g. strength of social ties, involvement in social activities, perceived social support), but findings generally converge to show that good social relationships play a protective role in physical health (Berkman, Glass, Briette, & Seeman, 2000; Uchino, 2006). Relatedly, there is a reliable negative association of social belongingness and morbidity (Cohen, 1988; Cohen, Gottlieb, & Underwood, 2000; House, Landis, & Umberson, 1988). Positive social relationships have also been linked with enhanced immune function and suppressed neuroendocrine responses (Cohen, 1988; Uchino, 2006). Following prior research, both PA and social connectedness are likely associated with better health when studied as independent predictors.

In addition, there has been recently a growing interest in how PA and social connectedness come together in predicting health. Studies focused on the reciprocal link between PA and positive social relationships that have been documented with Western samples (e.g., Ramsey & Gentlzer, 2015). Based on these findings, researchers who are examining PA as a focal predictor of health have proposed social connectedness as a potential pathway by which PA promotes health (Pressman & Cohen, 2005; Steptoe et al., 2009). Given that people who feel PA frequently were more likely to have better quality of social ties and engage in social activities (Diener & Seligman, 2002; Lyubomirsky, King, & Diener, 2005), and that the health outcomes associated with PA, such as longevity and stress hormones, are also predicted by social ties, social connectedness may mediate (at least partially) the link between PA and health. Kok et al. (2013) provided empirical evidence that increase in PA via loving-kindness meditation led to better health indicated by increase in vagal tone, and the effect was mediated by people's perceptions of their positive social relationships. Thus, the present study examined PA and social connectedness as separate predictors of health in the United States, along with considering whether social connectedness mediates the link between PA and health.

Objectives of the Present Study

The present study brought a cultural perspective to the growing research on links between PA and health. Although previous studies examined the relationships among PA, social connectedness, and health in Western cultures, the relationships have not been examined in other cultural contexts. In East Asian cultures, given the potential social unease PA may instill, social relationships are formulated as critical to the association between PA and health. In western cultures, based on the previous findings, both social relationship and PA

are expected to be positively linked to health, with social relationship mediating the link between PA and health. Therefore, the current study tested how PA and social connectedness came together in predicting health within each cultural context.

Health was measured by two objective indicators that represent well-functioning physiological systems: high-density lipoprotein (HDL) and dehydroepiandrosterone sulfate (DHEA-S) (Kubzansky, Boehm, & Segerstrom, 2015). Each biomarker reflects a healthy regulation of circulatory system and neuroendocrine system respectively. First, HDL plays a key role in cholesterol metabolism and circulatory system by removing excess cholesterol from the arterial wall and delivering it back to the liver. High HDL levels in blood prevent cholesterol from depositing on artery walls –caused by high levels of low-density lipoprotein (LDL) in blood, and thus have protective effect against coronary heart diseases (Gordon & Rifkind, 1989; Krieger, 1999; Toth, 2005; Wilson, Abbott, & Castelli, 1988). Second, DHEA-S indicates a healthy response of hypothalamic-pituitary-adrenocorticol (HPA) axis. It is known as one of anabolic hormones because it can counteract catabolic hormones (i.e. cortisol) that have deleterious effects on physical and mental health (Epel, Burke, & Wolkowitz, 2007). Furthermore, Low levels of DHEA-S have been linked to aging-related pathologies, such as abdominal obesity, diabetes, cardiovascular disease, rheumatoid arthritis, periodontal disease, cognitive decline and dementia (Barrett-Connor, Khaw, & Yen, 1986; Barrett-Connor, Von Mühlen, Laughlin, & Kripke, 1999; Carlson & Sherwin, 1999; Feldman, Johannes, McKinlay, & Longcope, 1998; Kalmijn et al., 1998; Mazat et al., 2001; Moriyama et al., 2000; Natawa, Yanase, Goto, Okabe, &Ashida, 2002; Savineau, Marthan, & Dumas de la Roque, 2013; ó Hartaigh et al., 2012). Therefore, HDL and DHEA-S are indices of biomarkers of which high levels indicate positive functioning across two distinct body systems.

Because of the role social connectedness plays in determining normativeness of PA in Japan (Mesquita & Karasawa, 2002; Uchida & Kitayama, 2009), a moderating approach was hypothesized, in which social connectedness was expected to work interactively with PA in predicting the health outcomes. That is, in Japan, for people with high social connectedness, higher PA was expected to contribute to higher levels of HDL and DHEA-S, whereas these associations were predicted to be weaker or absent for people with low social connectedness. On the other hand, based on the prior findings on the links among PA, social connectedness, and health among Western samples (e.g. Cohen, 1988; Pressman & Cohen, 2005; Steptoe et al., 2005), both high PA and high social connectedness were expected to independently predict higher levels of HDL and DHEA-S in the U.S. In addition, social connectedness was examined as a possible mediator of the association of PA with HDL, and DHEA-S.

Methods

Participants

American participants were a subset from the second wave of the Midlife in United States (MIDUS) survey. The first wave of MIDUS (1995–1996) was based on a national probability sample recruited through random digit dialing. The survey included a telephone interview and a self-administered questionnaire. A follow-up study was conducted in 2004, with a retention rate of 75%, adjusted for mortality. Biological data were collected from a

subset of MIDUS II respondents, who travelled to a General Clinical Research Centers (GCRC) for an overnight visit. Research sites for biological data collection were at the University of Wisconsin-Madison, the University of California-Los Angeles, and Georgetown University. The present analyses include 1043 participants for whom physical health data were available (472 males, 571 females; M = 55.24 years). The parallel survey, the Midlife in Japan (MIDJA), was conducted in 2008 with participants randomly selected from the Tokyo metropolitan area. They completed a self-administered questionnaire. A subset of the sample was recruited to participate in biological data collection (N = 382; 168 males, 214 females; M = 54.24 years). The data were collected at a clinic near the University of Tokyo (for details about the protocol of biomarker collection, see Coe et al., 2011).

Measures

The following self-rated measures were collected as a part of self-assessment questionnaires both in MIDUS II and MIDJA prior to physical examination.

Positive Affect—Participants were asked to rate how frequently they felt each emotion during the past 30 days (Mroczek & Almeida, 2004) using a 5-point rating scale: none of the time (1), a little of the time (2), some of the time (3), most of the time (4), and all the time (5). The measure included tem items: cheerful, in good spirits, extremely happy, calm and peaceful, satisfied, full of life, enthusiastic, attentive, active, and proud. Positive affect scores represent respondent's average rating of these items. Cronbach's Alphas of the scale were . 92 for both Japanese and Americans.

Social connectedness—To measure the extent to which participants have good social relationships or have personal traits that promote social connection, we included three psychological variables, each measuring different aspects of social relationships. First, we included support received from friends; social support is one of the most widely used indicators of social connectedness that have been linked to health (Cohen, 2004). At the same time, previous studies have suggested that Easterners use social support less than Westerners do (Kim, Sherman, & Taylor, 2008). We thus supplemented social support by two additional measures, namely agreeableness and interdependence, to capture the nature of social connectedness appropriate to East Asians as well. Agreeableness is a personality trait related to how individuals present themselves to others and how they are perceived by others in return (Graziano & Tobin, 2009); it indicates whether an individual is likable, kind and warm to others. Interdependence assesses the extent to which individuals defines themselves within social relationships. The measure is particularly relevant to social connectedness in East Asia where it is normative to value social relationships as a part of self.

Social support from friends was measured with 4 items modified from Schuster, Kessler, and Aseltine (1990) (e.g. "How much do your friends really care about you?", "How much do they understand the way you feel about things?"). The scores were rated on a 4-point scale, ranging from "not at all" to "a lot" and averaged to compute as a single measure (α = .879 for Americans and α = .805 for Japanese).

Agreeableness was assessed with the following 5 items: helpful, warm, caring, softhearted, and sympathetic. The adjectives were selected from existing trait lists and inventories (Goldberg, 1992; Trapnell & Wiggins, 1990). Participants were asked to rate how much each item describes them using a 4-point rating scale: not at all (1), a little (2), some (3), and a lot (4). The ratings of the 4 items were averaged to compute agreeableness scores (α = .817 for Americans and α = .877 for Japanese).

Interdependence was measured by 10-item-version Singelis Scale (Singelis, 1994). The examples of items are "It is important for me to maintain harmony or smooth relationships within my group", "It is important to listen to others' opinions". Participants rated how much they agree with each statement using a 7-point rating scale, ranging from strongly disagree (1) to strongly agree (7). Responses were averaged to compute an interdependent self-construal score (α = .973 for Americans and α = .710 for Japanese).

Biomarkers—For assessing biomarkers, frozen blood samples were collected at the clinic visit and shipped on dry ice from the 3 GCRC cites in the U.S. and from Tokyo in Japan to a single laboratory, MIDUS Biocore Lab in Madison, WI. To ensure consistency, all samples were collected and processed using standardized procedures.

High density lipoprotein (HDL) was assessed at Meriter Labs (Madison, WI) by using a Cobas Integra® analyzer (Roche Diagnostics, Indianapolis, IN). Because the distribution of HDL in our samples was positively skewed, values were log transformed for statistical analysis.

Dehydroepiandrosterone sulfate (DHEA-S) assay was performed at the Associated Regional & University Pathologists (ARUP) laboratory (Salt Lake City, UT) with a Roche Modular Analytics E170 analyzer, using an Elecsys® kit (Roche Diagnostics, Indianapolis, IN). To reduce the effects of extreme outliers and also correct for positively skewed distribution, DHEA-S were winsorized at three standard deviations from the mean in each culture and log transformed for statistical analysis.

Control variables—Analyses controlled for several confounding variables that have been linked to HDL and DHEA-S (Boehm, Williams, Rimm, Ryff, & Kubzansky, 2013; ó Hartaigh et al., 2012). Demographic variables including age, gender, and years of education were controlled for. We included negative affect (NA) to sharpen the focus on the independent effect of PA and social connectedness, net of psychological ill-being. NA had the following 11 items: so sad nothing could cheer you up, nervous, restless or fidgety, hopeless, that everything was an effort, and worthless, afraid, jittery, irritable, ashamed, and upset. Participants' ratings of 11 items were averaged into a single score for the analyses (α = .907 for Americans and α = .900 for Japanese).

Health behavior and health status were also controlled for. Health behavior was assessed with smoking and alcohol consumption. Smoking was categorized into 3 groups – never, former, current--while alcohol consumption was assessed in terms of the number of drinks consumed per week and log transformed to adjust the skewed distribution. Health status variables included chronic conditions and waist/hip ratio (WHR). The number of chronic

conditions that have been linked to lipid and hormone levels (heart disease, hypertension, stroke, blood clots, diabetes, cancer, depression, and arthritis; maximum=8 conditions) was assessed by the item “Have you ever had any of the following conditions or illnesses diagnosed by a physician?” The presence of any emotional disorders including depression and anxiety was controlled for as well (Yes/No). Waist and hip circumference were measured when participants visited clinic for physical examination. Waist/hip ratio (WHR) was calculated and log transformed to adjust the skewed distribution.

Results

Descriptive statistics of the key variables and control variables are presented in Table 1. Because different models were hypothesized for each culture, analyses were conducted separately for the Japanese and U.S. data. Separate multiple regression models were run for each health outcome variable as well as each social connectedness predictor variable. In each model, PA, social connectedness, and the interaction term were entered while controlling for basic demographic variables, negative affect, health behaviors (smoking and alcohol consumption) and health status (number of chronic conditions, depression/anxiety, and WHR). The results are summarized in Table 2 and Table 3.

Analyses in Japan

HDL—As predicted, there was an significant interaction between PA and support from friends on HDL, b= .032, t(329) =2.21, p=.028, η_p^2 =.015. The simple effects tests are shown in Figure 1a; the increase in PA was negatively associated with HDL levels among people low on support from friends (-1 SD from the mean level), b= −.037, S.E. = .013, t(329) = −2.772, p=.006, but not among people with high support from friends (+1 SD from the mean level), b=.009, t(329) =.609, p=.546. We further probed the interaction using the Johnson-Neyman technique (see Preacher, Curran, & Bauer, 2006) to demonstrate the region of significance on a moderator where the association between PA and HDL is significant. The negative association between PA and HDL in Japan was significant for people whose support from friends was lower than 2.2914 (39.4% of the sample). There was no association between PA and HDL for Japanese whose support from friends rating was higher than 2.2914.

DHEA-S—PA showed interaction effects with two social connectedness measures, interdependence and agreeableness [agreeableness: b= .15, t(329) = 2.363, p= .019, η_p^2 = .017; interdependence: b= .159, t(329) = 2.487, p=.013, η_p^2 = .020] . The pattern of the interactions on DHEA-S was in line with the interaction on HDL. PA was significantly associated with DHEA-S in a negative direction among people with low agreeableness, b= −.174, t(329) = −2.581, p=.010 (Figure 1b). Further, for people with agreeableness lower than 2.523 (39.7 % of the sample), PA was negatively associated with DHEA-S. However, there were no significant relationships of PA and DHEA-S for people whose agreeableness was above 2.523. Likewise, the negative association between PA and DHEA-S was found among people with low interdependence, b= −.147, t(329) = −2.298, p=.022 (Figure 1c). This negative association was significant for people whose interdependence was lower than 4.410 (28.5% of the sample). There were no significant relationships of PA and DHEA-S for

people with high levels of interdependence, except for three people whose interdependence was at the .09% highest of the sample. For them, PA was significantly associated with DHEA-S in a positive direction.

Analyses in the U.S

HDL—Supporting our hypothesis, PA positively predicted HDL when agreeableness was included as a social connectedness variable [b= .015, t(990) = 1.988, p=.047, η_p^2 = .004] and was marginal when support from friends [b= .014, t(988) = 1.850, p= .065, η_p^2 = .004] or interdependence [b= .014, t(993) = 1.863, p= 063, η_p^2 = .004] was included as a social connectedness variable. None of the social connectedness measures predicted HDL (Table 4).

DHEA-S—Contrary to our prediction, PA did not predict DHEA-S in any models (Table 4). Among the social connectedness measures, only interdependence marginally predicted DHEA-S, b= .069, t(990) = 1.934, p= .053, η_p^2 = .004, whereas the others did not (Table 4). The independent effects of PA and social connectedness on DHEA-S were largely unsupported.

Further, no evidence was obtained that social connectedness mediates the link between PA and HDL in the U.S., or that any interactions were evident in the prediction of HDL or DHEA-S.

Discussion

The present study investigated whether the roles of positive affect and social connectedness on two indicators of objective health (HDL, DHEA-S) differ by cultural context. In Japanese culture where positive affect might conflict with maintaining relational harmony, social connectedness was predicted to moderate the association between PA and health. In the U.S., both PA and social connectedness were expected to be associated with better objective health, and possibly that social connectedness might mediate the link between PA and health.

In Japan, supporting our hypothesis, the interaction effects between PA and social connectedness were found for HDL and DHEA-S health outcomes. Social support from friends moderated the association between PA and HDL, whereas interdependence and agreeableness moderated the association between PA and DHEA-S. The simple effect results underscored possible health costs associated with having high PA in combination with *low* social connectedness in Japan. Such findings suggest that in Japan having positive affect without *fulfilling social expectations*—maintaining harmonious social relationships— is associated with poorer health. Cultural norms about emotions in Japan (Kitayama et al., 2000; Kitayama et al., 2006) may account for these findings. That is, for those with low social connectedness, high levels of positive affect may constitute a kind of non-normative (deviant) profile in Japanese culture, and thus may invite social sanctions. That higher PA was associated with lower levels of healthy biomarkers among people with low social connectedness echoes the emphasis from previous studies that being attuned to cultural

norms is especially important for health in collectivistic contexts (Kitayama et al., 2010; Stephens, Townsend, Markus, & Phillips, 2012).

Interestingly, among people with high social connectedness in Japan, PA was mostly unrelated to health benefits or costs. Because those with high social connectedness are fulfilling social expectations to maintain harmony, their experience of high PA may be less likely to invite social sanctions and thus may be less costly. At the same time, the fact that PA was not associated with better health even among people with high social connectedness points to a possibility that health benefits of PA are generally weak in Japan, an interpretation that extends recent evidence showing a weaker or no association between NA and physical health in Japan (Curhan et al., 2014; Miyamoto et al., 2013). The results are also consistent with prior work showing that a focus on gaining positive features is less predictive of outcomes such as academic success and subjective well-being than a focus on preventing negativity, particularly social disruption, in East Asian cultures (Elliot, Chirkov, Kim, & Sheldon, 2001; Lockwood, Jordan, & Kunda, 2002).

In the U.S., PA was associated with higher HDL levels, which supported our hypothesis and converges with previous literature on the link between PA and health (Pressman & Cohen, 2005). DHEA-S was marginally associated with interdependence self-construal, but no support was found for the mediation of PA on health via social connectedness. The fact that PA predicted HDL independently of one's level of social connectedness underscores the importance of PA for health in the U.S.

Contrary to our hypothesis, social connectedness was not significantly associated with the health outcomes in the U.S. The lack of support might partly be attributed to our measures of social connectedness. Previous studies wherein social relationships have been linked with better heath often used direct assessments of structural or functional support or objective frequency of social connectedness such as the number of close friends and the number of social contacts (Seeman, 1996; Uchino, Cacioppo, & Kiecolt-Glaser, 1996). In comparison, the present study used three measures that each focused on different aspect of social relationships; the perceived quality of support received from friends, and the personality quality indicating how a person would interact with others in a likable manner, and the value that a person places on harmoniousness of social relationships. Furthermore, none of the prior literature linking social relationships to health has examined HDL and DHEA-S as used in the current study. Thus, these new indicators may also account for the lack of significant associations, though further research needed to confirm this explanation.

Previous studies examining psychosocial correlates of biological health have utilized negative biomarkers, which indicate malfunction, such as elevated inflammatory processes and stress hormones (Kubzansky et al., 2015). The present study, in contrast, examined biomarkers (HDL, DHEA-S) that indicate a healthy profile of lipids and hormones, respectively. Using these biomarkers, we found that PA interacts with social connectedness to predict HDL and DHEA-S in Japan, and that PA predicts HDL in the U.S. These results highlight the importance of examining positive biological processes to understand how PA and social connectedness can promote health. Moreover, the use of these biomarkers contributes to new directions to research on culture and health. Although biological risk-

factors have been examined in testing cultural differences in the associations of negative emotions and health (Kitayama et al., 2015; Miyamoto et al., 2013), no prior cross-cultural studies on *positive emotions* and health have examined biological measures (cf. Pressman et al., 2013; Pressman, Gallagher, Lopez, & Campos, 2014). Our results underscored the role of culture in that PA negatively predicted HDL and DHEA-S in Japan when accompanied by low levels of social connectedness, whereas PA positively predicted HDL in the U.S. Future research may benefit from examining other health indicators involved in cardiovascular and neuroendocrine systems (e.g. LDL, pro-inflammatory markers, cortisol). Given that different biomarkers work through their specific molecular mechanisms, extending the investigations may help us to sharpen the understanding of how emotion and cultural contexts "get under the skin" as well as how different mechanisms come together for optimal health.

Prior research has shown that the arousal level of PA plays an important role in cultural variation in valuation of PA. Although high-arousal PA (e.g. excitement, fun) is considered less desirable among East Asians compared to European Americans, low-arousal PA (e.g. calm, relaxed) is valued more by East Asians compared to European Americans (Tsai et al., 2006). Low arousal states help individuals pay attention to surroundings (Schupp, Cuthbert, Bradley, Birbaumer, & Lang, 1997) so it may not conflict with social tasks in East Asia, such as caring about feelings and needs of others. At the same time, it is also possible that even low-arousal PA may cause social unease if experienced by someone with low social connectedness, as low-arousal PA experienced in such contexts may still be non-normative. Thus, it is important to examine whether the interaction between social connectedness and PA would be mostly attributed to high-arousal PA but not to low-arousal PA. Unfortunately, because the measure of PA used in the present study only had one clear low-arousal PA item, it was difficult to test the effects of low vs. high arousal PA separately. Future investigation may benefit from supplementing emotion measure with different arousal levels of PA.

The present findings are limited by cross-sectional data, which makes it impossible to discern causal directionality between psychosocial factors and biomarkers. Longitudinal research will be needed to clarify whether PA and social connectedness in fact shape biological health. In addition, it would be worth investigating the cross-time dynamics between PA and social connectedness in Japan. In the U.S., studies have shown that PA can facilitate better social connectedness (Fredrickson et al., 2008; Lyubomirsky et al., 2005). In Japan, however, people may create worse impressions on others if they feel more positive emotions despite their low social connectedness, which could further impair their social relations. Employing experimental approaches would also be useful to elucidate characteristics of social interactions among Japanese with low social connectedness and high PA profiles (i.e. whether those people are perceived to be socially deviant by others during the interaction, and whether that perception by others causes negative physiological / psychological responses during social interactions). Also, future research may benefit from exploring whether the characteristics of events that trigger PA vary with the levels of social connectedness. People with high social connectedness and high PA may primarily experience PA from events that promote social relationship. On the other hand, however, people with low social connectedness and high PA may experience PA mainly from personal events, which could contribute to social disruption particularly in Japan (Kitayama et al.,

2000; Kitayama et al.;., 2006). Such research could clarify the interaction of PA and social connectedness over time among Japanese.

Although both social connectedness and PA have both been shown to be important for health in Western contexts, few studies have examined their interplay and no work has addressed their import for Eastern cultural settings. The present study addressed these omissions in the prior literature by investigating the predictive influence of social connectedness and positive affect on health, measured with two biomarkers. Findings underscored the interactive influence of both factors in Japan, via a pattern showing worse biological health among those with low social connectedness combined with high positive affect. Such interplay was not present in the U.S., where only positive affect was shown to predict better HDL cholesterol. These new results warrant further inquiry to assess their replicative consistency as well as to discern their cross-time dynamics.

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References

Bagozzi RP, Wong N, Yi Y. The role of culture and gender in the relationship between positive and negative affect. Cognition and Emotion. 1999; 13:641–672.

Barrett-Connor E, Khaw K-T, Yen SSC. A prospective study of dehydroepiandrosterone sulfate, mortality, and cardiovascular disease. New England Journal of Medicine. 1986; 315:1519–1524. [PubMed: 2946952]

Barrett-Connor E, Von Mühlen D, Laughlin GA, Kripke A. Endogenous levels of dehydroepiandrosterone sulfate, but not other sex hormones, are associated with depressed mood in older women: the Rancho Bernardo Study. Journal of the American Geriatrics Society. 1999; 47:685–691. [PubMed: 10366167]

Berk LS, Tan SA, Fry WF, Napier BJ, Lee JW, Hubbard RW, et al. Neuroendocrine and stress hormone changes during mirthful laughter. American Journal of the Medical Sciences. 1989; 298:390–396. [PubMed: 2556917]

Berkman LF, Glass T, Brissette I, Seeman TE. From social integration to health: Durkheim in the new millennium. Social Science & Medicine. 2000; 51:843–857. [PubMed: 10972429]

Boehm JK, Kubzansky LD. The heart's content: the association between positive psychological well-being and cardiovascular health. Psychological bulletin. 2012; 138:655–691. [PubMed: 22506752]

Boehm JK, Peterson C, Kivimaki M, Kubzansky L. A prospective study of positive psychological well-being and coronary heart disease. Health Psychology. 2011; 30:259–267. [PubMed: 21553969]

Boehm JK, Williams DR, Rimm EB, Ryff C, Kubzansky LD. Relation Between Optimism and Lipids in Midlife. The American Journal of Cardiology. 2013; 111:1425–1431. [PubMed: 23433765]

Carlson LE, Sherwin BB. Relationships among cortisol (CRT), dehydroepiandrosterone-sulfate (DHEA-S), and memory in a longitudinal study of healthy elderly men and women. Neurobiology of Aging. 1999; 20:315–324. [PubMed: 10588579]

Coe CL, Love GD, Karasawa M, Kawakami N, Kitayama S, Markus HR, Ryff CD. Population differences in proinflammatory biology: Japanese have healthier profiles than Americans. Brain, Behavior, and Immunity. 2011; 25:494–502.

Codispoti M, Gerra G, Montebarocci O, Zaimovic A, Raggi MA, Baldaro B. Emotional perception and neuroendocrine changes. Psychophysiology. 2003; 40:863–868. [PubMed: 14986839]

Cohen S. Psychosocial models of the role of social support in the etiology of physical disease. Health Psychology. 1988; 7:269–297. [PubMed: 3289916]

Cohen S. Social relationships and health. American Psychologist. 2004; 59:676–684. [PubMed: 15554821]

Cohen, S.; Gottlieb, BH.; Underwood, LG. Social relationships and health. In: Cohen, S.; Underwood, LG.; Gottlieb, BH., editors. Social support measurement and intervention : a guide for health and social challenges for measurement and intervention. New York: Oxford University Press; 2000. p. 3-27.

Curhan KB, Sims T, Markus HR, Kitayama S, Karasawa M, Kawakami N, Ryff CD. Just how bad negative affect is for your health depends on culture. Psychological Science. 2014; 25:2277–2280. [PubMed: 25304884]

Diener E, Oishi S, Lucas RE. Personality, culture, and subjective well-being: Emotional and cognitive evaluations of life. Annual Review of Psychology. 2003; 54:403–425.

Diener E, Seligman MEP. Very happy people. Psychological Science. 2002; 13:81–84. [PubMed: 11894851]

Ekman, P. Expression and the nature of emotion. In: Scherer, KR.; Ekman, P., editors. Approaches to emotion. Hillsdale, NJ: Erlbaum; 1984. p. 319-344.

Elliot AJ, Chirkov VI, Kim Y, Sheldon KM. A cross-cultural analysis of avoidance (relative to approach) personal goals. Psychological Science. 2001; 12:505–510. [PubMed: 11760139]

Epel, ES.; Burke, HM.; Wolkowitz, OM. The psychoneuroendocrinology of aging: Anabolic and catabolic hormones. In: Aldwin, CM.; Park, CL.; Spiro, A., editors. Handbook of health psychology and aging. New York: Guilford; 2007. p. 119-141.

Feldman HA, Johannes CB, McKinlay JB, Longcope C. Low dehydroepiandrosterone sulfate and heart disease in middle-aged men: cross-sectional results from the Massachusetts Male Aging Study. Annals of Epidemiology. 1998; 8:217–228. [PubMed: 9590600]

Fredrickson BL, Cohn MA, Coffey KA, Pek J, Finkel SM. Open hearts build lives: Positive emotions, induced through loving-kindness meditation, build consequential personal resources. Journal of Personality and Social Psychology. 2008; 95:1045–1062. [PubMed: 18954193]

Graziano, WG.; Tobin, RM. Agreeableness. In: Leary, MR.; Hoyle, RH., editors. Handbook of individual differences in social behavior. New York, NY: Guilford; 2009. p. 46-61.

Goldberg LR. The development of markers for the Big-Five factor structure. Psychological Assessment. 1992; 4:26–42.

Gordon DJ, Rifkind BM. High-density lipoprotein--the clinical implications of recent studies. The New England Journal of Medicine. 1989; 321:1311–1316. [PubMed: 2677733]

House JS, Landis KR, Umberson D. Social relationships and health. Science. 1988; 241:540–545. [PubMed: 3399889]

Kalmijn S, Launer LJ, Stolk RP, De Jong FH, Pols HAP, Hofman A, Lamberts SWJ. A prospective study on cortisol, dehydroepiandrosterone sulfate, and cognitive function in the elderly. Journal of Clinical Endocrinology & Metabolism. 1998; 83:3487–3492. [PubMed: 9768651]

Kim HS, Sherman DK, Taylor SE. Culture and social support. American Psychologist. 2008; 63:518–526. [PubMed: 18793039]

Kitayama S, Karasawa M, Curhan KB, Ryff CD, Markus HR. Independence and interdependence predict health and wellbeing: Divergent patterns in the United States and Japan. Frontiers in Cultural Psychology. 2010; 1(Article 163):1–10.

Kitayama, S.; Markus, HR. The pursuit of happiness and the realization of sympathy: Cultural patterns of self, social relations, and well-being. In: Diener, E.; Suh, EM., editors. Culture and subjective well-being. Cambridge, MA: MIT Press; 2000. p. 113-161.

Kitayama S, Markus HR, Kurokawa M. Culture, emotion, and well-being: Good feelings in Japan and the United States. Cognition and Emotion. 2000; 14:93–124.

Kitayama S, Mesquita B, Karasawa M. Cultural affordances and emotional experience: socially engaging and disengaging emotions in Japan and the United States. Journal of Personality and Social Psychology. 2006; 91:890–903. [PubMed: 17059308]

Kitayama S, Park J, Boylan JM, Miyamoto Y, Levine CS, Markus HR, Ryff CD. Expression of anger and ill health in two cultures: an examination of inflammation and cardiovascular risk. Psychological Science. 2015; 26:211–220. [PubMed: 25564521]

Kleinknecht RA, Dinnel DL, Kleinknecht EE, Hiruma N, Harada N. Cultural factors in social anxiety: A comparison of social phobia symptoms and “Taijin Kyofusho”. Journal of Anxiety Disorders. 1997; 11:157–177. [PubMed: 9168340]

Koivumaa-Honkanen H, Honkanen R, Viinamaeki H, Heikkila K, Kaprio J, Koskenvuo M. Self-reported life satisfaction and 20-year mortality in healthy Finnish adults. American Journal of Epidemiology. 2000; 152:983–991. [PubMed: 11092440]

Kok BE, Coffey KA, Cohn MA, Catalino LI, Vacharkulksemsuk T, Algoe SB, Fredrickson BL. How positive emotions build physical health perceived positive social connections account for the upward spiral between positive emotions and vagal tone. Psychological Science. 2013; 24:1123–1132. [PubMed: 23649562]

Krieger M. CHARTING THE FATE OF THE “GOOD CHOLESTEROL”: Identification and Characterization of the High-Density Lipoprotein Receptor SR-BI. Annual Review of Biochemistry. 1999; 68:523–558.

Kubzansky LD, Boehm JK, Segerstrom SC. Positive psychological functioning and the biology of health. Social and Personality Psychology Compass. 2015; 9:645–660.

Lockwood P, Jordan CH, Kunda Z. Motivation by positive or negative role models: regulatory focus determines who will best inspire us. Journal of Personality and Social Psychology. 2002; 83:854–864. [PubMed: 12374440]

Lyubomirsky S, King L, Diener E. The benefits of frequent positive affect: does happiness lead to success? Psychological Bulletin. 2005; 131:803–855. [PubMed: 16351326]

Maier H, Smith J. Psychological predictors of mortality in old age. Journal of Gerontology: Psychological Sciences. 1999; 54B:44–54.

Marsland, AL.; Pressman, S.; Cohen, S. Positive affect and immune function. In: Ader, R., editor. Psychoneuroimmunology. 4th. Vol. 2. San Diego, CA: Elsevier; 2007. p. 761-779.

Mazat L, Lafont S, Berr C, Debuire B, Tessier J-F, Dartigues J-F, Baulieu E-E. Prospective measurements of dehydroepiandrosterone sulfate in a cohort of elderly subjects: relationship to gender, subjective health, smoking habits, and 10-year mortality. Proceedings of the National Academy of Sciences. 2001; 98:8145–8150.

Mesquita B, Karasawa M. Different emotional lives. Cognition and Emotion. 2002; 16:127–141.

Miyamoto Y, Boylan JM, Coe CL, Curhan KB, Levine CS, Markus HR, Karasawa M. Negative emotions predict elevated interleukin-6 in the United States but not in Japan. Brain, behavior, and immunity. 2013; 34:79–85.

Miyamoto Y, Ryff CD. Cultural differences in the dialectical and non-dialectical emotional styles and their implications for health. Cognition and Emotion. 2011; 25:22–39. [PubMed: 21432654]

Miyamoto Y, Uchida Y, Ellsworth PC. Culture and mixed emotions: co-occurrence of positive and negative emotions in Japan and the United States. Emotion. 2010; 10:404–415. [PubMed: 20515228]

Moriyama Y, Yasue H, Yoshimura M, Mizuno Y, Nishiyama K, Tsunoda R, Saito Y. The Plasma Levels of Dehydroepiandrosterone Sulfate Are Decreased in Patients with Chronic Heart Failure in Proportion to the Severity 1. Journal of Clinical Endocrinology & Metabolism. 2000; 85:1834–1840. [PubMed: 10843161]

Mroczek DK, Almeida DM. The effect of daily stress, personality, and age on daily negative affect. Journal of Personality. 2004; 72:355–378. [PubMed: 15016068]

Nawata H, Yanase T, Goto K, Okabe T, Ashida K. Mechanism of action of anti-aging DHEA-S and the replacement of DHEA-S. Mechanisms of Ageing and Development. 2002; 123:1101–1106. [PubMed: 12044959]

Oishi S, Diener E. Goals, culture, and subjective well-being. Personality and Social Psychology Bulletin. 2001; 27:1674–1682.

Ong AD, Mroczek DK, Riffin C. The health significance of positive emotions in adulthood and later life. Social and Personality Psychology Compass. 2011; 5:538–551. [PubMed: 21927620]

Peng K, Nisbett RE. Culture, dialectics, and reasoning about contradiction. American Psychologist. 1999; 54:741–754.

Preacher KJ, Curran PJ, Bauer DJ. Computational tools for probing interactions in multiple linear regression, multilevel modeling, and latent curve analysis. Journal of Educational and Behavioral Statistics. 2006; 31:437–448.

Pressman SD, Cohen S. Does positive affect influence health? Psychological Bulletin. 2005; 131:925–971. [PubMed: 16351329]

Pressman SD, Gallagher MW, Lopez SJ. Is the Emotion-Health Connection a “First-World Problem”? Psychological Science. 2013; 24:544–549. [PubMed: 23443305]

Pressman SD, Gallagher MW, Lopez SJ, Campos B. Incorporating culture into the study of affect and health. Psychological Science. 2014; 25:2281–2283. [PubMed: 25287666]

Ramsey MA, Gentzler AL. An upward spiral: Bidirectional associations between positive affect and positive aspects of close relationships across the life span. Developmental Review. 2015

Ruby MB, Falk CF, Heine SJ, Villa C, Silberstein O. Not all collectivisms are equal: Opposing preferences for ideal affect between East Asians and Mexicans. Emotion. 2012; 12:1206–1209. [PubMed: 22775131]

Savineau JP, Marthan R, Dumas de la Roque E. Role of DHEA in cardiovascular diseases. Biochemical Pharmacology. 2013; 85:718–726. [PubMed: 23270992]

Schimmack U, Oishi S, Diener E. Cultural influences on the relation between pleasant emotions and unpleasant emotions: Asian dialectic philosophies or individualism-collectivism? Cognition and Emotion. 2002; 16:705–719.

Schuster TL, Kessler RC, Aseltine RH Jr. Supportive interactions, negative interactions, and depressed mood. American Journal of Community Psychology. 1990; 18:423–438. [PubMed: 2264558]

Schupp HT, Cuthbert BN, Bradley MM, Birbaumer N, Lang PJ. Probe P3 and blinks: Two measures of affective startle modulation. Psychophysiology. 1997; 34:1–6. [PubMed: 9009802]

Seeman TE. Social ties and health: The benefits of social integration. Annals of Epidemiology. 1996; 6:442–451. [PubMed: 8915476]

Sims T, Tsai JL, Jiang D, Wang Y, Fung HH, Zhang X. Wanting to maximize the positive and minimize the negative: Implications for mixed affective experience in American and Chinese contexts. Journal of Personality and Social Psychology. 2015; 109:292–315. [PubMed: 26121525]

Singelis TM. The measurement of independent and interdependent self-construals. Personality and Social Psychology Bulletin. 1994; 20:580–591.

Sommers S. Reported emotions and conventions of emotionality among college students. Journal of Personality and Social Psychology. 1984; 46:207–215.

Spencer-Rodgers J, Williams MJ, Peng K. Cultural differences in expectations of change and tolerance for contradiction: A decade of empirical research. Personality and Social Psychology Review. 2010; 14:296–312. [PubMed: 20435801]

Stephens NM, Townsend SSM, Markus HR, Phillips LT. A cultural mismatch: Independent cultural norms produce greater increases in cortisol and more negative emotions among first-generation college students. Journal of Experimental Social Psychology. 2012; 48:1389–1393.

Steptoe A, Dockray S, Wardle J. Positive affect and psychobiological processes relevant to health. Journal of Personality. 2009; 77:1747–1776. [PubMed: 19796062]

Steptoe A, Wardle J, Marmot M. Positive affect and health-related neuroendocrine, cardiovascular, and inflammatory processes. Proceedings of the National academy of Sciences of the United States of America. 2005; 102:6508–6512. [PubMed: 15840727]

Suh E, Diener E, Oishi S, Triandis HC. The shifting basis of life satisfaction judgments across cultures: Emotions versus norms. Journal of Personality and Social Psychology. 1998; 74:482–493.

Toth PP. The “Good Cholesterol”: High-Density Lipoprotein. Circulation. 2005; 111:e89–e91. [PubMed: 15699268]

Trapnell PD, Wiggins JS. Extension of the interpersonal adjective scales to include the Big Five dimensions of personality. Journal of Personality and Social Psychology. 1990; 59:781–790.

Tsai JL. Ideal affect: Cultural causes and behavioral consequences. Perspectives on Psychological Science. 2007; 2:242–259. [PubMed: 26151968]

Tsai JL, Knutson B, Fung HH. Cultural variation in affect valuation. Journal of Personality and Social Psychology. 2006; 90:288–307. [PubMed: 16536652]

Uchida Y, Kitayama S. Happiness and unhappiness in east and west: themes and variations. Emotion. 2009; 9:441–456. [PubMed: 19653765]

Uchino BN. Social support and health: a review of physiological processes potentially underlying links to disease outcomes. Journal of Behavioral Medicine. 2006; 29:377–387. [PubMed: 16758315]

Uchino BN, Cacioppo JT, Kiecolt-Glaser JK. The relationship between social support and physiological processes: a review with emphasis on underlying mechanisms and implications for health. Psychological Bulletin. 1996; 119:488–531. [PubMed: 8668748]

Wilson PW, Abbott RD, Castelli WP. High density lipoprotein cholesterol and mortality. The Framingham Heart Study. Arteriosclerosis, Thrombosis, and Vascular Biology. 1988; 8:737–741.

Wolkowitz OM, Epel ES, Reus VI. Stress hormone-related psychopathology: pathophysiological and treatment implications. The World Journal of Biological Psychiatry. 2001; 2:115–143. [PubMed: 12587196]

óHartaigh B, Loerbroks A, Thomas GN, Engeland CG, Hollands MA, Fischer JE, Bosch JA. Age-dependent and -independent associations between depression, anxiety, DHEA-S, and cortisol: from the MIPH Industrial Cohort Studies (MICS). Psychoneuroendocrinology. 2012; 37:929–936. [PubMed: 22133517]

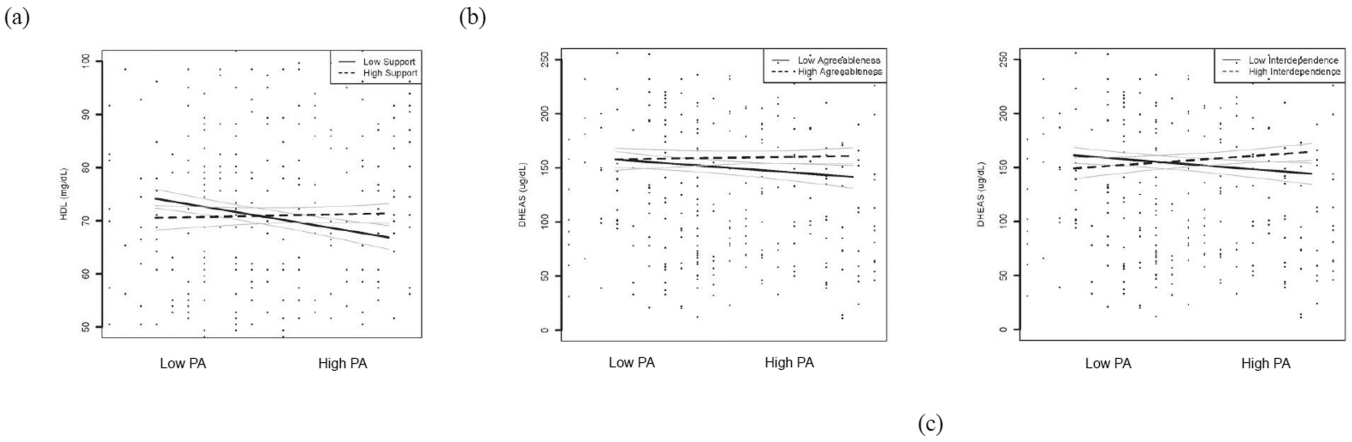

Figure 1.

HDL and DHEA-S as a function of social connectedness and PA in Japan controlling for all the covariates. "Low" is one standard deviation below the mean and "high" is standard deviation above the mean. (a) PA was negatively associated with HDL for Japanese with low support from friends, b=.034, SE = .013, t(329)=2.507, p = .013, but not for Japanese with high support from friends, b = .009, SE = .014, t(329) = .609, p = .546; (b) PA was negatively associated with DHEA-S for Japanese with low agreeableness, b=.174, SE = .067, t(329) = −2.581, p = .010, but not for Japanese with high agreeableness, b = .027, SE = .065, t(329) = .412, p = .681; and (c) PA was negatively associated with DHEA-S for Japanese with low interdependence, b = −147, SE = .064, t(329) = −2.298, p = .022, but not for Japanese with high interdependence, b = .073, SE = .067, t(329) = 1.083, p = .280. HDL = high-density lipoprotein; DHEA-S =dehydroepiandrosterone-sulfate; PA = positive affect.

Table 1

Descriptive statistics for the psychological, biological, and demographic variables from Japanese and American participants

	Japanese			Americans		
Variable	**N**	**M**	**SD**	**N**	**M**	**SD**
PA	381	3.3	0.75	1049	3.44	0.7
Social connectedness						
Agreeableness	381	2.69	0.63	1050	3.44	0.50
Support from friends	381	2.56	0.60	1048	3.33	0.64
Interdependence	381	4.80	0.64	1052	5.22	0.60
Biomarkers						
HDL	382	7.24	21.28	1043	54.63	17.61
DHEA-S	382	154.90	98.83	1040	105.43	76.21
Covariates						
Age	382	54.24	14.11	1054	55.26	11.78
Gender	382	1.56	0.50	1054	1.55	0.50
Education	378	13.62	2.40	1051	14.58	2.42
NA	381	1.70	0.65	1050	1.49	0.55
Smoking Status	356			1054		
Never smoker		48.4%			56.9%	
Former smoker		23.3%			32.4%	
current smoker		21.5%			10.6%	
Missing		6.8%			0.5%	
Alcohol (drinks/week)	379	7.24	11.75	1051	3.15	5.53
Depression/anxiety (% of Yes)	377	10.3%		1054	19.6%	
Chronic conditions	382	0.39	0.70	1054	0.89	0.10
WHR	382	0.83	0.08	1053	1.46	0.09

Note. Gender (1=male, 2=female). NA, negative affect. PA, positive affect. WHR, waist/hip ratio.

Table 2

Unstandardized regression coefficients in predicting HDL and DHEA-S as a function of positive affect, social connectedness, and the interaction between positive affect and social connectedness in Japan

	HDL		DHEA-S	
Predictors	**β**	***p***	**β**	***p***
PA	−.015	.165	−.086	.108
Agreeableness	−.008	.423	.070	.167
PA × Agreeableness	.015	.239	**.150**	**.019**
PA	−.017	.106	−.046	.373
Support from friends	.001	.901	−.032	.533
PA × Support from friends	**.033**	**.023**	−.088	.215
PA	−.019	.080	−.047	.453
Interdependence	.002	.803	.022	.764
PA × Interdependence	−.001	.967	**.159**	**.010**

Note. Results control for all the covariates (age, gender, education, negative affect, smoking, alcohol consumption, WHR, chronic conditions, depression/anxiety). Bolded coefficients are significant at the .05 level.

Table 3

Unstandardized regression coefficients in predicting HDL and DHEA-S as a function of positive affect, social connectedness, and the interaction between positive affect and social connectedness in the U.S.

	HDL		DHEA-S	
Predictors	**β**	***p***	**β**	***p***
PA	**.015**	**.047**	−.009	.836
Agreeableness	.001	.909	−.015	.751
PA × Agreeableness	.017	.078	−.001	.985
PA	.014	.065	.001	.971
Support from friends	.007	.251	−.028	.436
PA × Support from friends	.011	.159	.012	.786
PA	.014	.068	−.017	.686
Interdependence	.006	.363	.069	.053
PA × Interdependence	−.002	.767	−.015	.751

Note. Results are control for all the covariates (age, gender, education, negative affect, smoking, alcohol consumption, WHR, chronic conditions, depression/anxiety). Bolded coefficients are significant at the .05 level.

Table 4

Positive Emotion Co-Occurrence and Appraisal Overlap

Emotion by appraisal	$r_{E1.E2}$	$d_{POA.E1.E2}$	$d_{NOA.E1.E2}$	$d_{PI.E1.E2}$	$d_{POA–PI.E1.E2}$	$r_{E1.E2}d_{POA.E1.E2}$	$r_{E1.E2}d_{NOA.E1.E2}$	$r_{E1.E2}d_{PI.E1.E2}$	$r_{E1.E2}d_{POA–PI.E1.E2}$
Amusement									
Awe	.35	.27	.26	.13	.22	−.38	−.28	−.45	−.31
Challenge	.05		.43				−.34		
Contentment	.36	.29	.29	.13	.28	−.39	−.27	−.48	−.36
Gratitude	.29	.27	.28	.10	.25	−.33	−.30	−.34	−.32
Hope	.24	.27	.33	.12		−.44	−.29	−.44	
Interest	.42	.23	.28	.10		−.47	−.28	−.47	
Joy	.40	.31	.30	.17	.28	−.39	−.25	−.61	−.34
Love	.34	.26	.28	.09	.25	−.34	−.26	−.42	−.32
Pride	.31	.27	.28	.12	.25	−.37	−.22	−.37	
Relief	.20	.27	.31	.12		−.37	−.22	−.37	
Serenity	.28	.29	.30	.10	.28	−.36	−.30	−.40	−.36
Awe									
Challenge	.16	.29	.37		.29	−.32	−.37		−.32
Contentment	.29	.38	.32	.22		−.55	−.31	−.55	
Gratitude	.36	.26	.26	.12	.25	−.38	−.33	−.43	−.35
Hope	.26	.30	.32	.13	.28	−.32	−.31	−.42	−.26
Interest	.30	.34	.31	.20	.27	−.46	−.28	−.58	−.35
Joy	.21	.50	.36	.33		.63	−.31	−.63	
Love	.26	.28	.29	.12	.25	−.33	−.20	−.43	−.28
Pride	.32	.26	.27	.10	.25	−.38	−.25	−.42	−.36
Relief	.24	.24	.30	.13	.24	−.35	−.33	−.45	−.26
Serenity	.25	.29	.31	.15		−.42	−.35	−.42	
Challenge									
Contentment	−.02	.33	.49		.33	−.32	−.40		−.32
Gratitude	.12		.40						
Hope	.21	.38	.36		.38	−.38	−.36		−.38
Interest	.15	.33	.43		.33	−.33	−.38		−.33

Emotion by appraisal	$r_{E1.E2}$	$d_{POA.E1.E2}$	$d_{NOA.E1.E2}$	$d_{Pl.E1.E2}$	$d_{POA–Pl.E1.E2}$	$r_{E1.E2}d_{POA.E1.E2}$	$r_{E1.E2}d_{NOA.E1.E2}$	$r_{E1.E2}d_{Pl.E1.E2}$	$r_{E1.E2}d_{POA–Pl.E1.E2}$
Joy	−.09	.36	.54		.36	−.29	−.38		−.29
Love	.02	.31	.43		.31	−.26	−.34		−.26
Pride	.23	.29	.36		.29	−.30	−.36		−.44
Relief	.06	.46	.40		.46	−.48	−.36		−.48
Serenity	−.07	.35	.49		.35	−.34	−.39		−.34
Contentment									
Gratitude	.35	.31	.30	.16	.27	−.52	−.35	−.56	−.48
Hope	.35	.32	.34	.17		−.53	−.37	−.53	
Interest	.48	.22	.27	.08	.20	−.39	−.29	−.47	−.30
Joy	.56	.23	.22	.07	.22	−.44	−.36	−.58	−.41
Love	.34	.30	.31	.14	.27	−.39	−.30	−.51	−.33
Pride	.26	.34	.32	.21	.30	−.32	−.26	−.52	−.35
Relief	.33	.33	.31	.18		−.55	−.37	−.55	
Serenity	.41	.27	.27	.12	.26	−.40	−.37	−.50	−.38
Gratitude									
Hope	.34	.23	.29	.09		−.35	−.28	−.35	
Interest	.29	.28	.31	.14		−.51	−.32	−.51	
Joy	.31	.37	.33	.22	.27	−.49	−.32	−.58	−.40
Love	.37	.25	.27	.09	.24	−.35	−.32	−.39	−.33
Pride	.33	.26	.26	.08	.25	−.31	−.24	−.37	−.29
Relief	.34	.21	.28	.08		−.38	−.27	−.38	
Serenity	.32	.25	.29	.10	.23	−.36	−.31	−.37	−.34
Hope									
Interest	.47	.28	.28	.13	.23	−.43	−.40	−.55	−.31
Joy	.31	.41	.35	.25		−.64	−.37	−.64	
Love	.31	.27	.31	.11	.25	−.34	−.29	−.42	−.26
Pride	.32	.27	.28	.11	.24	−.36	−.26	−.41	−.32
Relief	.31	.30	.31	.10	.30	−.29	−.28	−.38	−.27
Serenity	.21	.27	.35	.13		−.33	−.32	−.33	
Interest									
Joy	.53	.24	.27	.09	.20	−.48	−.35	−.55	−.40

Emotion by appraisal	$r_{E1.E2}$	$d_{POA.E1.E2}$	$d_{NOA.E1.E2}$	$d_{Pl.E1.E2}$	$d_{POA–Pl.E1.E2}$	$r_{E1.E2}d_{POA.E1.E2}$	$r_{E1.E2}d_{NOA.E1.E2}$	$r_{E1.E2}d_{Pl.E1.E2}$	$r_{E1.E2}d_{POA–Pl.E1.E2}$
Love	.31	.29	.31	.12	.26	−.34	−.25	−.46	−.22
Pride	.30	.31	.29	.18	.26	−.36	−.22	−.49	−.30
Relief	.22	.30	.33	.16		−.47	−.34	−.47	
Serenity	.25	.28	.34	.14		−.41	−.33	−.43	−.39
Joy									
Love	.35	.33	.33	.21	.29	−.40	−.33	−.63	−.33
Pride	.22	.39	.36	.33	.33	−.36	−.29	−.61	−.30
Relief	.28	.43	.34	.25		−.64	−.31	−.64	
Serenity	.35	.30	.31	.19	.28	−.39	−.32	−.60	−.34
Love									
Pride	.30	.27	.28	.10	.26	−.29	−.28	−.39	−.26
Relief	.24	.25	.32	.11		−.39	−.27	−.39	
Serenity	.30	.27	.31	.11	.27	−.37	−.33	−.40	−.37
Pride									
Relief	.25	.25	.30	.11		−.64	−.31	−.64	
Serenity	.24	.28	.32	.13	.26	−.35	−.31	−.41	−.34
Relief									
Serenity	.28	.24	.30	.10		−.42	−.27	−.42	
Average		.29	.32	.14	.28	−.40	−.31	−.47	−.34

Note. All *p* values for $r_{E1.E2}$ have been adjusted using a False Discovery Rate (at .05 level) correction for multiple tests under dependency (Benjamini & Yekutieli, 2001). $r_{E1.E2}$: co-occurrence between emotions E1 and E2; $d_{POA.E1.E2}$: overlap in predicted overlapping appraisals (POA) between E1 and E2; $d_{NOA.E1.E2}$: overlap in non-predicted overlapping appraisals (NOA) between E1 and E2; $d_{Pl.E1.E2}$: overlap in Pleasantness between E1 and E2; $d_{POA–Pl.E1.E2}$: overlap in POA between E1 and E2 without Pleasantness; $r_{E1.E2}.d_{POA.E1.E2}$: correlation between r_{E1}.E2 and $d_{POA.E1.E2}$; $r_{E1.E2}.d_{NOA.E1.E2}$: correlation between r_{E1}.E2 and $d_{NOA.E1.E2}$; $r_{E1.E2}.d_{Pl.E1.E2}$: correlation between r_{E1}.E2 and $d_{Pl.E1.E2}$; rE1$_{E2}.d_{POA–Pl.E1.E2}$: correlation between r_{E1}.E2 and $d_{POAPl.E1.E2}$$p < .05$. $p < .01$. $p < .001$.