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Emotional Experience Improves With Age: Evidence Based on Over 10 Years of Experience Sampling

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Recent evidence suggests that emotional well-being improves from early adulthood to old age. This study used experience-sampling to examine the developmental course of emotional experience in a representative sample of adults spanning early to very late adulthood. Participants ($N = 184$, Wave 1; $N = 191$, Wave 2; $N = 178$, Wave 3) reported their emotional states at five randomly selected times each day for a one week period. Using a measurement burst design, the one-week sampling procedure was repeated five and then ten years later. Cross-sectional and growth curve analyses indicate that aging is associated with more positive overall emotional well-being, with greater emotional stability and with more complexity (as evidenced by greater co-occurrence of positive and negative emotions). These findings remained robust after accounting for other variables that may be related to emotional experience (personality, verbal fluency, physical health, and demographic variables). Finally, emotional experience predicted mortality; controlling for age, sex, and ethnicity, individuals who experienced relatively more positive than negative emotions in everyday life were more likely to have survived over a 13 year period. Findings are discussed in the theoretical context of socioemotional selectivity theory.

Keywords: emotion, emotion regulation, aging, socioemotional selectivity, experience-sampling

The observation that emotional well-being is maintained and in some ways improves across adulthood is among the most surprising findings about human aging to emerge in recent years (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Charles, Reynolds, & Gatz, 2001; Gross et al., 1997; Mroczek & Kolarz, 1998; Riediger, Schmiedek, Wagner, & Lindenberger, 2009). Cross-sectional age comparisons point to the possibility that there is steady and marked improvement in emotional experience from early adulthood into old age. Though findings from several studies suggest that negative experience may increase slightly at very advanced ages, even this late-life upturn fails starkly to rise to the levels reported early in adulthood (Carstensen et al., 2000; Griffin, Mroczek, & Spiro, 2006; Kunzmann, Little, & Smith, 2000) and is typically better predicted by closeness to death than chronological age (Gerstorf, Ram, Estabrook, Schupp, Wagner, & Lindenberger 2008).

The observation of preserved well-being so flies in the face of stereotypes about aging—as well as ample evidence for age-related losses—that it is often met with disbelief in both the general population and the research community. Despite empirical evidence to the contrary, old age is persistently viewed as a time of sadness and loss by younger people. Older people share these

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pessimistic views about the "typical" older person (Hummert, Garstka, Shaner, & Strahm, 1994; Nosek, Banaji, & Greenwald, 2002) even though the majority of older people describe themselves as quite satisfied (Myers & Diener, 1995).

The pattern is less surprising to life-span developmentalists. Several life-span theories point to possible explanations for improved well-being with age. By definition, development is a process of adaptation and successful development demands that people learn from experience, understand contingencies in their environments, approach rewarding situations, and avoid punishing ones. As a consequence, knowledge (or expertise) informs future actions, which are increasingly effective within relevant environments. One prominent model of adult development, selective optimization with compensation (Baltes & Baltes, 1990; Baltes, Lindenberger, & Staudinger, 2006), maintains that successful aging entails selective investment in goals and environments and drawing on accumulated expertise to optimize performance in selected domains to compensate for inevitable limitations. Socioemotional selectivity theory (SST), a life-span theory of motivation, argues that shorter time horizons become an increasingly important source of motivation, leading to the prioritization of emotional goals (Carstensen, 2006; Carstensen, Isaacowitz, & Charles, 1999). As people age and time horizons grow shorter, people invest in what is most important, typically meaningful relationships, and derive increasingly greater satisfaction from these investments. Reasoning from SST, emotional experience improves with age because people come to appreciate and invest more effort in matters of life important to them.

In the theoretical context offered by SST, improved well-being in adulthood does not mean that the emotional lives of older people are uniformly happy. Rather, investments in meaningful activities under time-limited conditions elicit richly complex emotional experiences, such as gratitude accompanied by a sense of fragility and happiness tinged with sadness. Our research group has observed an age-related increase in mixed emotions, which we (imperfectly) refer to as poignancy (Carstensen et al., 2000). We have also observed similar responses in younger people when experimental manipulations prime endings while people are imagining meaningful experiences (Ersner-Hershfield, Mikels, Sullivan, & Carstensen, 2008). Recent findings in the literature suggest that affective experiences also become more stable as people age, which may be a reflection of the use of increasingly efficient self-regulatory and self-stabilizing processes (Charles & Pasupathi, 2003; Roecke, Li, & Smith, 2009). We maintain that relatively nuanced emotional experiences may contribute to improved regulation. Ong and Bergeman (2004), for example, found that neuroticism is associated with relatively few co-occurrences of positive and negative emotional experiences; and in the psychopathology literature, the coupling of positive and negative emotions is associated with fewer depressive symptoms (Roberts & Gotlib, 1997). Thus, mixed emotions may contribute to emotional stability and ultimately to greater subjective well-being.

Yet despite reliable evidence that older adults report greater well-being than younger adults and the theoretical feasibility that emotional lives are not diminished over time, many questions about the developmental course of emotional regulation and well-being remain unanswered. A number of viable alternative explanations for findings about relative age advantages cannot be ruled out based on the existing literature. For one, rigorous examination of within-individual change is extremely limited—almost all of the relevant studies comparing older and younger adults are cross-sectional. In other words, it remains possible that the "Greatest Generation" is—and *always was*—better off emotionally than younger cohorts. Second, most existing studies rely on participants' global judgments about life, so reporting biases may strongly influence responses; older people, for example, may hold implicit theories about wisdom and satisfaction that positively influence their global reports about their subjective states quite independent of their actual experiences (e.g., Ross, 1989).

Compounding concerns about global self-reports is mounting evidence that older people attend to and remember the past more positively than younger people (Carstensen, Mikels, & Mather, 2006; Charles, Mather, & Carstensen, 2003; Isaacowitz, Wadlinger, Goren, & Wilson, 2006; Kim, Healey, Goldstein, Hasher, & Wiprzycka, 2008; Levine & Bluck, 1997; Mather & Carstensen, 2005; see also Carstensen & Löckenhoff, 2003). Termed the *positivity effect*, this pattern has been observed within short periods of time, e.g., across experimental sessions (Charles et al., 2003), over days (Mather & Johnson, 2000), and even over years as in autobiographical memory (Kennedy, Mather, & Carstensen, 2004), raising the possibility that older peoples' global reports about life are more positive than life is experienced in real time. Indeed, a viable competing hypothesis is that life is actually pretty miserable for older people but, either due to generational norms about putting a positive spin on the harshness of life or simply forgetting negative information, global reports misrepresent daily emotional experience.

Finally, there are several reports in the literature that individual characteristics, such as holding positive attitudes about aging (Levy, Slade, Kunkel, & Kasl, 2002) and describing oneself as happy (Danner, Snowdon, & Friesen, 2001), are associated with reduced mortality risk. While provocative, these associations lack explanatory mechanisms. To the extent that such self-descriptions are markers for chronically activated emotional experiences that persist across days and years, however, they may point to plausible mechanisms by which psychological experiences could interact with physiological systems and ultimately affect health and longevity. That is, negative emotional states activate biological systems that influence immune resistance, disease progression, and even gene expression (Cole et al., 2007). Positive states and emotional stability may limit negative effects. To date, however, there is little, if any, evidence that global reports like the ones noted above are associated with persistent emotional experience in daily life.

Resolution of these somewhat disparate findings is important. At a practical level, if day-to-day emotional experiences affect risk profiles for mortality, public health efforts could help to develop regulatory skills. And, theoretically, the tendency for emotional experience to improve with age would not only add nuance to decline models of aging but would challenge assumptions that emotional well-being is derived from assets, such as biological and cognitive hardiness, and make way for hypotheses that well-being is enhanced by appreciation for life's fragility and gratitude for time left (e.g., Cheng & Yim, 2008). If, as the end of life slowly but steadily nears, emotional experience grows more complex and overall more positive, it may represent the most fundamental paradox of human functioning.

We maintain that progress toward resolution in this area demands several steps: (a) charting intra-individual change over time, (b) inclusion of measures that tap everyday emotional experiences as they occur and do not rely on memory or global reports of well-being, and (c) examination of mortality differences between people who experience relatively more positive emotions in everyday life and those whose experiences are relatively negative.

Overview of the Present Study

Longitudinal investigation based on experience-sampling offers the opportunity to examine the developmental course of emotional experience as well as the relationships such patterns may have with longevity. The experience-sampling method (ESM) is widely considered the "gold standard" in the measurement of emotional experience because it obviates the deliberative and comparative processing that global judgments entail (Stone et al., 1998). Compare, for example, the different types of information that individuals draw upon to answer the following questions: (a) "How much anger do you feel *at this moment*?" and (b) "To what degree are you an angry person?" In the former, the respondent draws on immediate feeling states. The latter demands an averaging of emotional tendencies and a comparison of those tendencies to what he or she expects is typical of other people. The simplicity and face validity of the former are particularly relevant when attempting to understand age differences. ESM obviates potential age differences in memory biases noted above and offers a real time account of emotional experience in day to day life, which could address the provocative associations between global reports and longevity noted above.

In 2000, our research group reported findings from a cross-sectional study based on experience-sampling of 184 participants who ranged in age from 18 to 94 years (Carstensen et al., 2000). To the best of our knowledge, this experience-sampling study of emotion was the first to include a sample spanning the full adult age range. We have now followed this original group of participants over a ten-year period and assessed frequency, stability, and complexity (viz., co-occurrence of positive and negative emotions) of emotional experiences as they occurred in everyday life at five-year intervals using a measurement burst design, wherein data are obtained across multiple time scales (Nesselroade, 1991). Specifically, ESM data were collected multiple times per day for a one week period on three separate occasions spaced five years apart. The micro-time scale allowed for assessment of the frequency, stability, and complexity of individuals' emotions at a given age, while the macro-time scale allowed for examination of age-related development over the long term (see Ram & Gerstorf, 2009, for further discussion of such designs). At each wave, we also recruited new participants, matched on demographic characteristics of lost participants, and recruited new young people into the study as continuing participants "aged out" of the youngest group.

This project affords the opportunity to carefully examine within-individual change in emotional experience and also uniquely address the issues raised above. We tested the following hypotheses. The first three are theoretical hypotheses derived from SST. The fourth is a statistical hypothesis based on prior reports in the literature:

Hypothesis 1: As people age, positive emotions are increasingly more common than negative emotions.

Hypothesis 2: As people age, emotional experience is more stable in day-to-day life.

Hypothesis 3: As people age, emotional experiences are increasingly mixed, with positive and negative emotions more likely to be reported during the same sampling episode.

Hypothesis 4: Emotional well-being (i.e., more frequent positive and/or less frequent negative emotions) predicts survival.

Method

Participants

The initial sample consisted of 184 English-speaking participants recruited by a survey research firm located in the San Francisco Bay area in 1993 and 1995. Because the methods were relatively demanding and we were interested in normal aging, we instructed the firm to restrict recruitment to participants who reported that their health was "as good or better than most people their age." The sample was restricted to two ethnic groups in order to allow for statistically meaningful analyses of two subsamples: 31% of the participants were African American and the remaining 69% were European American. Fifty-four percent of participants were women and 46% were men; 41% of participants were blue-collar workers and 59% were white-collar workers.[1] Education ranged from 5 to 22 years (M = 15.0, SD = 2.7). Participants ranged in age from 18 to 94 years (M = 55, SD = 20.4). Importantly, ethnicity, gender, and socioeconomic status were stratified across age.

Following an initial wave of data collection (1993-1995), two subsequent waves of data were collected at 5-year intervals (Wave 2, 1998-2001; Wave 3, 2004-2005) in a burst design. At each wave, additional participants were recruited to replace those lost to attrition as well as a new group of young people to replace those who aged out of the youngest group.[2] A total of 191 participants completed Wave 2 and 178 participants completed Wave 3. The sociodemographic composition of the samples did not differ across waves (see Table 1 for details).

In order to address selective attrition, we compared participants who were retained from one wave to the next with those who did

[1] Socioeconomic status was identified before individuals were invited to participate in the study. Individuals were classified as blue or white collar by the survey research firm based on household income, occupation, and years of education.

[2] Of the Wave 1 participants, 73 were lost to attrition in Wave 2, and 86 Wave 2 participants were lost to attrition in Wave 3. From those lost to attrition in Wave 2, 7 did not complete the sampling period, 20 were deceased, 3 were incapacitated, 7 refused participation, and 36 could not be located. From those lost to attrition in Wave 3, one person did not complete the sampling period, 16 were deceased, 10 were incapacitated, 9 refused participation, and 50 could not be located. In the event that a participant could not be contacted by phone or mail, every effort was made to obtain updated information from phone directories, the social security death index, and other public records. A licensed private search agency was hired to locate individuals who could not be located in such a manner. Of participants who we were able to contact, 94% agreed to participate.

Table 1
Demographic Characteristics of the Sample

Characteristic Statistic	Sample description		
	Wave 1 (n = 184)	Wave 2 (n = 191)	Wave 3 (n = 178)
Mean age (*SD*)	54.83 (20.57)	55.62 (22.05)	57.33 (21.34)
Age range	18.0–94.0	18.0–93.0	18.0–94.0
Mean years of education (*SD*)	14.77 (2.85)	15.17 (2.62)	15.47 (2.43)
Sex	54% women	53% women	53% women
	46% men	47% men	47% men
Ethnicity	31% African American	31% African American	29% African American
	69% European American	69% European American	71% European American
Socioeconomic status	41% blue-collar	37% blue-collar	39% blue-collar
	59% white-collar	63% white-collar	61% white-collar
Mean number of children (*SD*)	1.60 (1.61)	1.54 (1.48)	1.56 (1.34)

not continue participating. As is typical in longitudinal studies, retained participants were more likely to be European American, $\chi^2(1, 218) = 4.21$, $p < .05$, and to have more years of education, $M = 15.31$ vs. 14.52, $t(375) = 2.80$, $p < .01$. We performed the same analyses excluding those participants who had died between waves and these differences remained significant. Otherwise, there were no differences by age, gender, socioeconomic status, or health (all ps $> .20$) in the composition of the samples across waves.

Since the commencement of the first wave of data collection, information about mortality has been obtained from the Social Security Death Index database at regular intervals, and death certificates with information on date and cause of death have been obtained from the Office of Vital Statistics. In the fall of 2009, roughly 15 years after study initiation, 61 participants originally recruited in Wave 1 had died (all from natural causes) and 123 participants were still alive.

Procedure

Following screening by the survey research firm, participants were scheduled at their convenience for an initial interview at Stanford University or at the offices of the San Francisco-based survey research firm that did the initial recruiting (Wave 1). At Waves 2 and 3, participants who were unable to come to Stanford due to poor health or lack of transportation were interviewed in their homes or in a private meeting room at the San Francisco Public Library. Participants were informed that the purpose of the study was to examine feelings in everyday life. After obtaining informed consent and background information, such as education level, the participants completed questionnaires that assessed physical health, personality, happiness, and cognitive ability.

At that point, participants were provided with detailed instructions about the experimental procedures. Then they were given an electronic pager, were familiarized with the operations of the pager (e.g., how to set it for vibration or sound, how to indicate that they had received the page by pushing a button, etc.), and were instructed to complete the emotion response sheets each time they were paged. During the ensuing week, participants were paged five times each day. Paging times were determined by random selections from all possible 10-min intervals between 9 a.m. and 9 p.m. The only constraint on sampling times was that participants were not sampled more than once within a single 20-min period. At the end of each day, participants returned the five completed response sheets by mail in pre-addressed stamped envelopes, allowing us to monitor responses during the data collection period and assure adherence to the experimental protocol. Participants were encouraged to telephone the laboratory if procedural questions or problems arose, and periodic calls were made to participants as well to ensure that they were not having any difficulty with the procedure. After participants completed the week-long experience-sampling data collection, they returned to the laboratory for a follow-up interview, at which time they were debriefed and paid for their participation.

Materials

Emotion sampling. Participants rated the degree to which they were feeling each of 19 emotions using a 7-point scale that ranged from 1 (*not at all*) to 7 (*extremely*). The list of emotions included 8 positive (happiness, joy, contentment, excitement, pride, accomplishment, interest, and amusement) and 11 negative emotions (anger, sadness, fear, disgust, guilt, embarrassment, shame, anxiety, irritation, frustration, and boredom). Thirty-five daily samplers (5 per day, 7 days) were bound into an 8.5 in. by 5.5 in. pad to allow for easy transport during the week of paging.

Cornell Medical Index (CMI). The CMI (Brodman, Erdmann, & Wolff, 1956) is a 195-item index of physical and mental health problems that allows for the computation of a general health index, as well as subscales that represent particular subsystems (e.g., vision, allergies, cardiovascular, neurological, etc.). Participants answer 195 questions about family history and symptoms they have experienced. We computed one index representing the total number of symptoms of physical illness (e.g., "Are you troubled by constant coughing?).

Verbal fluency. Participants are asked to name as many different types of animals as possible within 90 seconds. This test shows a strong association with general intellectual ability and has been extensively used with older adults (Lindenberger, Mayr, & Kliegl, 1993).

Happiness. Participants indicated their current level of happiness by completing the 4-item Subjective Happiness Scale (Lyubomirsky & Lepper, 1999). Participants indicate on a 7-point Likert-scale how generally happy they are (1 = *not a very happy*

person, 7 = *a very happy person*) and how happy they are relative to their peers (1 = *less happy*, 7 = *more happy*). Two additional items require participants to indicate the extent to which a description of a "very happy" and a "very unhappy" person, respectively, characterizes them (1 = *not at all*, 7 = *a great deal*). The fourth item is reversed scored and higher scores for the overall scale indicate greater subjective happiness.

Personality. At Wave 1, personality was assessed using a list of 54 adjectives representing the Big Five factors of personality presented in the form of self-descriptive sentences (John & Srivastava, 1999). At Waves 2 and 3, these personality dimensions were assessed using the 60-item NEO-Five Factor Inventory (NEO-FFI; Costa & McCrae, 1992). We computed scores for each of the Big Five factors: Neuroticism, Extraversion, Openness to Experience, Agreeableness, and Conscientiousness. Personality scores for the three waves were Z-standardized and aggregated across waves, yielding five time-invariant personality scores for each person that were used as covariates in growth curve analyses.

Results

Below we describe preliminary analyses and results for each of the four key hypotheses. In testing these hypotheses, we proceeded in a two-step fashion. We first sought to replicate cross-sectional effects across the three waves to establish the robustness of effects. We then combined data from all three waves and applied multilevel growth curve modeling to test intra-individual change in emotional experience across adulthood. Finally, we present analyses concerning the role of emotion in longevity.

> *Hypothesis 1:* As people age, emotional experience becomes more positive.

Preliminary analyses. Each participant provided ratings of 19 different emotions at each of 35 sampling occasions, yielding 665 data points per participant per wave. We adapted the data reduction procedures used by Carstensen et al. (2000). For each participant, we calculated two indices for each of the 19 emotions to summarize that participant's experience across 35 occasions: frequency and intensity. Frequency was computed as the proportion of occasions that a participant reported experiencing a given emotion to any degree; that is, the proportion of times the participant's rating was greater than 1. Intensity of emotion was computed as the average rating of that emotion across all 35 sampling occasions where the participant reported having that emotion (i.e., gave ratings greater than 1; see Schimmack & Diener, 1997, for a discussion of this kind of decomposition).

This procedure yielded, for each participant, one frequency and one intensity score for each of 19 emotions, which were then averaged separately across all positive emotions and all negative emotions. To further reduce the number of variables in our analyses and given that we were interested in the overall quality of emotional experience, we computed an index of *positive emotional experience* by subtracting the average of negative emotions from the average of positive emotions for each participant (separately for frequency and intensity, see Table 2 for descriptive statistics). Based on the results by Carstensen et al. (2000), we did not expect and did not find reliable age differences for the intensity measure. Therefore, we will not discuss affect intensity further. Our index of the frequency of positive emotional experience was moderately stable across waves ($r_{\text{Wave 1-Wave 2}} = .60$; $r_{\text{Wave 2-Wave 3}} = .59$; $r_{\text{Wave 1-Wave 3}} = .60$; all $ps < .05$).

Cross-sectional results. Linear as well as quadratic effects of age on frequency of emotional experience were examined. We tested a quadratic effect of age because as people get older and start experiencing age-related problems, the increase in positivity of emotional experience may level off (Carstensen et al., 2000). A regression analysis was conducted, separately for each wave, regressing positive emotional experience on age (centered) and age squared. Results of these analyses were consistent across the three waves. As hypothesized, at each wave, positive emotional experience increased into the late 60s and then stopped increasing (Wave 1: $\beta_{age} = .12$, $p > .05$; $\beta_{age^2} = -.26$, $p < .001$; Wave 2: $\beta_{age} = .21$, $p < .01$; $\beta_{age^2} = -.17$, $p < .05$; Wave 3: $\beta_{age} = .24$, $p < .01$; $\beta_{age^2} = -.17$, $p < .05$).

Next, we examined the robustness of findings when controlling for other variables that may be related to emotional experience. We used the following variables as covariates in the regression equations: personality (neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness), physical health, verbal fluency, along with ethnicity, gender, and socioeconomic

Table 2
Descriptives of Central Study Variables

	Wave 1		Wave 2		Wave 3	
Variable	*M*	*SD*	*M*	*SD*	*M*	*SD*
Positive emotional experience	.53	.27	.48	.26	.55	.24
Emotional lability	.81	.33	.85	.32	.82	.31
Poignancy	−.36	.32	−.34	.32	−.36	.29
Physical health	14.35	9.85	16.62	10.76	14.87	11.12
Verbal fluency	23.65	9.65	25.24	9.00	26.24	8.80
Happiness	5.33	.98	5.32	1.09	5.32	1.07
Personality						
Neuroticism	.39	.27	3.17	.37	3.16	.36
Extraversion	.59	.26	3.84	.33	3.86	.31
Openness	.65	.21	4.15	.35	4.14	.31
Agreeableness	.82	.20	4.26	.32	4.25	.29
Conscientiousness	.72	.22	3.49	.35	3.48	.33

status. The previously found significant linear and quadratic effects of age remained significant across waves, with the exception of the linear effect of age at Wave 2 and 3.[3]

Growth curve analysis. Incorporating data from all three waves simultaneously, we used growth curve analysis to test the hypothesis that emotional experience improves within individuals as they grow older. To accommodate the nested aspect of the data (waves within persons), we ran a series of multilevel models of change (McArdle & Nesselroade, 2003; Singer & Willet, 2003). Specifically, we began by fitting a multilevel model with random intercept, linear age, and quadratic age components to the measure of positive emotional experience. Incomplete data and differential number of assessments per person were accommodated under the missing at random assumptions underlying accelerated longitudinal designs (McArdle & Bell, 2000). Following usual model building procedures, random effect components were removed in a step-by-step fashion until the most parsimonious within-person (Level 1) model was found. The age-related effects were then assessed and interpreted. Subsequently, time-varying control variables (physical health, verbal fluency) were added to the model as within-person predictors (Level 1), and time-invariant control variables (five personality factors, ethnicity, gender, socio-economic status) were added to the model as between-person predictors (Level 2). Results are displayed in the first column in Table 3.

We found that the random effects of age in this and all further growth curve models were not significant and were thus eliminated from the model. The lack of significant amounts of between-person variance in age effects suggests that in this sample, age-related changes in emotional experience proceed in a homogeneous fashion and that deviations from the normative age-related change trajectory are not systematic. Any individual differences are thus modeled as residual variance.

In line with the hypothesis, the positive emotional experience index significantly increases with age whether modeled as a linear or polynomial function (age $\gamma = .0026$, $p < .001$; age^2 $\gamma = -.0001$, $p < .001$). This again supports the hypothesis that the frequency of positive relative to negative experiences increases up to a certain age and then levels off. Model-based predictions, given average levels of all covariates and cautiously interpreted in the context of model assumptions, indicate that the peak is at age 64. The trajectory can be seen in Figure 1A. Among control variables, physical health as well as openness to experience also predicted the frequency of positive emotional experience. Greater frequency of positive relative to negative emotions was associated with higher scores on openness to experience and fewer physical health symptoms. Interactions between the control variables and the age-related changes were not significant.[4]

> *Hypothesis 2:* As people age, there is greater stability in emotional experience.

Preliminary analyses. For analyses of emotional stability, we first quantified the extent of intraindividual variation across 35 occasions within each burst (Ram & Gerstorf, 2009). A time-series statistic, the Mean Square Successive Difference (MSSD; Von Neumann, Kent, Bellinson, & Hart, 1941), was applied to both positive and negative emotional intensity to operationalize emotional lability.[5] The calculation of MSSD is similar to the calculation of a standard deviation, with one major difference: Instead of summing differences between each individual score (in this case the emotion rating on one sampling occasion) and the mean for all scores (in this case the mean emotion rating across all sampling occasions), one takes the sum of differences between each score and the score obtained from the very next sampling occasion. We took the square root of MSSD to make it analogous to standard deviation. By accounting for sequential changes from one sampling occasion to the next, this statistic has been demonstrated to be an adequate measure of instability (i.e., lability) when applied to the type of time series data obtained here (Jahng, Wood, & Trull, 2008; Leiderman & Shapiro, 1962).

Scores were initially calculated separately for positive and negative emotions. However, given the similarity of results across the two measures, we investigated the parsimony of using an average of the positive and negative MSSD scores as a single measure that would reflect a general lack of stability. Positive and negative emotional lability were correlated at Wave 1 ($r = .57$), Wave 2 ($r = .41$), and Wave 3 ($r = .36$, all ps $< .001$). Across all persons and waves, they also correlated in an expected manner ($r = .44$) and were both reflected in the average ($r_{pos,ave} = .86$; $r_{neg,ave} = .84$). Given substantial similarity of findings with each measure separately, we use the average score in presenting and interpreting the analyses in a parsimonious manner. The general emotional lability index was moderately stable across waves ($r_{Wave\ 1\text{-}Wave\ 2} = .63$; $r_{Wave\ 2\text{-}Wave\ 3} = .54$; $r_{Wave\ 1\text{-}Wave\ 3} = .58$; all ps $< .05$; see Table 2 for descriptive statistics).

Cross-sectional results. As predicted, general emotional lability was negatively correlated with age at Wave 1 ($r = -.37$, $p < .001$), Wave 2 ($r = -.14$, $p < .05$), and Wave 3 ($r = -.33$, $p < .001$). The same pattern was present for both the positive (*rs* for Waves 1, 2, 3 $= -.37, -.18, -.26$, respectively) and negative (*r*s $= -.27, -.06, -.28$) emotional lability measures. No quadratic effects were significant (all *p*s $> .45$). This pattern of relationships suggests that at each wave older adults reported less lability (i.e., more stability) in emotional experience between successive sampling occasions than younger adults. When adding control variables, age effects were still found in Waves 1 and 3, yet not in Wave 2.[6]

Growth curve analysis. Consistent with cross-sectional analyses, growth curve analysis revealed significant age-related change

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[3] The only other significant predictors in these regression equations were neuroticism in Waves 2 ($\beta = -.39$, $p < .01$) and 3 ($\beta = -.22$, $p < .05$), and extraversion in Wave 2 ($\beta = .19$, $p < .05$).

[4] Although there were some predictable gender differences in emotional experience (e.g., women experience more positive and negative emotions), there were no gender interactions in the reported findings.

[5] The formula to calculate our measure of lability, based on the MSSD was as follows: $\delta^2 = \frac{\sum_{t=1}^{m-1}(X_t - X_{t-1})^2}{m-1}$, with X_t denoting a person's score at time t, X_{t-1} denoting this person's score at the previous time point, and *m* denoting the overall number of measurements per person.

[6] Among control variables, gender and three of the personality dimensions predicted variability in emotional experience, albeit not consistently across waves. More variable emotions were found in women relative to men in Wave 1 ($b = .169$) and Wave 3 ($b = .238$), in individuals with higher neuroticism in Wave 2 ($b = .166$), in individuals with higher extraversion in Wave 2 ($b = .160$) and Wave 3 ($b = .162$), and in individuals with lower openness in Wave 3 ($b = -.170$, all *p*s $< .05$).

Table 3
Results of Multilevel Growth Curve Analyses Testing the Effect of Age and Control Variables on Three Aspects of Emotional Experience

	Positive emotional experience	Emotional lability	Poignancy
Fixed effects estimates			
Intercept	.6414***	.7123**	−.3604***
Age	.0030***	−.0040**	.0033***
Age^2	−.0001***	.0001	.0001
Ethnicity	.0335	−.0462	.0516
Sex	−.0091	.0817*	−.0616
SES	.0243	.0047	.0263
Physical health	−.0062***	.0022	−.0014
Verbal fluency	.0005	.0023	−.0020
Personality			
Neuroticism	−.0245	.0212	−.0123
Extraversion	.0242	.0567*	−.0353
Openness	.0606***	−.0419	−.0320
Agreeableness	.0167	.0487	.0596
Conscientiousness	−.0078	−.0871	−.0584
Random effects estimates			
Variance intercept	.0290***	.0467***	.0500***
Residual variance	.0276***	.0389***	.0882***
−2LL	15.90	213.10	475.20

Note. Unstandardized estimates are presented. All standard errors are ≤ .07. Intercept is centered at age 56 years; Ethnicity, sex and SES are categorical variables coded 0, 1 with Caucasian, male, and white-collar as the default categories; *−2LL* = −2 Log Likelihood.
* $p < .05$. ** $p < .01$. *** $p < .001$.

in lability. As seen in Table 3, the fixed effect of linear age was significant ($\gamma = -0.0040$, $p < .05$), indicating that as people get older they tend to report less lability of emotional experiences ($\gamma_{pos} = -0.0051$, $p < .05$; $\gamma_{neg} = -0.0034$, $p < .05$). There was not a significant quadratic age effect. The trajectory for the general emotional lability measure is plotted in Figure 1B (as stability: –MSSD). Among control variables, gender and extraversion were significant predictors of emotional lability. Higher lability was associated with being female and being more extraverted.

> *Hypothesis 3:* As people age, emotional experiences become more mixed, with positive and negative emotions increasingly likely to co-occur during the same sampling episode.

Preliminary analyses. To operationalize "poignancy," we examined the degree to which individuals experience both positive and negative emotions on the same sampling occasion. The index was computed by calculating, separately for each participant, a correlation between the participant's mean positive and mean negative affect ratings across the 35 sampling occasions for each wave of data collection. Across all three waves, the mean of this correlation across participants was $r = -.36$ ($SD = 0.31$), suggesting that positive and negative affect tended *not* to be present on the same sampling occasion. Intra-person correlations were subjected to Fisher's *r*-to-*z* transformation before relating them to other variables, such as age. Poignancy was moderately stable across waves ($r_{\text{Wave 1-Wave 2}} = .43$; $r_{\text{Wave 2-Wave 3}} = .34$; $r_{\text{Wave 1-Wave 3}} = .49$; all *p*s $< .05$; see Table 2 for descriptive statistics).

Cross-sectional results. While there was no significant age effect of poignancy at Wave 2 ($r_{190} = 0.08$, $p = .27$), for Waves 1 and 3, the expected significant linear age effect did emerge, with older age associated with a greater potential for the co-occurrence of positive and negative emotions (Wave 1: $r_{181} = .26$, $p < .001$; Wave 3: $r_{177} = .24$, $p < .001$). There were no quadratic age effects. Results held when control variables were added.[7]

Growth-curve analysis. Significant age-related changes were also evident in the multilevel analyses. As seen in Table 3, significant age-related effects were found for poignancy ($\gamma = 0.003041$, $p < .05$). In line with the theoretical predictions, this effect suggests that poignancy increases within individuals as they grow older (see Figure 1C for the prototypical age trajectory). None of the control variables emerged as additional predictors.

> *Hypothesis 4:* People who have relatively positive emotional profiles survive longer than people with relatively negative emotional profiles.

To test Hypothesis 4, we examined differences in survival for participants who were relatively positive and compared them to survival for participants who were relatively negative. We excluded participants who were 45 years old or younger at Wave 1 because, as Pressman and Cohen (2005) note, the association of emotional experience and mortality is weak, if existent, in early adulthood when mortality risk is extremely low. Recall that the survey research firm was instructed to recruit participants who considered themselves relatively healthy. Nonetheless, we observed a nonsignificant trend at Wave 1 for people with more

[7] Only one control variable emerged as additional predictor in Wave 1: African Americans, as compared to European Americans, had a greater likelihood of experiencing mixed emotional states ($b = .184$, $p < .05$).

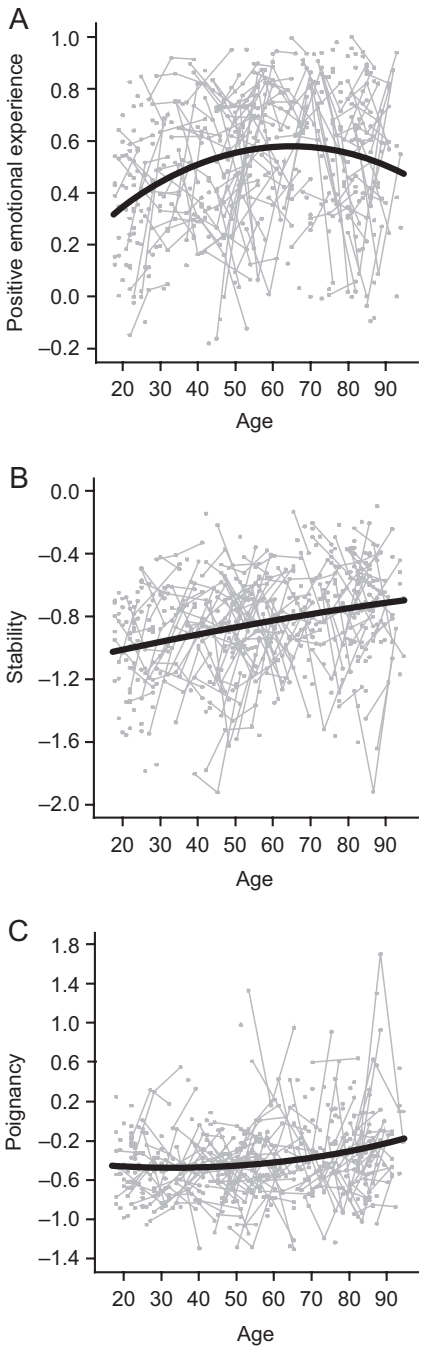

Figure 1. Prototypical age trajectories for (A) positive emotional experience (frequency of positive emotions minus negative emotions), (B) emotional stability (−MSSD), and (C) poignancy (r-to-z transformed intraperson correlation between positive and negative emotion ratings).

positive emotional experiences to have endorsed fewer physical symptoms ($r = -.14$, $p = .07$; controlling for age). To avoid, as best we could, the confounding of negative emotional experience with acute illness, we considered only those deaths that occurred two or more years after Wave 1 data collection. Of these 111 participants, 56 were deceased by 2009, and 55 were still alive. For the 56 participants who had died, the mean age at death was 82.71 years ($SD = 9.77$; range 57–101 years) and occurred on average 101.04 months ($SD = 45.59$, range 29–180 months) after the initial Wave 1 assessment.

Cox regression analyses were conducted to predict probability of survival by the positive emotional experience index obtained in Wave 1. Age and positive emotional experience were used as predictors of survival (controlling for gender and ethnicity). Not surprisingly, age was significantly associated with the hazard of dying, with a hazard ratio (HR) of 1.07, 95% confidence interval (CI) = 1.05–1.10; $p < .001$. As hypothesized, positive emotional experience was also a significant predictor of mortality, HR (95% CI) = .34 (.12–.94), $p < .05$. That is, those persons who experienced positive emotions relatively more frequently than negative emotions at the initial measurement survived longer than those who experienced relatively more frequent negative emotions. To illustrate, we split the sample into groups with high versus low positive emotional experience using a median split. Figure 2 shows the survival function separately for these two groups. Emotional stability and poignancy were unrelated to survival.

Because questionnaire measures of such qualities as happiness and purpose in life have been associated with survival in large survey studies, and we had included the widely used 4-item happiness measure developed by Lyubomirksy and Lepper (1999) in our original data collection, we also could examine the degree to which it predicted survival. Happiness correlated significantly ($r = .39$, $p < .01$) with experienced positive emotion, and the happiness measure also predicted survival: HR (95% CI) = .72 (.54–.98), $p < .05$ (controlling for age, gender, and ethnicity). When both happiness and experienced emotion were entered in a regression simultaneously, neither was significant, suggesting that their shared variance accounts for the prediction.

Summary of Results

Four main findings emerged from these analyses. First, we observed improvement in overall emotional well-being with age, as well as a significant quadratic age trend consistent with earlier cross-sectional findings, suggesting that developmental gains in emotional well-being may level off in the 7th decade. Second, we found that with advancing age, emotional experiences become more stable. Third, emotional experience appears to become more

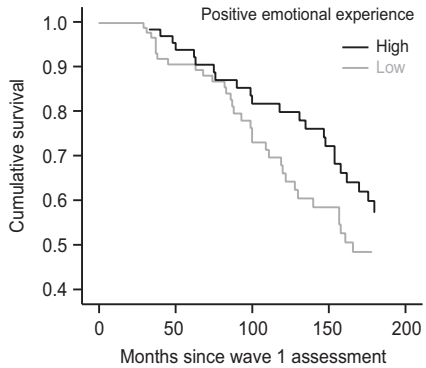

Figure 2. Survival function over 13 years for Wave 1 participants with high versus low positive emotional experience.

mixed as people age, as indicated by a decrease in the negative correlation between positive and negative affect as people get older. All of these findings are largely consistent across types of analysis (cross-sectional and growth curve modeling) and remain robust after accounting for other variables that may be related to emotional experience (personality, verbal fluency, physical health, and demographic variables). Finally, emotional experience is associated with mortality. Across a thirteen-year period—controlling for age, sex, and ethnicity—individuals who experienced relatively more positive than negative emotions in everyday life were more likely to have survived.

Discussion

To the best of our knowledge, the present study is the only one of its kind measuring emotional experiences as they occur in daily life in participants who span the entire adult age range. The longitudinal nature of the project allowed us to address fundamental questions that have long plagued the literature on emotion and aging but could not be properly answered with cross-sectional data. Using growth curve analyses to model the patterns across adulthood, we observed a strong replication of the cross-sectional findings our group first reported in 2000. Whereas the initial study compared a sample spanning an age range of 76 years at a single point in time, the present set of findings focused on within-individual change across a 10 year period and statistically modeled change across the full age-spectrum of adulthood. There appears to be steady improvement in the ratio of positive to negative experience, and that process is first evident early in adulthood. The quadratic fit suggests that improvement either plateaus or slightly declines at very advanced ages. However, as in the original cross-sectional study, at no point in adulthood do levels return to ones as negative as observed in younger adults. Contrary to the popular view that youth is "the best time in life," the present findings suggest that the peak of emotional life may not occur until well into the 7th decade.

By using experience sampling, we were able to assess, with considerable fidelity, the emotions that people have in "real time" as they live their lives. All four of the hypotheses that motivated the original cross-sectional study and this longitudinal follow up received support: Positive emotions are experienced more often as people age. Emotional experiences grow more stable. The co-occurrence of positive and negative emotions or "poignancy" steadily increases. Finally, individuals who are relatively positive survive longer. We argue that the first three theoretical hypotheses are interrelated, that is, the concurrent experience of positive and negative emotions contributes to emotional stability and emotional stability is associated with well-being. The fourth is a confirmation of previous reports from survey studies that people who describe themselves as happy live longer than those who do not. We discuss the first three hypotheses together below and then return to a discussion of survival.

Emotional Lives Improve With Age

This study was designed to examine stability and change in emotional experience across adulthood. Reports of relative age advantages in emotional experience and regulation began to emerge in the late 1980s and 1990s (e.g., Blanchard-Fields, 1986). Since that time, considerable evidence has accrued suggesting that aging may be related to improvements in the regulation and experience of emotion. SST maintains that emotional experience improves because people become increasingly motivated to pursue emotionally meaningful goals and thus invest psychological and social resources to optimize emotional well-being. However, nearly all of the empirical evidence for the theoretical postulate have been cross-sectional and, as such, could not resolve questions of age *change*. The present findings do resolve key age change questions. There appears to be steady improvement in the ratio of positive to negative experience across adulthood. That process becomes evident sufficiently early in adulthood to deny the possibility that enhanced well-being in late life simply reflects selective mortality. The second hypothesis, namely that emotional experiences grow more stable with age, was also supported. Lability of emotional experience was reduced over time, which is consistent with recent findings suggesting that older people respond less strongly to the situational vicissitudes of daily life. Roecke et al. (2009), for example, observed that older people are less reactive to daily events—both good and bad—compared to their younger counterparts and that they maintain a relatively stable mix of emotions regardless of positive or negative events. Roberts, Walton, and Viechtbauer (2006) also observed reduced lability in emotional experience from young to middle age.

Consistent with the third hypothesis, we observed that the co-occurrence of positive and negative emotions steadily increases. We suspect that mixed emotional states tamp down extreme highs and lows and consequently contribute to emotional stability. We maintain that stability, poignancy, and well-being are interrelated, that is, the concurrent experience of positive and negative emotions contributes to emotional stability and emotional stability is associated with well-being.

Findings also bear on alternative explanations for observations of improved emotional experience, such as the possibility that older people deny negative emotions or that selective mortality accounts for positive age profiles. Our findings show that while negative emotions are less frequent, they increasingly co-occur with positive emotions as people age. The absence of age differences in the *intensity* of emotions (positive and negative) also speaks against denial. When emotions were reported, intensities did not vary by age. And, as noted above, the fact that improvement in experience was clearly evident before the age of 50, and no participant under 50 died during the course of the study, findings do not support the contention that selective mortality can explain positive age profiles.

We maintain that such changes arise from a shift in goals associated with constraints on time horizons. According to socioemotional selectivity theory (Carstensen, 1993; Carstensen, 2006), constraints on time horizons result in the chronic activation of goals related to emotional meaning. Of course, observational studies cannot directly expose the mechanisms underlying observed phenomena. Ours are no exception. The present findings cannot rule out the possibilities that reduced emotional variability reflects habituation processes (Frederick & Loewenstein, 1999) or age-related changes in life contexts and social roles (e.g., retirement, empty nest), making daily life more stable and predictable and easier to regulate emotionally for older adults (Almeida & Horn, 2004; Brown & Moskowitz, 1998; Roecke et al., 2009). Nor can they rule out biological explanations for the findings (although see

Samanez-Larkin & Carstensen, in press). The a priori hypotheses that directed the study were, however, generated by a theory about motivation. Notably, one recent experience sampling study that simultaneously assessed both emotional experience and individuals' attempts to alter those experiences reported age differences in emotion similar to those we reported in 2000 but also assessed age differences in motivation. In a sample aged 14 to 86 years, Riediger et al (2009) queried participants about their emotional states and asked them on the same sampling occasions whether they wanted to enhance, maintain, or dampen those states. Younger people were more likely to report the desire to maintain or enhance negative emotions and dampen positive emotions than older adults. Older adults in contrast were more likely to report the desire to maintain positive states. To the best of our knowledge, the Riediger findings are the first to assess both experience and motivation simultaneously.

Together with experimental findings suggesting that older people outperform younger people on laboratory tasks that demand regulation (Charles & Carstensen, 2007; Phillips, Henry, Hosie, & Milne, 2008; Scheibe & Blanchard-Fields, 2009), these findings offer support for developmental growth in the emotion domain. It is possible that aging demands improvement in emotion regulation.

Emotional Experience and Mortality

Following the first-wave participants over the following 15 years, we find that the rate of mortality is statistically lower in the subset with higher emotional status than the subset with lower emotional status. The trend begins in midlife and the distinction between the two subsets increases monotonically with age. Given the short time span since the second and third waves of this study, we were unable to predict mortality by longitudinal indicators of emotional *change*, yet as time progresses we will be able to do so using this data set. The association of positive emotional experience with survival is consistent with a number of reports in recent years that document a relationship between positive attitudes and beliefs with longevity (Boyle, Barnes, Buchman, & Bennett, 2009; Danner et al., 2001; Gerstorf, Smith, & Baltes, 2006; Jacobs, Hammerman-Rozenberg, Cohen, & Stessman, 2008; Levy et al., 2002), as well as the converse, namely, that neuroticism is associated with increased mortality risk (Mroczek, Spiro, & Turiano, 2009). The strong assumption has been that the self-reports by which researchers assess these trait-like markers represent differences in the chronic experience of positive and negative emotions over sufficiently long periods that they could affect health. In their comprehensive review of the happiness literature, including its relationship to physical health, Lyubomirsky, King, and Diener (2005) make the assumption explicit: "Although many definitions of happiness have been used in the literature, ranging from life satisfaction and an appreciation of life to momentary feelings of pleasure, we define happiness here as a shorthand way of referring to the frequent experience of positive emotions. In our theoretical framework, it is the experience of positive emotions that leads to the behavioral outcomes we review, and 'happiness' describes people who experience such emotions a large percentage of the time" (p. 820).

Though logical and compelling at a conceptual level, to date, the relationship of global self-reports to enduring individual differences in the frequency of positive experience has not been demonstrated. Thus, the finding that the rank ordering of individual differences in emotional experience persisted across three bursts of data collection, each separated by five years, is revealing. Indeed, an individual's week of emotions sampled at one wave was highly correlated with emotions sampled another week 5 and even 10 years later. These correlations were as high as those for measures of personality traits, which is actually quite surprising given the obvious situational influences on randomly selected moments of experience.

Stability in individual differences in daily emotional experience over many years makes way for plausible links between emotional dispositions and physical health. Whereas stress activates norepinephrine pathways that can affect disease progression (see Cole, Korin Fahey, & Zack, 1998), positive affect is related to reduced neuroendocrine, cardiovascular, and inflammatory activity (Steptoe, Wardle, & Marmot, 2005). Individuals who are more efficient in reducing amygdala activation associated with negative moods show more adaptive patterns of diurnal cortisol secretion (Urry et al., 2006). Yet, in order for such mechanisms to affect mortality, associated emotional states would need to persist for long periods of time. The present findings offer evidence that individual differences in experienced emotions do indeed persist over many years.

One obvious alternative explanation for the relationship of emotional dispositions to longevity is that sick people are unhappy and the causal direction is reversed. Indeed, survey studies show a decline in satisfaction among people who are likely to die within a four-year period (Gerstorf et al., 2008). The beauty of examining the relationship of emotional experience to mortality in this sample is that none of the participants was seriously ill at the time they joined the study and the association of positive emotional experience to longevity was still observed. Even so, participants who were most positive at the start of the study reported somewhat better health than those who were less positive. When physical health at Wave 1 was entered into the regression before emotional experience, emotional experience no longer predicted survival. We are not convinced that research can fully disentangle physical health from emotional experience. There may be genetic differences, for example, between happy and unhappy people that are associated with biological hardiness. Even if emotional experience plays a causal role in physical health, those effects would predate recruitment into studies. It is clear, however, that positive emotional experiences *predict* survival and we hope that the present findings contribute to an understanding of the interplay between mental and physical health.

Note that Lyubomirksy and Lepper's (1999) four-item happiness measure was strongly correlated with levels of positive experience in everyday life and surprisingly good at predicting survival. Given the enormous difference in effort involved in sampling experience on multiple occasions and administering a short questionnaire, there are clear efficiencies in using single-occasion survey methods to obtain useful information about the general nature of people's lives. However, additional value beyond the prediction of a major event is likely limited. For instance, individuals' overall happiness scores provide little to no information about where, in people's daily lives, the potential intervention points for increasing longevity may be. We maintain that ESM data like those described here are essential for capturing important aspects of emotional experience unaddressed by surveys (e.g., changes in stability and complexity) and that such data provide

new opportunities for studying the underlying dynamic characteristics, processes, and causal mechanisms that connect positive emotional experience and survival and for designing and delivering interventions that can change people's lives (Bolger, Davis, & Rafaeli, 2003; Ram & Gerstorf, 2009; Shiffman, Stone, & Hufford, 2008).

Future Directions

Participants in this study were sampled during typical weeks of their lives. Thus, we cannot speak to emotional experience in the context of major life events. Maintaining positive and stable emotional experiences is much more challenging during times of extreme uplift or adversity, and it is an open question whether, with age, individuals are better able to maintain emotional balance in the face of significant stress. We are currently assessing a subset of the sample in an intensive laboratory assessment in order to examine under controlled conditions whether those people with relatively positive profiles in daily life differ in stress regulation and whether they show different neural responses under experimental conditions that expose them to emotional stimuli. We are also collecting genetic data related to variation in dopamine or serotonin function related to individual differences in emotional experience. Another idea we are pursuing concerns the possibility that aging and its biological consequences demand improvement in emotion regulation. As time progresses, we will be able to predict mortality by longitudinal indicators of emotional change.

Conclusion

There is growing consensus that from early adulthood to old age emotional well-being improves. To the best of our knowledge, these are the first longitudinal, experience-sampling findings involving a sample that spans the adult age range that support this observation. No doubt, the story of emotion and health, once, if ever, fully revealed, will be complicated and interactive. However, evidence is growing that experiencing positive emotions may not only improve quality of life, it may add years to life.

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