

Positive Emotions in Early Life and Longevity: Findings from the Nun Study

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Handwritten autobiographies from 180 Catholic nuns, composed when participants were a mean age of 22 years, were scored for emotional content and related to survival during ages 75 to 95. A strong inverse association was found between positive emotional content in these writings and risk of mortality in late life ($p < .001$). As the quartile ranking of positive emotion in early life increased, there was a stepwise decrease in risk of mortality resulting in a 2.5-fold difference between the lowest and highest quartiles. Positive emotional content in early-life autobiographies was strongly associated with longevity 6 decades later. Underlying mechanisms of balanced emotional states are discussed.

Longevity may be related to a variety of factors including heredity, gender, socioeconomic status, nutrition, social support, medical care, and personality and behavioral characteristics (Robine, Vaupel, Jeune, & Allard, 1997). These factors might operate throughout life or at particular life stages. Recent findings from the Nun Study, a longitudinal study of older Catholic sisters, indicated that linguistic ability in early life is associated with survival in late life (Snowdon, Greiner, Kemper, Nanayakkara, & Mortimer, 1999). In that study, the idea density (proposition, information, and content) of autobiographies written at a mean age of 22 years was strongly related to survival and longevity 6 decades later. Because

the autobiographies appeared to contain emotional content that might be associated with idea density (Snowdon et al., 1996), we investigated the relationship between emotional content in these early life writings and survival in late life.

A growing body of literature has shown positive and negative emotion-related attitudes and states to be associated with physical health, mental health, and longevity. For example, in a longitudinal study of Harvard graduates, Peterson (Peterson, Seligman, & Vaillant, 1988) found the ways in which young men explained bad events predicted health outcome decades later. Such studies appear to be based on assumptions that emotion-based constructs reflect patterns of coping with negative life events and stresses that can be harmful or beneficial to health. The assumptions of the current longitudinal investigation of emotions and longevity are very similar and evolved from what is known about the underlying relationships among emotion, temperament, and physiology that might influence longevity. This study builds on the knowledge that there are universal, patterned emotional responses that affect physiology in ways that are potentially damaging or beneficial.

Over the past 30 years, emotion researchers have identified basic emotions such as happiness, sadness, anger, fear, and disgust (Ekman & Friesen, 1969). More recently, these basic emotions have been associated with differentially patterned autonomic nervous system (ANS) responses (Ekman, Levenson, & Friesen, 1983; Levenson, Carstensen, Friesen, & Ekman, 1991; Levenson, Ekman, & Friesen, 1990; Levenson, Ekman, Heider, & Friesen, 1992). The functional characteristics of the associated patterns of emotion and ANS activation (Levenson, in press) strongly suggest the potential for a lifelong pattern of emotional arousal affecting health and longevity. Furthermore, numerous studies have shown that complex emotional states, such as anxiety, produce elements of ANS patterns associated with specific negative emotions (Lazarus, 1991). These same elements of elevated galvanic skin response, heart rate, and blood pressure are found in the patterned

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ANS responses to the arousal of basic emotions and potentially could affect health and longevity.

Laboratory research also has found that the suppression of emotional states can exacerbate ANS responses (Gross & Levenson, 1997). A lifelong pattern of suppressing the expression of emotion has the potential for adverse effects on essential body systems. Although no ANS pattern has been found to be associated with positive emotion that differentiates it from baseline (Levenson et al., 1990), studies have demonstrated the potential muting effects of positive emotion on the bodily responses to negative emotion (Fredrickson & Levenson, 1998). This healing effect of positive emotion may have the potential to reduce stress on the cardiovascular system even in the face of inevitable negative life events. In other words, constructs such as optimism and positive attitude may imply the following sequence: Events arousing negative affect are approached with confidence that the future holds something positive and better, thus internally generating a positive emotional state that mutes the adverse effects of the prolonged arousal of a negative emotion.

The basic research of Fredrickson, Gross, and Levenson cited above has laid the groundwork for the study of how sustained and repetitious patterns of emotional arousal might relate to physical health and survival and, more specifically, how the emotion system is intimately tied to the ANS, which activates cardiovascular responses that could have cumulative adverse or salutary effects on health (Krantz & Manuck, 1984). What is needed is an explanation for why a particular pattern of emotional and ANS responses would be repeated with sufficient frequency to produce such cumulative effects. As part of this explanation, it is necessary to examine the relationship among patterns of emotional responsiveness, temperament, and the development of personality.

Temperament, the biologically based propensity for individuals to respond to events in particular ways, is considered by some theorists to contribute to the development of personality (Izard, Libero, Putnam, & Haynes, 1993; Malatesta & Wilson, 1988). Moreover, temperament is proposed to reflect the degree to which emotions are generally expressed, as well as the differing frequencies with which specific emotions or patterns of emotions are displayed or suppressed (Izard et al., 1993). Early and continuing styles of emotional expression are proposed to constitute some characteristics of personality (Izard et al., 1993; Malatesta & Wilson, 1988). Supporting this line of reasoning, work by Headey (Headey & Wearing, 1992) suggests that individuals maintain levels of positive or negative affect that are determined by their personalities and that after emotional arousal or stress these levels return to individual baselines (Diener, 2000). When an individual's response pattern is frequent or sustained negative emotional arousal with slow return to a tranquil baseline, the autonomic response could prompt cardiovascular activity that accelerates disease mechanisms such as atherosclerosis. In contrast, a pattern of relatively infrequent negative emotional arousal or one that rapidly returns to a calm baseline following negative arousal could have beneficial effects on health.

Such a balance of emotional states, either by avoiding suppression of the expression of aroused emotion or by readily resolving negative arousal, is compatible with Vaillant's proposal that mature defenses work to promote a positive psychology that enhances the ability to work, love, and play (Vaillant, 2000). Vaillant provided evidence that earlier life manifestations of mature ego

defenses that balance and attenuate multiple sources of conflict predict enhanced physical and mental health 20 years later and suggests that mature ego defenses may reflect inborn traits. If so, Vaillant's proposition may offer yet another pathway for how potentially beneficial or harmful patterns of emotional responses may be expressed and balanced and may be mediated through patterns of problem solving throughout a lifetime, thereby influencing longevity.

A pattern of emotional arousal and temperament may be disclosed, in part, by the written expression of language. Research by Pennebaker and his colleagues has used written language as a means of understanding how emotion influences both physical and psychological health (Hughes, Uhlmann, & Pennebaker, 1994; Pennebaker, 1993; Pennebaker & King, 1999). The early-life autobiographies in our study afford another opportunity to examine emotional content in written language and its relationship to health. If the use of emotional content in these writings reflects reactions to inevitable stressful life events, then these writings may reveal characteristic responses to intense or sustained arousal that produces *allostatic load*—indicators of physiological response to stress (McEwen, 1998; Singer & Ryff, 1999; Sterling & Eyer, 1988). Furthermore, if the use of positive and negative emotional content in writing reflects a general readiness to express emotion, then these writings may indicate a pattern that avoids the adverse effects of suppressing the expression of emotions. On the other hand, if the use of positive emotional content in writing reflects a readiness to resolve negative arousal, then writings may be revealing a pattern of balance in emotional response indicating *allostasis*, adaption to change while maintaining physiological systems within a normal range (Singer & Ryff, 1999; Sterling & Eyer, 1988; McEwen, 1998). Both the avoidance of suppression and the positive resolution of life's stresses could have beneficial effects on health and longevity.

Seligman emphasizes that an insightful, positive attitude in dealing with life events, an optimistic explanatory style in contrast to a pessimistic one, can lead to greater feelings of well-being and perhaps even to longer life (Seligman, 2000). In support, a recent study found optimism, as measured by a new optimism-pessimism scale of the Minnesota Multiphasic Personality Inventory (Swenson, Pearson, & Osborne, 1973), was associated with a lower risk of death in 839 Mayo Clinic patients observed over a 30-year period (Maruta, Colligan, Malinchoc, & Offord, 2000). However, in another long-term study of more than a thousand bright California school children, cheerfulness (i.e., parental judgments of optimism and a sense of humor) had an inverse relationship with longevity during middle and old age (Friedman, 1999). In the latter study, the cheerful participants also were found to be more likely to engage in activities known to be risk factors for mortality. On the other hand, in another analysis of the California data, Peterson and colleagues used the Content Analysis of Verbatim Explanations technique (Peterson, Seligman, Yurko, Martin, & Friedman, 1998) to code questionnaires completed by the participants in early adulthood and found evidence of a negative relationship between pessimism and longevity.

The early-life autobiographies and mortality data available for participants in the Nun Study offer a unique opportunity to investigate the possible association of written emotional expression to longevity. Participants in our study had the same reproductive and marital histories, had similar social activities and support, did not

smoke or drink excessive amounts of alcohol, had similar occupations and socioeconomic status, and had comparable access to medical care. Therefore, even though it may be difficult to generalize from this unique population of Catholic sisters, many factors that confound most studies of longevity have been minimized or eliminated.

Method

Study Population

The Nun Study is a longitudinal study of aging and Alzheimer's disease (Snowdon, 1997; Snowdon et al., 1996, 1999). Participants were members of the School Sisters of Notre Dame religious congregation who, before their retirement, lived and taught in the schools of cities and towns in the midwestern, eastern, and southern United States. In 1991 through 1993, all American School Sisters of Notre Dame born before 1917 were asked to join the Nun Study. Six hundred seventy-eight women agreed to participate in all phases of the study and gave informed written consent to allow access to their archived and active records, participate in annual assessments of cognitive and physical function, and donate their brains at death. At the first annual exam, the 678 participants were 75 to 102 years old ($M = 83$).

A search of the convents' archives revealed that the Mother Superior of the North American sisters, who resided in Milwaukee, Wisconsin, had sent a letter on September 22, 1930, requesting that each sister write an autobiography. A mix of handwritten and typed autobiographies for many of the 678 sisters in the study was found and these autobiographies became an invaluable research source. Criteria used to select autobiographies for intensive study were that the writers were born and raised in the United States and thus had the opportunity to master the English language and that the autobiographies were handwritten and therefore could be authenticated as unaltered by clerical staff.

We found that the number of available handwritten autobiographies was related to the convent in which the sister lived and the year she wrote her life story. A large number of autobiographies meeting criteria were found for participants from the Milwaukee, Wisconsin, and the Baltimore, Maryland, convents who took their religious vows and formally joined the religious congregation during 1931 to 1943 (Snowdon et al., 1999). Of the 678 sisters in the Nun Study, 218 took their vows in these two convents during that time period and handwritten autobiographies were found for 180 (83%) of these participants; that is, 101 participants from the Milwaukee, Wisconsin, convent and 79 from the Baltimore, Maryland, convent.

These 180 autobiographies were written some time between the ages of 18 and 32 ($M = 22$) depending on the age at which the sister joined the congregation. At the time of writing the autobiographies, 82% of the sisters had earned a high school diploma. By the beginning of the mortality follow-up period in 1991, 91% had earned at least a bachelors degree. During the mortality follow-up period of November 13, 1991, to September 1, 2000, the participants ranged in age from 75 to 95 years and 76 (42%) had died (Milwaukee sample = 43%, Baltimore sample = 42%).

Autobiographies

Beginning in 1930, each sister who took her final vows was asked to

write a short sketch of [her] life. This account should not contain more than two to three hundred words and should be written on a single sheet of paper . . . include place of birth, parentage, interesting and edifying events of childhood, schools attended, influences that led to the convent, religious life, and outstanding events.

Clearly, the instructions were not intended to influence the manner in which these life events were described nor were they intended for the study of emotional content, coping styles, or patterns of reasoning. Rather, we suspect that the autobiographies may have been used in part by the convent

leaders to gather information that might help to determine future educational and occupational paths, as well as to provide information useful for creating obituaries.

Despite uniformity in the events that were described, the manner in which the life facts were told in the autobiographies reflected individual style and ranged from simply stating that these life events happened and when they occurred to elaborations of the simple facts that included the emotions experienced by the writer or others involved in the life event. The following sentences, from the beginning and ending of two autobiographies, demonstrate differences in emotional content:

Sister 1 (low positive emotion): I was born on September 26, 1909, the eldest of seven children, five girls and two boys . . . My candidate year was spent in the Motherhouse, teaching Chemistry and Second Year Latin at Notre Dame Institute. With God's grace, I intend to do my best for our Order, for the spread of religion and for my personal sanctification.

Sister 2 (high positive emotion): God started my life off well by bestowing upon me a grace of inestimable value. . . . The past year which I have spent as a candidate studying at Notre Dame College has been a very happy one. Now I look forward with eager joy to receiving the Holy Habit of Our Lady and to a life of union with Love Divine.

Coding the Autobiographies and Generating Scores

The coding system used in classifying the written autobiographies was designed specifically for this study (Danner, Friesen, & Snowdon, 2000). All coding and review of the autobiographies were done without knowledge of the health or functional status of the study participants. Two coders identified all words in the 180 autobiographies that reflected an emotional experience and classified them as positive, negative, or neutral. Later, a third coder verified each coded word for accuracy and determined the specific type of emotional experience or state referenced by each word.

Coders were instructed on the distinctions between descriptions of possible elicitors of emotion (e.g., death of a family member), the emotion that was experienced (e.g., sadness), subsequent behaviors (e.g., crying), and attempts to control the overt expression of the emotion. They were instructed not to code descriptions of possible elicitors, but to code only words that in context described the emotion that was experienced and behaviors subsequent to emotional arousal. Further, they were instructed not to code words such as *good* and *bad* that have positive or negative connotations or might imply an emotional reaction but do not directly describe an emotional experience.

The coders were provided with examples of words related to the experience of the positive emotions of accomplishment, amusement, contentment, gratitude, happiness, hope, interest, love, and relief; the negative emotions of anger, contempt, disgust, disinterest, fear, sadness, and shame; and the neutral emotion of surprise. The two coders, one with a background in psychology and the other with training in education, then independently read the autobiographies. They marked words that conveyed emotion as experienced by the writer or others and classified the valence of the emotional content as positive, negative, or neutral. When necessary for comprehension, the coders were instructed to identify and code phrases rather than single words.

Two procedures were used to generate scores for the primary analysis on the basis of the positive, negative, and neutral scoring. The first procedure simply used the raw count of positive, negative, and neutral emotion words for each autobiography. The second procedure used these coded emotion words to classify each sentence as containing one or more positive, negative, or neutral words or as containing no emotion words. The first two columns of Table 1 show the number of positive, negative, and neutral emotional words and sentences as determined by each individual coder. The table shows that the two coders identified very similar numbers of positive, negative, and neutral emotional words.

Table 1
Reliability of the Emotion Coding as Indicated by the Number of Emotion Words and Sentences Scored by Two Coders for Autobiographies Written in Early Life by 180 Participants in the Nun Study

Unit of analysis and emotion	Count		Correlation of counts		
	Coder A	Coder B	Coders A and B ^a	Final coding and each coder ^a	
				Coder A	Coder B
Words					
Positive	1,243	1,242	.96 (.95, .97)	.99 (.98, .99)	.98 (.98, .99)
Negative	206	192	.89 (.85, .94)	.97 (.94, .99)	.94 (.91, .97)
Neutral	16	17	.78 (.64, .93)	.97 (.90, 1.00)	.82 (.69, .95)
Sentences					
Positive	1,006	1,017	.97 (.96, .98)	.99 (.98, .99)	.99 (.98, .99)
Negative	196	179	.90 (.85, .95)	.97 (.96, .99)	.94 (.91, .97)
Neutral	16	17	.78 (.64, .93)	.97 (.90, 1.00)	.82 (.69, .95)

Note. For all correlations, $p < .0001$.

^a 95% confidence intervals appear in parentheses.

In the verification phase of the coding, the words scored by the two coders were extracted from the autobiographies and a nonredundant list of words was reviewed by a third person (Wallace V. Friesen) for accuracy. This review was done without knowledge of whether one or both coders had scored the word or how frequently the word was scored. Words that did not meet the original criteria for an emotional experience were removed from the list. The 1,598 words retained in the final scoring constituted 1.8% of the total words in the autobiographies and 95% of the words scored by one or both coders. Of these emotional words, 84% were classified as positive, 14% as negative, and 1% as neutral. As described above for the single coders, the verified coding of emotion words was used to determine the number of sentences with one or more positive, negative, and neutral emotion words.

As a part of the verification process, each unique emotion word was classified as referring to a specific type of positive or negative emotions (only one emotion, surprise, was scored in the neutral category). Initially, the purpose of the categorization was to aid in the verification of the positive, negative, and neutral scoring of Coders A and B. If a word could not be categorized, its validity as an emotion word was questionable. We carefully reviewed this categorization of the emotion words and disagreements were discussed and arbitrated. The final list of subcategories and the number and percentage of sentences containing one or more words in each category is presented in Table 2.

Intercoder Reliability

Two types of intercoder reliability were assessed: the overall agreement in selecting and classifying the valence of emotional words and the degree to which the coders' scoring and the verified scoring of the autobiographies were correlated. Kappa coefficients were used to assess overall agreement between the two coders on the selection and classification of emotion words. The coefficient values were .83 and .84, .85, and .79 for all emotion, positive, negative, and neutral words respectively, indicating a satisfactory level of intercoder reliability both overall and for the individual types of emotion words. Additional analyses indicated that most differences between the two coders were due to one coder identifying a word that the other failed to detect and that this occurred with similar frequencies for the two coders. Examination of these disagreements indicated that the coder who failed to code apparently simply did not see the word because the same word was identified and classified identically by the errant coder in different places in the autobiographies. In other words, had the errant coder

noticed the word when reading the autobiography, it almost certainly would have been scored in agreement with the accurate coder.

In addition to the kappa coefficients of agreement, each coder's scoring and the verified scoring were used to generate positive, negative, and neutral counts for both words and sentences for each autobiography. Correlations were used to test the comparability of the three sets of coding. The resulting correlations are shown in the three columns on the right of Table 1. It can be seen here that the correlations between Coders A and B and verified counts of the numbers of emotional words and sentences were very high, indicating that virtually identical results would have been obtained in subsequent survival analysis had either Coder A's or Coder B's scoring been used in place of the final verified scores.

Linguistic Measures

Recent findings from studies of the same 180 autobiographies indicated that linguistic ability in early life was associated with survival in late life (Snowdon et al., 1999). In that study, the idea density (proposition, information, and content) of these autobiographies was associated with survival and longevity 6 decades later. Idea density of the early-life autobiographies also had a strong inverse association with Alzheimer's disease (Snowdon et al., 1996; Snowdon, Greiner, & Markesbery, 2000). Because idea-dense sentences of the autobiographies were observed to contain emotional words (Snowdon et al., 1996), idea density and grammatical complexity were used as control variables in one of the analyses in the current study. The following is a brief description of how idea density and grammatical complexity were measured.

Without the linguistic coders' knowledge of the age or cognitive function of each sister during late life, each autobiography was scored for two indicators of linguistic ability: idea density (Kintsch & Keenan, 1973; Turner & Greene, 1977) and grammatical complexity (Cheung & Kemper, 1992). Mean idea-density and grammatical-complexity scores were computed from the last ten sentences of each autobiography. Idea density was defined as the average number of ideas expressed per ten words. Ideas corresponded to elementary propositions, typically a verb, adjective, adverb, or prepositional phrase. Complex propositions that stated or inferred causal, temporal, or other relationships between ideas also were counted. Grammatical complexity was computed using the Developmental Level metric originally developed by Rosenberg and Abbeduto (Rosenberg & Abbeduto, 1987) and modified by Cheung and Kemper (1992). The Developmental Level metric classifies sentences according to eight levels of

Table 2
Distribution of the Different Types of Emotion Sentences in the Autobiographies Written in Early Life by 180 Participants in the Nun Study

Type of emotion	No. (and %) of sentences		
	Milwaukee convent	Baltimore convent	Both convents
Positive			
Happiness	109 (6.10)	341 (12.51)	450 (9.97)
Interest	160 (8.95)	281 (10.31)	441 (9.77)
Love	36 (2.01)	131 (4.81)	167 (3.70)
Hope	21 (1.17)	30 (1.10)	51 (1.13)
Gratefulness	6 (0.34)	41 (1.50)	47 (1.04)
Contentment	19 (1.06)	21 (0.77)	40 (0.89)
Unspecified	11 (0.62)	14 (0.51)	25 (0.55)
Accomplishment	7 (0.39)	15 (0.55)	22 (0.49)
Relief	2 (0.11)	4 (0.15)	6 (0.13)
Amusement	0 (0.00)	1 (0.04)	1 (0.02)
Negative			
Unspecified	19 (1.06)	36 (1.32)	55 (1.22)
Sadness	8 (0.45)	46 (1.69)	54 (1.20)
Afraid	4 (0.22)	18 (0.66)	22 (0.49)
Disinterest	7 (0.39)	13 (0.48)	20 (0.44)
Confused	5 (0.28)	13 (0.48)	18 (0.40)
Anxiety	1 (0.06)	16 (0.59)	17 (0.38)
Suffering	8 (0.45)	9 (0.33)	17 (0.38)
Shame	4 (0.22)	6 (0.22)	10 (0.22)
Hopelessness	2 (0.11)	2 (0.07)	4 (0.09)
Frustration	1 (0.06)	1 (0.04)	2 (0.04)
Disgust	1 (0.06)	1 (0.04)	2 (0.04)
Anger	0 (0.00)	2 (0.07)	2 (0.04)
Contempt	0 (0.00)	1 (0.04)	1 (0.02)
Neutral			
Surprise	3 (0.17)	14 (0.51)	17 (0.38)

Note. A small percentage of sentences contained more than one type of emotion word. Nonspecific positive and negative emotion words were classified as unspecified (e.g., words such as *liked* and *filled with emotion*). These are words that definitely refer to an emotional experience but might refer to several different basic or complex emotional states.

grammatical complexity, ranging from 0 (simple one-clause sentences) to 7 (complex sentences with multiple forms of embedding and subordination).

Data Analysis

The dependent variables in the analyses were simple measures of all-cause mortality such as the percent who died by the end of an approximately 9-year follow-up period and the mortality rate (i.e., deaths per person-years of observation) for that same period of time. The primary multivariate method used to investigate mortality was Cox proportional hazards regression (Allison, 1995). This regression yielded the relative risk of death, which refers to the ratio of mortality rates (or, more exactly, to the ratio of hazard functions). Age was adjusted in these analyses by using age as the time scale for the regression (Allison, 1995). Educational level at the time the autobiographies were written in early life was adjusted by including it as an ordinal variable in the regression. Age- and education-adjusted survival curves (the probability of a 75-year-old surviving to different advanced ages) were created using the baseline feature of the Cox regression procedure in the SAS statistical program (Allison, 1995).

In the regression analyses, ordinal variables were used to characterize the percentile ranking of each type of emotional expression; that is, the number of positive emotional words. Binary variables were used in the regression to characterize the quartile rankings of each type of emotional

expression. These percentile and quartile rankings of emotional-word usage were derived using the distribution within each of the two convents. This was done to obtain comparable scales of emotional expression across convents because the distribution of emotion-word usage differed between convents (see Table 2). The primary analyses used three measures of emotion word usage: (a) the percentile or quartile rankings derived from the number of sentences containing one or more positive or negative emotion words or no emotion words; (b) percentile and quartile ranks derived from the simple counts of positive emotion words; and (c) percentile and quartile ranks of a diversity score generated by counting the number of different positive emotion categories (see Table 2) scored in each autobiography.

Results

The current study included 180 participants from the Milwaukee, Wisconsin, and Baltimore, Maryland, convents of the School Sisters of Notre Dame. Handwritten autobiographies composed when the sisters were a mean age of 22 years were scored for positive, negative, and neutral emotional content. When these autobiographies were written in early life, 82% of the participants had earned a high school diploma. At the beginning of the Nun Study in 1991, approximately 58 years later, 91% of them had earned at least a bachelors degree. During the 9-year mortality surveillance period, the 180 participants ranged in age from 75 to 95 years and 76 (42%) of them had died (Milwaukee sample = 43%, Baltimore sample = 42%).

Compared with the Baltimore participants, the Milwaukee participants had a lower mean number of positive emotion sentences (Milwaukee = 3.2, Baltimore = 9.7; $p < .001$), negative emotion sentences (Milwaukee = 0.6, Baltimore = 2.0; $p < .001$), and nonemotion sentences (Milwaukee = 14.1, Baltimore = 23.5; $p < .001$). (Given the very low frequency of neutral emotions, shown in Tables 1 and 2, their possible relationship to mortality was not examined.) Although the exact reasons for the differences between convents in written emotional expression is not known, the differences in lengths of the autobiographies could simply reflect more time allowed for the Baltimore sisters to complete the task. Because of differences in the distribution of these measures between convents, all analyses were based on percentile and quartile rankings within each convent.

Four basic types of analyses were conducted and all were age and education adjusted. The first examined the relationship between risk of mortality and the percentile ranking of the number of positive emotion sentences, negative emotion sentences, and non-emotion sentences in the autobiographies from early life. The second examined the relationships between the risk of mortality and the quartile ranking of the number of positive emotion sentences, positive emotion words, and different types of positive emotion words (i.e., categories). The third analysis examined the age-adjusted survival curves (length of life) as a function of the quartile rankings of positive-emotion sentences, positive-emotion words, and different categories of positive emotion words. A fourth analysis examined the relationships between positive emotion usage and survival after controlling for linguistic ability demonstrated in the early-life autobiographies, the level of education attained at the time the autobiographies were written, and the lifetime occupation of the participants.

The first Cox regression model we used to investigate mortality used the percentile ranking of positive emotion sentences, negative

emotion sentences, or no emotion sentences and was adjusted for age and education. The results of these analyses are presented in Table 3 (Model I). Statistically significant inverse associations were found between the percentile ranking of the number of positive sentences in the early-life autobiographies and the risk of mortality in late-life within each of the convents and in both convents combined. For example, for every 1.0% increase in the number of positive-emotion sentences there was a 1.4% decrease in the mortality rate (i.e., the hazard function from the Cox regression model). In contrast, there were no statistically significant associations between the risk of mortality and the percentile rankings of the number of negative emotion sentences or the number of nonemotion sentences.

In another regression model that included age, education, and the percentile rankings of all three types of sentences (Model II; see Table 3), the strength of the associations with mortality were statistically unchanged from those above (Model I). Overall, the findings from these regressions suggest that positive and negative content reflected different aspects of written emotional expression. Because of these findings, the remaining analyses focused on positive emotions.

We further explored the association between positive emotion content and survival using quartile rankings of positive emotion sentences. Both the percent who had died and the mortality rate had inverse associations with the quartile rankings of the number of positive-emotion sentences (see Table 4). Findings from age- and education-adjusted Cox regression analyses also indicated that the relative risk of death increased in a stepwise fashion as the quartile ranking of positive emotion sentences decreased, with a 2.5-fold difference in mortality between the lowest and highest quartiles of positive emotional expression. Two other methods of characterizing positive-emotion content, the number of positive-emotion words and the number of different positive emotions, also had strong inverse associations with mortality (see Table 4).

Cox regression also was used to create age- and education-adjusted survival curves, that is, probabilities of a 75-year-old surviving to different advanced ages. Figure 1 shows a strong association between the quartile rankings of the number of positive emotion sentences and survival: The median age at death was 86.6 years for those in the lowest quartile for the number of positive emotion sentences, 86.8 for the second quartile, 90.0 for the third

quartile, and 93.5 for those in the highest quartile, that is, a difference of 6.9 years between the highest and lowest quartiles of positive emotion sentences. Survival curves for the other two measures of positive emotion content (not shown) indicated even stronger associations with survival; in other words, the difference in the median age at death between the highest and lowest quartiles was 9.4 years for the number of positive emotion words and 10.7 years for the number of different positive emotions.

Other analyses indicated that there were no material changes in the association between positive emotion content and survival after controlling for measures of linguistic ability as demonstrated in the autobiographies; that is, the 2.5-fold difference in risk of mortality between the lowest and highest positive emotion sentence quartiles in Table 4 was a 2.2-fold difference in risk when adjusted for idea density. Furthermore, the relationship between positive-emotion content and survival was still apparent after limiting the analyses to 162 college-educated, lifetime teachers.

Discussion

This study found a very strong association between positive emotional content in autobiographies written in early adulthood and longevity 6 decades later. Such a finding is congruent with other studies by investigators that have found relationships between longevity and emotion-related concepts. Features of the current study differ from other studies that have investigated relationships between emotion-relevant behaviors and longevity or mortality and may account for the strength of the relationship observed in the current study: the population sample and the technique used to measure emotion.

Our findings are compatible with recent longitudinal studies that suggest that optimism is associated with longer life (Maruta et al., 2000; Peterson et al., 1998), but incompatible with another study indicating that cheerfulness measured in early life was not associated with longer survival (Friedman, 1999). In the latter study, the investigators reported that there were behaviors related to risk and substance abuse in late-life activities of the more cheerful participants that may account for their findings (Friedman, 1999). These types of behaviors should be less of an issue in our study of Catholic sisters given the relative homogeneity of their adult lifestyles and environments.

Table 3
Percent Change in the All-Cause Mortality Rate Per Single Percentile Change in the Ranking of the Number of Sentences

Sentence type	Model I			Model II, both convents
	Milwaukee convent	Baltimore convent	Both convents	
Positive emotion	-1.4 (-2.5, -0.2)*	-1.4 (-2.7, -0.1)*	-1.4 (-2.3, -0.6)***	-1.4 (-2.3, -0.5)**
Negative emotion	-0.7 (-1.9, 0.6)	-0.7 (-1.9, 0.6)	-0.7 (-1.5, 0.2)	-0.2 (-1.2, 0.8)
No emotion	0.5 (-0.6, 1.6)	-0.6 (-1.9, 0.7)	-0.1 (-0.9, 0.7)	0.3 (-0.6, 1.2)

Note. 95% confidence intervals appear in parentheses. The mortality rate refers to the hazard function from Cox regression. Both Models I and II were adjusted for age by using age as the time scale in the regression. The level of education achieved at the time in early life when the autobiography was written was included as an ordinal variable in both Model I and II regressions. Three regressions were used for Model I, that is, each included only one sentence-type variable, as well as age and education. One regression was used in Model II, that is, it included each of the three sentence-type variables, as well as age and education.

* $p \leq .05$. ** $p < .01$. *** $p < .001$.

Table 4

Positive Emotion Expression in Autobiographies Written in Early Life and the Risk of All-Cause Mortality in Late Life for 180 Participants in the Nun Study

Categories and quartiles	Age at follow-up	No. of participants			% died	Mortality rate ^b	Relative risk of mortality (and 95% CI)
		Dead	At-risk	Survival ^a			
Positive emotion sentences							
I (low)	80.1	25	46	253.3	54	10	2.5 (1.2, 5.3)**
II	81.1	23	40	221.8	58	10	2.4 (1.1, 5.2)*
III	80.1	18	52	333.4	35	5	1.4 (0.6, 3.0)
IV (high)	79.4	10	42	296.9	24	3	1.0
Positive emotion words							
I (low)	79.9	23	42	233.0	55	10	3.2 (1.5, 6.8)**
II	81.1	30	51	279.5	59	11	3.1 (1.5, 6.4)**
III	79.7	13	40	255.6	33	5	1.6 (0.7, 3.7)
IV (high)	79.9	10	47	337.3	21	3	1.0
Different positive emotions							
I (low)	81.3	11	17	91.0	65	12	4.3 (1.7, 10.4)**
II	80.4	26	58	331.0	45	8	2.3 (1.1, 4.7)*
III	80.2	29	65	388.0	45	7	2.2 (1.1, 4.6)*
IV (high)	79.4	10	40	295.5	25	3	1.0

Note. CI = confidence interval. The relative risks were adjusted for age and education (i.e., age was adjusted by using it as the time scale in the Cox regression analyses, and the level of education achieved at the time in early life when the autobiography was written was included as an ordinal variable in regressions). The quartiles are not equal size groups because of the distribution of the variables. Positive emotion sentences refer to the number of such sentences, and different positive emotions refer to up to 10 different types of positive emotions.

^a In person-years. ^b Deaths per 100 person-years.

* $p \leq .05$. ** $p < .01$.

There were, however, other important differences between the studies of Maruta et al. (2000), Peterson et al. (1988), and Friedman (1999) and the current study in addition to the sample populations. Maruta used items from the first Minnesota Multiphasic Personality Inventory to develop a scale of optimism. Peterson measured globality of explanatory style (a tendency to ascribe a single cause across negative life events) in samples of writing. Friedman, studying the same population as Peterson, used parental reports of children's degree of cheerfulness as a measure of positive affect. Thus, there were notable differences in the sources of information and the constructs that were measured as predictor variables in previous research. The current study used a different source of data and an emotion-specific measurement technique.

Given the unique lifestyle and culture of our study population of Catholic sisters and the fact that the autobiographies were written 6 decades ago, we created a coding system appropriate for this sample of writings. It has face validity and good reliability. Based on knowledge of emotion research and theory, it was designed to identify positive and negative emotional content in writings and requires little or no inference to apply. However, such coding does not attempt to measure more complex reactions to life events such as long-term positive or negative attitudes, forward thinking, types of explanatory style, mature ego defenses, pessimism, or optimism. Further research is required to discover how the use of emotion words in written text is related to other constructs that have been found to be related to better health and longevity.

Although the scoring tool used in this study was designed to measure both positive and negative emotion, the emotional content of the writings describing the early lives of the participants in our study was overwhelmingly positive. This finding does not differ substantially from what other research studies using similar mea-

surement tools have found (Pennebaker & Francis, 1999). Moreover, an examination of cross-cultural and developmental data for 13 cultures by Boucher and Osgood (1969) found a universal tendency to learn positive words earlier than negative words in the acquisition of language, to more readily retain positive words in tests of memory, and to use more positive than negative words when communicating.

Contextual factors also may have influenced the use of positive emotion words in this set of writings. For example, the Catholic sisters in our study may have been aware, or at least believed, that the content of the autobiographies would be used by their superiors to determine their careers in the religious congregation, and therefore they may have been cautious about revealing memories of negative emotion. Even more likely to have influenced the tone of these autobiographies was that they were written during a period of time when the sisters would be expected to feel happy and positive about the future; namely, when they were about to leave the convent and begin working (mainly teaching) in the community. Having completed years of study and preparation for entry into the religious order, the sisters wrote these autobiographies just prior to taking their final vows. A goal toward which they had worked was being realized. Yet, despite the forces that may have resulted in predominantly positive content that was relatively constant for all of the authors of the autobiographies, there were individual differences in the use of positive emotion words that predicted longevity.

Because there was relatively little negative emotional content in the autobiographies, it was not possible to address directly questions related to the underlying mechanisms responsible for the current findings. Whether a generalized suppression of emotional expressiveness presented a risk factor for longevity (Gross &

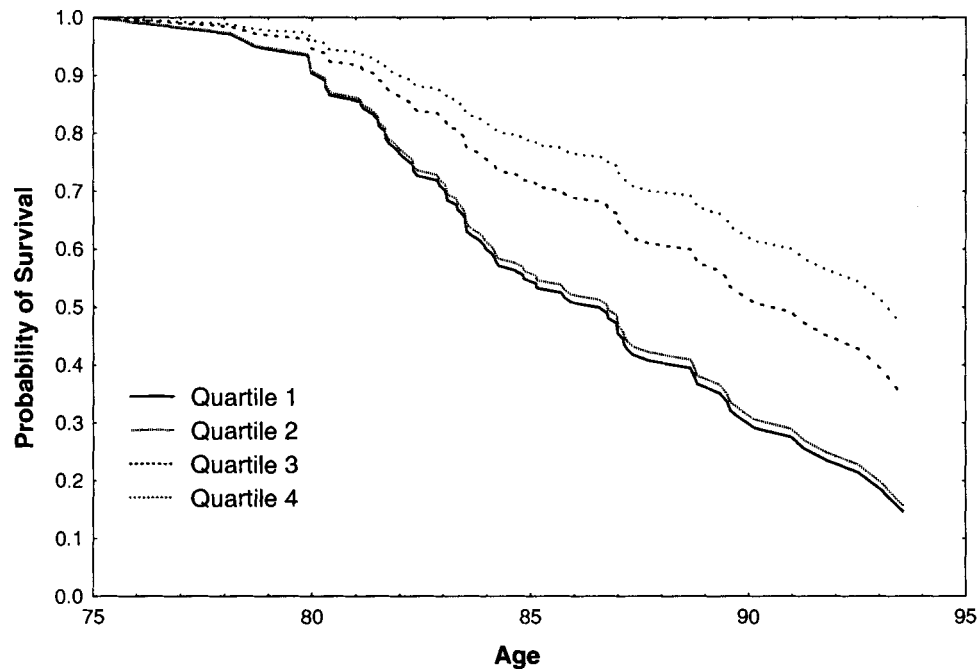


Figure 1. Quartile rankings of the number of positive emotion sentences in autobiographies written in early life and the probability of survival in late life for 180 participants in the Nun Study. (Note that the survival curves for Quartiles 1 and 2 are virtually overlaid on each other.)

Levenson, 1997), or, conversely, whether those persons using more positive emotion words were in fact more expressive of all emotions and thereby reduced allostatic load by avoiding the detrimental effects of suppression could not be tested. Although negative life events were sometimes mentioned in the autobiographies, the participants had not been instructed to include such events or to elaborate on their resolution. The absence of negative emotion words in relating negative incidents did not allow a direct test of whether positive emotion might have been a factor in muting the adverse effects of negative emotional arousal (Fredrickson & Levenson, 1998). Finally, the relative absence of negative emotional content limited the statistical power to detect associations with mortality. However, the analysis that we could perform indicated that in this context written negative emotional content is not the opposite of positive emotional content but, rather, is a reflection of something different. This finding that positive emotion may be a different phenomenon from negative emotion (depression) also was reported by Ostir and colleagues (Ostir, Markides, Black, & Goodwin, 2000).

Our investigation raises questions about why the positive emotional content in early-life writings might have such a powerful relationship to longevity. Unfortunately we had no independent measures of temperament, personality, or emotional tendencies for participants, and we can only speculate that individual differences in emotional content in the autobiographies reflect life-long patterns of emotional response to life events.

A pattern of emotional expression that accentuates positive affect undoubtedly has behavioral correlates that could enhance or disrupt the positive effects on physiology and health. One behavioral pathway is suggested by the study by Friedman (1999) in

which cheerful participants were more likely to engage in behaviors that are health risks such as excessive drinking and smoking. Such a pathway would be expected to disrupt the potential physiological benefits of a pervading pattern of positive emotional responsiveness. In contrast, all participants in the current study had lived a lifestyle in which such health-risk behaviors were improbable and therefore the physiological impact of a positive emotional style was almost certainly enhanced. Because many alternative paths that might be the consequence of a positive style were not a part of this study, generalization of the current findings is limited.

Many of the limitations of our study also could be considered strengths. As mentioned earlier, participants in our study were all female, had the same reproductive and marital histories, had similar social activities and support, did not smoke or drink excessive amounts of alcohol, had virtually the same occupation and socio-economic status, and had comparable access to medical care. Furthermore, the 180 participants had successfully completed a lifetime within their careers and living situations and many had lived beyond average life expectancy for their generation by the time they were enrolled in this study. Although it may be difficult to generalize from this unique population of Catholic sisters, the findings of the study should not be minimized. Despite factors in these sisters' lives that are known to extend life and that might have overwhelmed any contribution of the mechanisms underlying our findings, the phenomenon represented by the use of positive emotion words in early-life writings effectively added to longevity.

It could be argued that the results of this study may not apply to a sample of participants less than 75 years of age. We are in the process of searching the convent archives for the autobiographies of sisters who died prior to the beginning of the study and in

particular those who died before age 75. This information will allow us to examine the possibility that what was found in this study was the late stages of a relationship between the use of positive emotion words and longevity that was evident years earlier. Furthermore, increasing the sample size will increase the statistical power of future analyses and allow the investigation of relationships between survival and different types of positive emotional words, such as interest, love, and hope. Finally, our continued follow-up of the population will allow us to determine whether this association continues beyond age 95.

Finding such a strong association of written positive emotional expression to longevity indicates a need for research that sheds light on the underlying mechanisms and mediators responsible for and associated with this relationship. Within the context of the Nun Study, evidence that the expressive patterns observed in the early-life autobiographies were stable over time would help substantiate a relationship between emotional expression and temperament and personality. In future research, we will study late-life writings and spoken speech samples from the sisters for consistency of the expressive patterns found in early life.

Archived records of medical history and career path will be examined for evidence of social and health-related patterns associated with what has been observed in the autobiographical writings and that might suggest pathways taken by participants differing in their use of positive emotional words that might have contributed to their longevity or mortality. Considering the potential impact of positive expressiveness on relationships, we feel that research is needed to examine possible differences in social and professional behaviors that may have amplified the effects of a positive style on longevity.

Given that there have been annual examinations of cognitive and physical functioning, it will be possible to study relationships between the emotional content of the early-life writings and late-life capacities. Also, the results of neurological examinations will allow study of relationships with neurological functioning and related disease and disability. Finally, because there will be brain autopsies on all participants, it will be possible to study relationships between written emotional expressions and neuropathology and brain structure. These future studies hold promise for identifying underlying mechanisms and mediators that may account for the findings of the current study.

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