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Autonomic, Subjective, and Expressive Responses to Emotional Films in Older and Younger Chinese Americans and European Americans

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Previously, the authors found that during idiosyncratic emotional events (relived emotions, discussions about marital conflict), older European American adults demonstrated smaller changes in cardiovascular responding than their younger counterparts (R. W. Levenson, L. L. Carstensen, W. V. Friesen, & P. Ekman, 1991; R. W. Levenson, L. L. Carstensen, & J. M. Gottman, 1994). This study examined whether such differences held when the emotional events were standardized, and whether they extend to another cultural group. Forty-eight old (70–85 years) and 48 young (20–34 years) European Americans and Chinese Americans viewed sad and amusing film clips in the laboratory while their cardiovascular, subjective (online and retrospective), and behavioral responses were measured. Consistent with previous findings, older participants evidenced smaller changes in cardiovascular responding than did younger participants during the film clips. Consistent with earlier reports, old and young participants did not differ in most subjective and behavioral responses to the films. No cultural differences were found.

In most people's minds, aging is associated with gradual and ubiquitous declines in functional capacity (e.g., intellectual decline, loss of physical prowess). Growing empirical evidence, however, suggests that age-related declines are hardly uniform across psychological domains, even within the cognitive domain (e.g., Burke, 1997; Wang & Kaufman, 1993) and that emotional functioning, in particular, may be well maintained (Carstensen & Charles, 1999). Studies have demonstrated that although the intensity of everyday emotions appears not to change with age (Malatesta, Izard, Culver, & Nicholich, 1987), emotion-focused coping and understanding advance with age (Diehl, Coyle, & Labouvie-Vief, 1996; Diener, Sandvik, & Larsen, 1985; Folkman, Lazarus, Pimley, & Novacek, 1987; Labouvie-Vief & DeVoe, 1991), and emotion regulation improves (Gross, Carstensen, Pasupathi, Tsai, & Götestam Skorpen, 1997). Surprisingly few studies, however, have examined how aging influences basic emotional reactivity (i.e., the physiological, subjective, and behavioral changes that occur in response to emotion-eliciting events). Even fewer studies have examined age differences in emotional reactivity under well-controlled laboratory conditions. As a result, it is unclear whether older adults exert control over their emotions by carefully selecting their environments, such that negative emotions are avoided altogether (Carstensen, Gross, & Fung, 1997), or whether the emotion program itself is changed in a more fundamental way. Given well-documented changes in biological functioning with age, the autonomic substrate of emotion is particularly important to explore (Frol'kis, 1977).

In prior work, our research team has examined the physiological component of emotion in two principle ways, by having participants (a) relive emotional events (Levenson et al., 1991) or (b) discuss emotionally evocative conflicts with their spouses (Levenson et al., 1994). Across two very different methods, we reliably have found that cardiovascular reactivity (heart rate and pulse transmission time) associated with emotional responding is reduced in older adults (Levenson, Carstensen, Friesen, & Ekman, 1991; Levenson, Carstensen, & Gottman, 1994; see also Levenson, in press). Interestingly, our findings, which are derived from directly measuring physiology during emotional episodes, are also reflected in research questionnaire studies in which older adults' describe their physiological reactions. Namely, older adults reliably report less surgency and less physiological responsiveness during emotional experiences than do younger adults (Gross et al., 1997; Lawton, Kleban, Rajagopal, & Dean, 1992).

In contrast to changes in the physiological component of emotion, no consistent pattern of age-related change in subjective experience or expressive behavior has emerged in our own work or in that of other researchers. For instance, during a relived emotions task, older and younger adults reported similar levels of emotional

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experience and did not differ in the occurrence of spontaneous facial expressions (Levenson et al., 1991; Levenson, Ekman, & Friesen, 1990). These findings were consistent with those of Malatesta et al. (1987), who found that older and younger adults reported experiencing similar intensities of emotion in their everyday lives, and Levine and Bluck (1997), who found age similarities in reported emotion in response to a political event. Indeed, we have only observed one behavioral difference between middle-aged and older married couples: Older adults expressed more affection to their spouses in the midst of expressions of negative emotion than their middle-aged counterparts (Carstensen, Gottman, & Levenson, 1995).

Age-related reductions in cardiovascular reactivity may play an important role in observed improvements in emotional regulation. Global, age-related reductions in physiological reactivity may render emotions easier to control. If so, emotional experience may be less focused on or bounded by physiology and may become more cognitive over time, a notion entertained many years ago by Jung (1960). Subsequently, its modulation may be less difficult. Alternatively, the same pattern of findings may reflect changes in regulatory competence and coping ability, that is, older adults may regulate their emotions such that they are less physiologically taxing, thus helping to buffer themselves from the potentially toxic effects of intense cardiovascular reactivity on physical health (Krantz & Manuck, 1984). To recapitulate, two findings have been established reliably: (a) emotion regulation as observed in or reported by older adults appears to improve with age, and (b) lesser physiological activation is associated with emotion in older adults. The degree to which these two findings are related, if at all, however, is unknown.

The Present Study

We pursued two objectives in this study. First, we explored physiological reactivity using a standardized emotion-induction procedure. Second, to begin to investigate potential ethnic differences in emotional responding, we recruited two culturally different subsamples, first generation Chinese Americans and European Americans. Our rationale for pursuing each of these objectives is described more fully below.

In our previous studies, the tasks used to elicit emotion required participants to generate the emotional-eliciting stimuli themselves, either through memory or social interaction. During the relived emotions task, participants are asked to generate and relive past emotional episodes from their own lives. During the marital interaction task, participants are asked to discuss an important conflict in their relationship. These emotion-induction procedures have a number of advantages, especially in terms of their authenticity and subjective meaning to research participants. However, as the pattern of findings described above emerged, we realized that the emotion-eliciting tasks we had been using might be particularly susceptible to influence by online emotion regulation. That is, in the process of generating an emotional memory or navigating an emotional interaction with one's spouse, people can maneuver around the most arousing aspects of the emotional experience. Thus, in our previous work, we inadvertently maximized the likelihood that emotions would be regulated as they were produced. In the present study, we elected to use short film clips to stimulate positive and negative emotions. In this way, not only do we extend the research program to yet another type of emotion-eliciting task, but we also examine age differences in emotional responding under conditions where emotion elicitors are the same for all participants, external to the person, and, thus, less amenable to online control.

Regarding ethnicity, virtually all of our own research and that reported in the literature, focuses on European Americans. Yet, if lesser physiological reactivity reflects a global, age-related process, then it should be evident across different cultures. Subsequently, we reasoned that a particularly informative comparison would be to an ethnic group that holds different beliefs about the expression and regulation of emotion. Compared with American culture, anthropological reports suggest that Chinese culture more strongly emphasizes the control and moderation of emotional expression (Russell & Yik, 1996). Moreover, whereas members of some European American cultures believe that emotional expression promotes one's health and improves one's relationships with others, members of Chinese culture believe just the opposite (Potter, 1988; Russell & Yik, 1996; Zheng & Berry, 1991). These cultural beliefs about emotion have been used to explain cultural differences in emotional styles (Song, 1985; Wu & Tseng, 1985), with Chinese Americans described as demonstrating greater emotional restraint, inhibition, and control than European Americans. Consistent with these ethnographic notions, in previous laboratory studies, we have found that Chinese American college students moderate and control their emotions more than their European American counterparts (i.e., report less variable and less positive affect) during conversations about conflict in their dating relationships (Tsai & Levenson, 1997). No studies to date, however, have examined possible differences in emotional reactivity between elderly Chinese Americans and European Americans.

Hypotheses

On the basis of prior findings, we hypothesized that older adults would demonstrate smaller changes in cardiovascular reactivity to sad and amusing films compared with their younger counterparts. Also on the basis of previous findings, we predicted no age differences in subjective experience or expressive behavior. Second, on the basis of ethnographic descriptions and our prior findings, we predicted that Chinese Americans would demonstrate less intense emotional responses (physiological, subjective, and behavioral) to the films than would European Americans.

Method

Participants

A community sample (N = 96) of 48 younger and 48 older participants residing in the San Francisco Bay Area were recruited by an independent San Francisco-based survey research firm. Equal numbers of Chinese American and European American men and women were recruited within each age group. The research firm was instructed to recruit a sample comprised of 30% blue-collar workers and 70% white-collar workers for both cultural groups. Table 1 provides descriptive information for each age and cultural group.

Selection criteria. To increase homogeneity within cultural groups, Chinese Americans and European Americans were required to meet specific selection criteria. All Chinese American participants represented the first generation of their families to be born in the United States; had parents who were born in China, Taiwan, or Hong Kong; and spoke English

Table 1
Characteristics of Cultural and Age Groups

	Group							
	European Americans				Chinese Americans			
	Young		Old		Young		Old	
Characteristic	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Age (years)	27.90	4.35	75.67	4.00	26.65	3.52	73.64	3.85
Level of education (years)	15.61	1.88	15.62	3.76	16.00	3.52	14.08	3.24
Level of acculturation[a]	3.95	0.22	4.16	0.36	3.20	0.28	3.16	0.29
Emotional expressivity (BEQ)[b]	5.01	0.17	4.44	0.17	4.59	0.17	4.49	0.17
Emotional control (CEC)[c]	2.32	0.10	2.56	0.10	2.23	0.12	2.48	0.11

Note. BEQ = Berkeley Expressivity Questionnaire; CEC = Courtauld Emotional Control Scale.
[a] Higher scores indicate greater acculturation to American culture. [b] Higher scores indicate greater emotional expressivity. [c] Higher scores indicate greater emotional control.

fluently. All European American participants also spoke English fluently and were born in the United States to parents who were born in the United States or Europe.

To assess variation among individuals and subgroups, we also measured orientation to American culture, or acculturation. Chinese Americans completed a modified version of the Suinn–Lew Asian Self-Identity Acculturation Scale (SL-ASIA; Suinn, Rickard-Figueroa, Lew, & Vigil, 1987) at the end of the experimental session.[1] Participants used a 5-point Likert scale ranging from 1 (*very Asian*) to 5 (*very American*) to rate 25 multiple-choice items relating to their cultural identification, food and entertainment preferences, and language proficiency. Cronbach's alpha for our Chinese American sample was .77. The mean level of acculturation for our Chinese American sample was 3.18 ($SD = 0.28$, $range = 2.60–3.80$), suggesting that they were approximately equally oriented to Chinese and American cultures. There were no differences in levels of acculturation between younger and older Chinese Americans (Table 1).

European Americans also completed a modified version of the SL-ASIA, using a 5-point Likert scale ranging from 1 (*very European*) to 5 (*very American*). European Americans' mean acculturation level was 4.05 ($SD = 0.31$, range = 3.09–4.60). Cronbach's alpha was .81 for European Americans. Older European Americans reported being significantly more American than their younger counterparts, $F(1, 46) = 5.53$, $MSE = .09$, $p < .05$ (see Table 1). As expected, across age groups, European Americans were more American than Chinese Americans, $F(1, 92) = 218.00$, $MSE = .08$, $p < .001$.

Apparatus and Dependent Measures

Physiological measures. Continuous recordings of participants' physiological responses were collected throughout the experimental session, using a system consisting of a 12-channel Grass Model 7 polygraph and a Gateway 2000 microcomputer equipped with analog and digital input/output capabilities. The methods used to collect the physiological data were similar to those used in previous studies (Levenson et al., 1991, 1994; Tsai & Levenson, 1997) and followed standard psychophysiological measurement procedures (Jennings et al., 1981; Fowles et al., 1981).

Physiological measures were drawn from the cardiac, electrodermal, respiratory, and somatic systems—systems thought to be particularly relevant to emotion. Although we predicted age-related differences only in cardiovascular reactivity, we included other measures to examine whether such reductions generalized to other response systems. A total of eight physiological measures were obtained from each participant. *Cardiovascular* measures included (1) interbeat interval (ms), or the time between successive R waves of the electrocardiogram (EKG); (2) finger-pulse amplitude (arbitrary units), or the amount of blood in the vasculature at the tip of the finger; (3–4) pulse transmission times to the finger and ear (ms), or the time between the R wave of the EKG and the arrival of the pulse pressure wave at the finger and ear, respectively; and (5) finger temperature (degrees Fahrenheit), or the temperature of the participant, measured at the tip of the participant's fifth finger. To reduce the number of variables we included in our analyses, we created an aggregate of the cardiovascular measures that are influenced by the sympathetic nervous system, which includes all of the cardiovascular measures with the exception of cardiac interbeat interval, which is influenced by both the sympathetic and parasympathetic nervous systems. We have used this "sympathetic aggregate" before in other studies to reduce the number of statistical tests (e.g., Gross & Levenson, 1997). To create this aggregate, we calculated the mean of the standardized *z* scores of finger-pulse amplitude, pulse transmission times to the ear and finger, and finger temperature. Positive values of this aggregate measure indicated increases in sympathetic arousal. It is important to note that this aggregation is done a priori on physiological grounds (that is, to have an index that reflects sympathetic activation across cardiac and vascular systems). Because of the breadth of systems incorporated in the aggregate, Cronbach's alpha was low (.31 for the amusing film clip and .34 for the sad film clip). Given the low alpha for this aggregate, we conducted exploratory univariate analyses for the individual cardiovascular variables to ensure that using this aggregate did not distort our findings.

The *electrodermal* measure was (6) skin conductance level (μmhos), or sweat gland activity, and the *respiratory* measure was (7) intercycle interval (ms), or the time between successive inspirations. The *somatic* measure was (8) general somatic activity (arbitrary units), or the amount of participant's overall body movement.

Second-by-second recordings of participants' physiological responses were averaged to calculate (a) the mean level of physiological response for the 1-min period immediately preceding each film (prefilm baseline period) and (b) the mean level of physiological response during each film (film period).

[1] The SL-ASIA has received much criticism regarding its unidimensional-bipolar scale; however, at the time we conducted this study, it was the most widely used acculturation assessment tool for Asian Americans. We used the SL-ASIA in this study to maintain comparability with other studies of Asian American populations. For a recently developed bidimensional measure of acculturation for use with Chinese American samples, please see Tsai, Ying, and Lee (2000).

Reports of subjective emotional experience. Participants reported how they felt in response to the film clips in two ways: (a) online, by providing continuous reports of positive and negative affect while they were watching the clips; and (b) retrospectively, by rating how intensely they experienced specific emotions after all of the films had been viewed.

Participants provided online reports of emotional experience by moving a rating dial that indicated how positive and negative they felt moment by moment while watching the film clips. The rating dial traversed a 180° path, with anchors including 1 (*extremely negative*), 5 (*neutral*), and 9 (*extremely positive*). The validity of this approach as a means of obtaining continuous reports of affect has been established previously (Gottman & Levenson, 1985). Parallel to the reduction of the physiological data, second-by-second recordings of participants' rating dial responses (online reports of affect) were averaged to calculate (a) the mean level of rating dial response for the 1-min period immediately preceding each film (prefilm baseline period) and (b) the mean level of rating dial response during each film (film period).

Participants provided retrospective reports of emotional experience by completing an inventory that listed specific positive (amusement, contentment, happiness, pleasant) and negative emotions (anger, disgust, fear, sadness). Participants used a scale ranging from 0 (*not at all*) to 8 (*the most in my life*) to report how intensely they felt each of these emotions while they watched each film clip. An aggregate measure of positive emotional experience was created by calculating the mean rating of the specific positive emotions; similarly, an aggregate measure of negative emotional experience was created by calculating the mean rating of specific negative emotions. Because of experimenter oversight, these data were not collected for 20 participants; in analyses of these variables, missing data were replaced with group means. Cronbach's alpha for the positive aggregate was .72 (n = 76) for the amusing film and .78 (n = 76) for the sad film. Cronbach's alpha for the negative aggregate was .91 (n = 76) for the amusing film and .78 (n = 76) for the sad film clip.

Expressive behavior. Participants' expressive behavior was coded from the video recordings, using a system adapted from Gross and Levenson (1993). The coding system assigns a score on a 6-point scale that reflects the intensity, duration, and frequency of each of a number of emotional behaviors that occur during a designated period of time. Our version of this system was comprised of five emotional behavioral codes: happiness, laughing, smiling, crying, and sadness. Behavioral codes for anger, disgust, fear, and surprise were also utilized, but they were dropped from subsequent analyses because their base rates during the film clips were too low to allow sufficient interrater reliability.

Two male coders in their mid-20s, who were unaware of the film that the participant was viewing, scored participants' expressive behavior during the prefilm baseline and film periods from the videotaped recordings. Interrater reliability was derived by having 20% of the participants coded by both coders independently. Interrater reliability was .70 (SD = 0.09). The reliabilities for each of the specific behavioral codes were .73 for crying, .73 for happiness, .55 for laughing, .64 for sadness, and .82 for smiling. An aggregate measure of positive emotional behavior was created by calculating the mean of specific positive behaviors (smiling, happiness, laughing); similarly, an aggregate measure of negative emotional behavior was created by calculating the mean of specific negative behaviors (sadness and crying). Cronbach's alpha for the positive emotional behavior aggregate was .83 for the amusing film and .72 for the sad film clip; Cronbach's alpha for the negative emotional behavior aggregate was .02 for the amusing film clip (very few negative emotional behaviors occurred during the amusing film clip) and .65 for the sad film clip. Given the low alpha for the aggregate of negative emotional behavior, we did not include this measure in our analyses of emotional behavior during the amusing film clip.

Emotional expressivity and control inventories. Eight-two of the 96 (85%) participants completed and returned by mail the Berkeley Expressivity Questionnaire (BEQ; Gross & John, 1997) and the Courtauld Emotional Control Scale (CEC; Watson & Greer, 1983). The 16-item BEQ measures difficulty in controlling one's emotional impulses and the expression of positive and negative emotions. Cronbach's alpha for the BEQ was .79 for European Americans and .86 for Chinese Americans. These values were comparable with those reported by Gross and John (1997). The 21-item CEC assesses control of three negative emotions, each of which comprises a separate subscale: (a) anger, (b) anxiety, and (c) unhappiness. Cronbach's alpha for the CEC was .91 for European Americans and .81 for Chinese Americans. These values were comparable with those reported by Watson and Greer (1983). For both the BEQ and CEC, participants' overall scores on the questionnaires were calculated by averaging their responses to each of the items of the questionnaires (see Table 1 for group means).

Procedure

Participants arrived at the laboratory and were greeted by either a Chinese American or European American experimenter. The ethnicity of the experimenter was counterbalanced to control for the possibility that participants' responses would be influenced by the experimenter's cultural background. Two remotely controlled high-resolution video cameras, partially hidden behind darkened glass between bookcase shelves, were used to record participants' facial expressive behavior. The recorded image included the participant's face and body from the shoulders up. The experimenter attached the sensors needed to record the physiological data. Participants were then trained to use a rating dial to provide continuous online reports of how they felt while they watched the film clips. Further experimental instructions were presented to participants through a video monitor.

Participants were shown three film clips of (a) a woman talking to her friends about her daughter (used to acclimate participants to the experimental task), (b) a comedian talking about his relationship with his parents (used to elicit amusement), and (c) a boy mourning the death of his father (used to elicit sadness). The latter two film clips were selected because they have been found to reliably elicit reports of the targeted emotions (Gross & Levenson, 1995). The order of the amusing and sad clips was not counterbalanced because results of piloting have shown that watching the sad clip before the amusing clip limits the effectiveness of the amusement induction, whereas the opposite is not the case. Each of these three film clips was preceded by a 2-min film clip comprised of abstract visual displays (used to induce an emotionally neutral state) and instructions to relax and clear their minds of all feelings, thoughts, and memories by staring at an *X* on the screen (used to obtain measures of participants' physiological responses during baseline). After each film clip, participants were shown a blank screen for 3 min (to ensure that their emotional responses during one film clip did not influence their emotional experiences during subsequent clips).

After watching all of the film clips, participants were asked to remember each film clip in turn and to rate how intensely they had experienced a number of emotions (viz., amusement, contentment, happiness, anger, disgust, fear, sadness) while they were watching that film clip. Participants also completed the appropriate version of the SL-ASIA to indicate how oriented they were to American culture. To examine whether found age and culture differences in emotional reactivity were due to individual or group differences in self-reports of general emotional expressivity or control, we gave participants the BEQ and CEC to complete at home and mail back to the experimenter.

Data Analysis and Results

The $p < .05$ rejection level was used to identify statistically significant effects and interactions. Age, culture, and sex were initially treated as between-subjects factors; film was treated as a within-subjects factor. A hierarchical analysis of variance (ANOVA) strategy was used. Only significant main effects and interactions involving age and culture were further decomposed. Because no significant Age × Sex, Culture × Sex, or Age × Culture × Sex interactions were found, we collapsed across both sexes in all subsequent analyses.

Prior to testing our specific hypotheses about the effects of age and culture on emotional reactivity, we examined whether there were group differences during the prefilm baseline periods. Analyses revealed a significant main effect for age in cardiac interbeat interval, old = 887.31 (SE = 17.80), young = 819.00 (SE = 17.80); $F(1, 92) = 7.37$, $MSE = 30407.08$, $p < .01$; and electrodermal activity, old = 1.52 (SE = .25), young = 2.38 (SE = .25) $F(1, 92) = 6.08$, $MSE = 5.80$, $p < .05$. To control for these age differences during baseline, we based all subsequent analyses on change scores (film period level minus prefilm baseline period level; see Rogosa, 1995, for a discussion of the advantages of change scores over other ways of dealing with baseline differences).

Subjective and Behavioral Responses to Films: Effects of Age and Culture

To examine the effects of culture and age on reports of subjective emotional experience, we conducted separate 2 × 2 × 2 [Age (Old, Young) × Culture (European American, Chinese American) × Film (Amusing, Sad)] ANOVA for online rating dial responses of subjective experience, retrospective reports of positive emotional experience, and retrospective reports of negative emotional experience. Analyses revealed no significant main effects or interactions involving age or culture for rating dial responses or retrospective reports of negative emotion. However, analyses did reveal a significant effect of age on retrospective reports of positive emotion, old = 2.49 (SE = .15); young = 3.09 (SE = .14); $F(1, 71) = 8.12$, $MSE = 1.58$, $p < .01$: In retrospect, older adults reported experiencing less positive emotion during both film clips than did younger adults. There were no significant main effects or interactions involving culture for retrospective reports of positive emotion. Tables 2 and 3 report the means and standard deviations of these measures for the four groups.

To ensure that found age differences in retrospective reports of positive emotion were not mediated by levels of acculturation, emotional expressivity (as measured by the BEQ), or emotional control (as measured by the CEC), we conducted mediational analyses, as suggested by Kenny, Kashy, and Bolger (1998). To establish that these variables mediated the relationship between age and retrospective reports of positive emotion, we would need to show that (a) there is a significant correlation between age and retrospective reports of positive emotion; (b) there is a significant correlation between age and the mediator; (c) there is a significant correlation between the mediator and retrospective reports of positive emotion, controlling for age; and (d) for complete mediation, the effect of age on retrospective reports of emotion, after controlling for the mediator, is zero (Kenny et al., 1998). We conducted these analyses, following the procedures laid out by Kenny et al. (1998). If one criterion was not met, subsequent analyses testing the remaining criteria were not conducted. Acculturation met the first criterion, but not the second; emotional expressivity and emotional control met the first and second criteria, but not the third. Therefore, neither acculturation, emotional expressivity, nor emotional control mediated the found relationship between age and retrospective reports of positive emotion.

To examine the effects of culture and age on emotional behavior, we conducted a 2 × 2 × 2 [Age (Old, Young) × Culture (European American, Chinese American) × Film (Amusing, Sad)] univariate ANOVA for positive emotional behaviors and a 2 × 2 [Age (Old, Young) × Culture (European American, Chinese American)] univariate ANOVA for negative emotional behaviors during the sad film clip (very few negative emotional behaviors occurred during the amusing film clip). No significant effects or interactions involving age or culture emerged for positive or neg-

Table 2
Means and Standard Deviations of Emotional Responses During the Amusing Film Clip

	Old				Young			
	EA		CA		EA		CA	
Measure	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Reports of emotional experience								
Online-rating dial[a]	0.92	2.03	1.37	1.13	1.44	1.43	1.75	1.57
Retrospective: positive[b]	4.19	1.88	4.39	1.50	5.18	1.43	4.88	1.30
Retrospective: negative[b]	0.91	2.19	0.93	1.39	0.32	0.52	0.66	0.93
Expressive behavior								
Positive[c]	1.08	0.80	0.95	0.78	1.20	0.80	1.16	1.03
Negative[d]	—		—		—		—	
Physiology								
Cardiac interbeat interval[e]	1.67	23.10	1.75	16.27	−17.87	39.71	−9.10	32.43
Sympathetic aggregate[f]	0.09	0.46	−0.12	0.55	0.17	0.45	0.04	0.44
Skin conductance level[g]	0.19	0.40	0.24	0.38	0.56	1.06	0.31	0.75
Respiratory intercycle interval[h]	−372.90	598.81	−298.74	446.43	−895.56	1459.21	−762.71	503.70
General somatic activity[i]	0.07	0.09	0.04	0.07	0.12	0.19	0.07	0.14

Note. EA = European Americans; CA = Chinese Americans.
[a] Positive values indicate positively valenced emotion. [b] On a scale from 1 (*not at all*) to 8 (*the most intense in my life*). [c] In units. [d] These values are not reported because of the low alpha of this variable. [e] In ms. [f] In standardized units. [g] In μmhos. [h] In ms. [i] In arbitrary units.

Table 3
Means and Standard Deviations of Emotional Responses During the Sad Film Clip

Measure	Old				Young			
	EA		CA		EA		CA	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Reports of emotional experience								
Online-rating dial[a]	−1.02	1.69	−1.47	1.33	−1.43	0.86	−1.48	0.84
Retrospective: positive[b]	0.62	0.47	0.76	0.90	1.32	1.36	0.98	0.70
Retrospective: negative[b]	2.42	1.39	2.89	1.73	2.82	1.72	3.08	1.48
Expressive behavior								
Positive[c]	0.06	0.17	0.02	0.07	0.11	0.21	−0.03	0.27
Negative[c]	0.35	0.45	0.14	0.22	0.24	0.40	0.24	0.49
Physiology								
Cardiac interbeat interval[d]	9.40	21.34	0.52	22.29	20.69	34.90	38.53	34.57
Sympathetic aggregate[e]	−0.04	0.43	−0.09	0.38	0.09	0.38	0.05	0.61
Skin conductance level[f]	0.01	0.23	0.11	0.36	0.12	0.28	0.02	0.30
Respiratory intercycle interval[g]	−322.49	475.02	−465.53	1019.28	−495.13	972.94	−356.44	674.24
General somatic activity[h]	−0.02	0.08	0.02	0.04	−0.03	0.09	−0.04	0.04

Note. EA = European Americans; CA = Chinese Americans.
[a] Negative values indicate negatively valenced emotion. [b] On a scale from 1 (*not at all*) to 8 (*the most intense in my life*). [c] In units. [d] In ms. [e] In standardized units. [f] In μmhos. [g] In ms. [h] In arbitrary units.

ative emotional behaviors. Tables 2 and 3 show the means and standard deviations for these variables.

In summary, consistent with most of our previous findings and those of other researchers, older and younger adults did not differ in most subjective and behavioral responses to the emotional films. No significant age differences emerged in online reports of subjective emotional experience, retrospective reports of negative emotion, positive emotional behavior, or negative emotional behavior during the film clips. Older adults did differ from younger adults in their retrospective reports of positive emotion, however. Older adults reported less positive emotion during both film clips than did their younger counterparts. This finding held across cultural groupings, levels of acculturation, emotional expressivity, and emotional control. Contrary to our culture hypothesis, no significant differences emerged between Chinese Americans and European Americans in subjective emotional experience or expressive behavior.

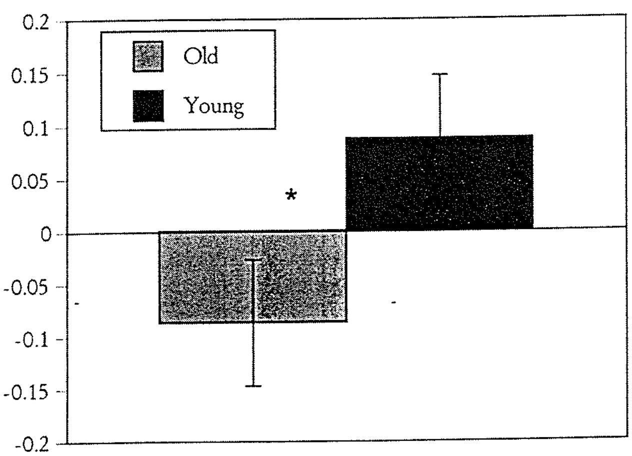

Figure 1. Mean change and standard error for the sympathetic aggregate (in units) by age group, across both film clips. Axes are oriented so that the upward direction from the origin indicates greater physiological arousal. $*p < .05$.

Physiological Responses to Films: Effects of Age and Culture

To examine the effects of age and culture on physiological reactivity during the film clips, we conducted 2 × 2 × 2 [Age (Old, Young) × Culture (European American, Chinese American) × Film (Amusing, Sad)] univariate ANOVAs on cardiac interbeat interval, the sympathetic aggregate, skin conductance level, intercycle interval, and somatic activity. Analyses revealed a significant main effect of age on the sympathetic aggregate, old = −.087 (SE = .06), young = .087 (SE = .06); $F(1, 92) = 4.15$, $MSE = .35$, $p < .05$. Consistent with our first hypothesis that age differences would emerge in cardiovascular reactivity and with our previous findings, older adults demonstrated decreases in sympathetic arousal, whereas younger adults demonstrated increases in sympathetic arousal during both film clips (Figure 1).[2]

Analyses also revealed significant Age × Film interactions for respiratory intercycle interval, $F(1, 90) = 5.85$, $MSE = 427, 878$,

[2] Because of the low alpha of the sympathetic aggregate, we conducted separate exploratory analyses on the individual cardiovascular variables included in the aggregate. Because of the exploratory nature of these tests, we used the Bonferroni correction to determine our level of significance (.05/4 = .015). No significant effects or interactions involving age were found for pulse transmission times to the ear or finger. Significant age differences were found for finger temperature, old = −.12 (SE = .05), young = −.41 (SE = .05); $F(1, 92) = 14.33$, $MSE = .28$, $p < .001$, and finger-pulse amplitude, old = −.39 (SE = .26), young = −1.70 (SE = .26); $F(1, 92) = 13.07$, $MSE = 6.27$, $p < .001$, in the direction of older participants showing smaller changes in cardiovascular response and less cardiovascular arousal than younger participants.

$p < .05$, and cardiac interbeat interval, $F(1, 92) = 32.98$, $MSE = 577.93$, $p < .001$. During the amusing film clip, older adults showed smaller decreases in intercycle interval (indicating less physiological arousal) than did younger adults, old = −335.40 (SD = 516.49), young = −825.87 (SD = 1060.86); $F(1, 92) = 8.15$, $MSE = 708438.50$, $p < .01$; however, there were no age-related differences in respiratory activity during the sad film clip (Figure 2, top panel).

Consistent with our first hypothesis, during the amusing film clip, older participants demonstrated increases in cardiac interbeat interval (indicating decreases in arousal), whereas younger participants demonstrated decreases in cardiac interbeat interval (indicating increases in arousal), old = 1.71 (SD = 19.77), young = −13.49 (SD = 36.14), $F(1, 92) = 6.47$, $MSE = 856.77$, $p < .05$

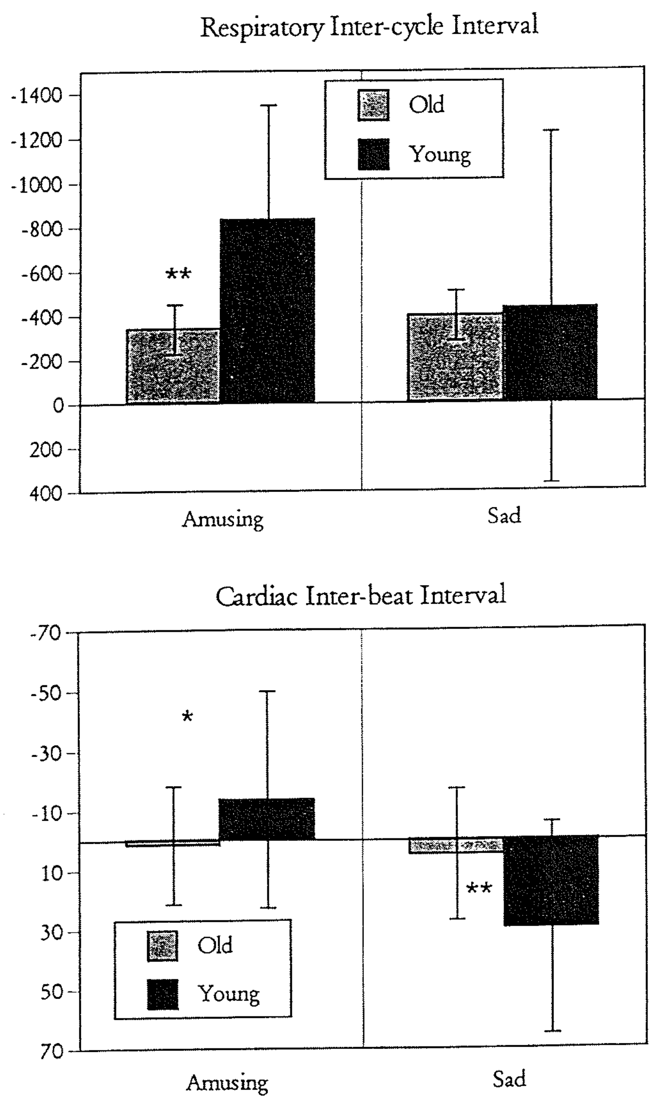

Figure 2. Mean change and standard deviations for respiratory intercycle interval (top panel, in ms) and cardiac interbeat interval (bottom panel, in ms) during each film clip by age group. Axes are oriented so that the upward direction from the origin indicates greater physiological arousal. $*p < .05$. $**p < .01$.

(Figure 2, bottom panel). During the sad film clip, older participants demonstrated smaller increases in cardiac interbeat interval than did younger participants, old = 4.96 (SD = 22.05), young = 29.61 (SD = 35.53), $F(1, 92) = 17.34$, $MSE = 841.31$, $p < .001$. This finding was also consistent with our hypothesis that older adults would show smaller changes in cardiovascular response than their younger counterparts. However, because increases in cardiac interbeat interval are associated with decreases in physiological arousal, this finding suggests that older adults were actually more physiologically aroused than their younger counterparts during this film clip. This pattern is different from our previous findings in which older adults show less physiological arousal than their younger counterparts. However, our previous studies did not use film clips to elicit sadness. Previous work has shown that sadness, when elicited with film clips, is associated with increases in cardiac interbeat interval (Gross & Levenson, 1997), whereas sadness during the relived emotions task is associated with decreases in cardiac interbeat interval (Levenson et al., 1991). Thus, the implications of age-related reductions in cardiac interbeat interval for cardiovascular arousal during sadness are different when this emotion is elicited with standardized rather than idiosyncratic stimuli.

To ensure that none of the above differences were due to previously reported age differences in retrospective reports of positive emotion, we controlled for such differences in our analyses and found similar results. Contrary to our second hypothesis that Chinese Americans would demonstrate less physiological reactivity than European Americans, there were no significant main effects or interactions involving culture.

To examine whether age differences in physiological responding could be explained in terms of differences between the age groups in acculturation, emotional expressivity, or emotional control, we conducted mediational analyses similar to those described above (Kenny et al., 1998). As before, if one criterion was not met, subsequent analyses that tested the remaining criteria were not conducted. For the sympathetic aggregate during the amusing film clip, cardiac interbeat interval during both clips, and respiratory intercycle interval during both film clips, acculturation did not meet the second criterion, and emotional expressivity and emotional control did not meet the third criterion. For the sympathetic aggregate during the sad film clip, neither acculturation, emotional expressivity, nor emotional control met the first criterion. Therefore, levels of acculturation, emotional expressivity, and emotional control did not mediate the age differences in physiology described above.

In summary, consistent with previous findings and our first hypothesis, older adults demonstrated reduced sympathetically influenced cardiovascular activity during both film clips compared with their younger counterparts. During the amusing film clip, we found age-related reductions in cardiac interbeat interval and respiratory intercycle interval. These findings held across cultural subgroups and across levels of acculturation, emotional expressivity, and emotional control. Also consistent with our first hypothesis, during the sad film clip, older adults demonstrated smaller increases in cardiac interbeat interval than younger adults; however, there were no age differences in respiratory intercycle interval. These differences also held across cultural subgroups and across levels of acculturation, emotional expressivity, and emotional control. Contrary to our second hypothesis, there were no differences in physiological responding between Chinese Americans and European Americans.

Discussion

Age-Related Differences in Cardiovascular Reactivity

In this study, we examined whether previous findings regarding age-related changes in cardiovascular reactivity generalized to emotional tasks that were standardized and externally elicited as opposed to the relatively idiosyncratic, self-generated stimuli used in previous studies. We also explored whether age-related emotional responses to emotion-eliciting film clips differed in two cultures that hold rather different beliefs about emotional expression. In support of our first hypothesis that cardiovascular responses to the films would be smaller with age, we found that older adults of both cultural groups demonstrated *smaller* changes in cardiovascular responding (sympathetic aggregate and cardiac interbeat interval) than did younger adults. During the amusing film clip, similar response reductions with age were also found in respiratory intercycle interval. Of course, the respiratory and cardiovascular systems are not completely independent of each other (e.g., respiration influences the vagal mediation of heart rate; Porges & Byrne, 1992), and therefore, it is possible that the two findings are manifestations of the same underlying age-related biological changes. Importantly, as in previous studies, these age-related reductions in physiological responding occurred against a backdrop of no age-related differences in online reports of subjective emotional experience or expressive behavior and after controlling for age differences in retrospective reports of positive emotion.

Interestingly, age differences in respiratory reactivity did not hold during the sad film clip, suggesting that age-related declines in certain aspects of physiological reactivity may not occur for certain emotions elicited under specific conditions. Moreover, although older adults showed smaller increases in cardiac interbeat interval than younger adults, these differences suggest that older adults were more physiologically aroused than younger adults during the sad film clip. This finding suggests that sadness (especially when elicited under conditions in which older adults have little on-line control) may be an emotion that holds particular significance for older adults, who are more likely to have experienced powerful sadness-eliciting events, such as the death of family members and close friends than their younger counterparts. Replication of these findings with a more complete array of emotions and other types of emotional stimuli is needed to determine whether age differences in physiological reactivity are emotion and condition specific (e.g., are not observed when sadness is elicited using stimuli that allow little online control and that are external to the person) and whether they are specific to particular systems of physiological response.

Similarities in Emotional Experience and Behavior Across Age Groups

We did not hypothesize that older and younger adults would differ in their reports of subjective emotional experience or in their expressive behavior during the film clips, and we found few such differences. Taken together, these results support our previous findings that subjective emotional experience and expressive behavior are relatively well preserved with age. In terms of reports of subjective emotional experience and expressive behavior, our findings resembled those of Levenson et al. (1991), in which no age differences were found for subjective and behavioral measures while participants were asked to relive past emotional episodes in their lives.

The one difference that did emerge in reports of emotional experience occurred in retrospective reports of positive emotion. Older adults (across both cultural groups) reported experiencing less positive emotion in retrospect than did younger adults for both film clips. It is possible that the older adults had experienced more profoundly positive events in their lifetimes (e.g., birth of grandchildren, leisure during retirement), and therefore, the film clips were viewed less positively by older adults when placed in the larger context of older adults' lives. This speculation may derive additional support from the finding that age differences were only found in the retrospective reports (which may allow for more reflection regarding past emotional events) and not in online reports (which require continual immediate judgments of emotional state and thus are not as amenable to more complex and inclusive comparisons; see also Levine & Bluck, 1997).

One important issue that cannot be resolved by this study is whether the reductions in cardiovascular activity in older participants compared to younger participants that were found in this study and in previous reports reflect a more generalized age-related change in cardiovascular functioning at the neural or end-organ level (e.g., decreases in overall levels of cardiovascular arousal) or whether they are specific to emotion. The only finding that we can call in support of a more specific response are the hints in the present and one of our previous studies that for one emotion—sadness—older adults show greater arousal than younger adults in cardiac interbeat interval. Of course what is really needed is a comparison of age-related responses to emotional and nonemotional stimuli. The existing literature is not particularly helpful in this regard. For example, Lakatta (1985) has found both increases and decreases in cardiovascular reactivity in old age. Jennings, Kamarck, Manuck, Everson, and Kaplan (1997) found that age was associated with reductions in heart rate during psychologically challenging tasks. Studies from the exercise and stress literature also reliably demonstrate age-related decreases in heart rate (Fleg et al., 1995; Pearson, Morrell, Brant, Landis, & Fleg, 1997). At first consideration, one might interpret these studies as demonstrating that age-related reductions in cardiovascular functioning are quite general and not specific to emotion. However, Thayer (1989) has argued that people do have emotional responses to exercise and stress, and thus these kinds of studies do not provide the critical comparisons necessary to settle this issue. Future studies that include clearly emotional and clearly nonemotional tasks will be necessary to settle this issue; we are currently conducting such studies in our laboratories.

Lack of Cultural Differences in Emotional Reactivity

In keeping with ethnographic descriptions of emotional moderation in Chinese culture, we had predicted that we would find cultural differences in emotional responses to the film clips in the form of more moderate responses for Chinese Americans compared with European Americans. In retrospect, we probably stacked the deck against finding such differences. First, we did not study Chinese, but rather Chinese Americans, who provide a less clear-cut contrast. Second, although Chinese Americans reported being less American than their European American counterparts, we chose Chinese Americans who had lived in the United States for all of their lives. For these two reasons, our Chinese American participants may have had less exposure to Chinese cultural values than we wished. Thus, the cultural differences that existed between the two groups may not have been pronounced enough to influence emotional reactivity in the context of our experimental procedures. Although the BEQ and CEC were not direct measures of cultural values, they did capture self-perceptions of emotional expressivity and control, respectively. Chinese Americans and European Americans did not differ in their reported levels of overall emotional expressivity, $F1, 77 = .96$, $MSE = .59$, $p > .05$, and control, $F1, 72 = .62$, $MSE = .21$, $p > .05$, which further suggests that the groups were more culturally similar than different. Interestingly, across both cultural groups, age differences in reports of emotional expressivity, $F1, 77 = 4.18$, $MSE = .59$, $p < .05$, and control, $F1, 72 = 4.95$, $MSE = .21$, $p < .05$, did emerge: Older adults reported greater emotional control than did younger adults (Gross et al., 1997).[3] To provide a more definitive test of this culture hypothesis, future studies should include samples that differ not only in acculturation, but also in reported values and beliefs regarding emotional expression. It is also possible that cultural influences on emotional reactivity would be more likely to emerge in more social contexts than the situation in the present study, where participants watched the film clips while sitting in a room by themselves. We should be better able to evaluate this latter possibility when we complete a series of ongoing studies of the interaction between culture and experimental context.

Emotion in Old Age

What do our findings tell us about emotion and aging? Clearly the subjective and behavioral data lend little support to the notion that emotion follows the familiar path of decline with age that is found with other psychological domains (e.g., fluid intelligence). Although the age-related reductions in cardiovascular activity may be influenced by multiple factors, our previous and present findings suggest that although certain emotional stimuli may, over the life span, elicit different levels of physiological response, such changes are relatively disconnected from the subjective experience or expression of that emotion. Considering only the physiological and subjective findings for a moment, the balance between physiological and cognitive factors in emotion may shift more toward the cognitive side in old age. This notion is consistent with studies from other researchers; for example, Labouvie-Vief, DeVoe, and Bulka (1989) have demonstrated that emotional understanding is more cognitively complex in older adults than in younger adults (see also Labouvie-Vief & DeVoe, 1991). Of course, our findings also suggest that certain emotions, namely sadness, may not show diminution in physiological arousal with age. As mentioned previously, future studies that sample a broader range of emotions will determine whether or not the age-related reductions in physiology that we have found in previous studies and in this study are found for most emotions, or whether they are limited to certain emotions. These studies should also begin to illuminate whether such age-related reductions in cardiovascular reactivity are associated with the numerous gains in emotional functioning that have been found to accompany old age (Carstensen & Charles, 1999).

[3] There were no significant Culture × Age interactions for self-reports of emotional expressivity or control.

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