Psychology and Aging
1991, Vol. 6, No. 1, 28-35

0882-7974/91/$3.00

Emotion, Physiology, and Expression in Old Age

Robert W. Levenson
University of California, Berkeley

Laura L. Carstensen
Stanford University

Wallace V. Friesen and Paul Ekman
University of California, San Francisco

Emotion-specific autonomic nervous system (ANS) activity was studied in 20 elderly people (age 71–83 years, $M = 77$) who followed muscle-by-muscle instructions for constructing facial prototypes of emotional expressions and relived past emotional experiences. Results indicated that (a) patterns of emotion-specific ANS activity produced by these tasks closely resembled those found in other studies with younger Ss, (b) the magnitude of change in ANS measures was smaller in older than in younger Ss, (c) patterns of emotion-specific ANS activity showed generality across the 2 modes of elicitation, (d) emotion self-reports and spontaneous production of emotional facial expressions that occurred during relived emotional memories were comparable with those found in younger Ss, (e) elderly men and women did not differ in emotional physiology or facial expression, and (f) elderly women reported experiencing more intense emotions when reliving emotional memories than did elderly men.

Emotion is a prominent feature of life, increasingly thought to play a central role in a wide range of human processes spanning normal and abnormal development, including social bonding, intrapsychic dynamics, memory and cognition, and mental and physical health and illness. Old age provides a unique opportunity to study emotion at the end point of what might be a lifelong process of emotional development. Indeed, several psychological phenomena *related* to emotion have been extensively studied in old age (Schulz, 1985). These include the individual's sense of well-being (e.g., George & Bearon, 1980) and personality traits such as neuroticism and extraversion (e.g., Costa et al., 1986). Yet, almost completely lacking are empirical studies of emotion per se in old age—that is, research concerned with specific emotions; their physiological, expressive, and subjective manifestations; and modes of emotion elicitation.

That the study of emotion, a seemingly critical aspect of old age, has eluded careful laboratory study is unfortunate and probably reflects theoretical notions of emotion in old age that have dominated the area. Old age has been described by several theorists as a time of pensive self-focus and dampened emotional intensity (Buhler, 1968; Erikson, 1959; Jung, 1933). Cumming and Henry's (1961) highly influential disengagement theory views emotional disinvestment from the social world as the central psychological task of old age, allowing for a symbolic preparation for death. In this view, emotional flattening in old age is not only expected, it is highly adaptive.

A small empirical literature can be cited in support of the view of diminished emotionality in old age. First, stress has been shown to produce longer periods of autonomic nervous system (ANS) reactivity in the old relative to the young (Bondareff, 1980; Eisdorfer, 1970; Powell, Eisdorfer, & Bogdonoff, 1964). If strong emotions have similar age-related prolongation of autonomic reactivity, and if such reactivity is considered to be aversive, older people may avoid strong emotions partly to escape these aversive physiological consequences. Second, social involvement has been found to decline in old age (Palmore, 1981), with older people reporting reduced interest in entire classes of social partners (Carstensen, 1987; Fredrickson & Carstensen, 1990). Interpersonal interaction is a potent elicitor of emotion (e.g., Levenson & Gottman, 1983), and thus reduction in social involvement in old age may partly be motivated by the attendant reduction in emotional experience.

Other research findings, however, provide persuasive evidence that emotions continue to play a crucial role in later life. Studies have demonstrated in elderly subjects that (a) emotionally laden social ties predict lower morbidity and mortality (Berkman & Syme, 1979; Blazer, 1982), (b) induced emotional calm is associated with improved immunological response (Kiecolt-Glaser & Glaser, 1989), (c) bereavement-associated sadness and grief are associated with reduced immunological response (Schliefer, 1989), and (d) the importance placed on emotions and the prominence of negative emotions are comparable with young adults (Malatesta & Kalnok, 1984). Thus, the importance of emotion to both physical and psychological well-being in old age is unequivocal.

Still, most of the research on emotion in old age is indirect or anecdotal, in striking contrast to the recent explosion of research interest in emotional development in infants and young children (see recent reviews by Harris, 1989; Thompson, in

This research was supported by National Institute of Mental Health (NIMH) Grant MH39895 and National Institute on Aging (NIA) Grant AG07476 to Robert W. Levenson, by NIA Grant AG05592 to Laura L. Carstensen, and by NIMH Grant MH38691 and Research Scientist Award MH06092 to Paul Ekman.

Correspondence concerning this article should be addressed to Robert W. Levenson, Department of Psychology, University of California, Berkeley, California 94720.

press). Even the emergence of life span theories of emotional development (e.g., Izard & Malatesta, 1984) has failed to stimulate a large number of empirical studies of the nature of emotion in old age. In short, although there is persuasive evidence of the importance of emotion in late life, there is little empirically based knowledge of its nature.

Emotion-Specific ANS Activity

In an earlier study (Ekman, Levenson, & Friesen, 1983), we found that the emotions of anger, disgust, fear, happiness, sadness, and surprise have different patterns of associated ANS activity. This research used young and middle-aged subjects (actors and scientists) and two eliciting tasks: (a) a novel task (the directed facial action task), in which subjects were instructed to move voluntarily certain facial muscles that would produce facial configurations with the morphology of universal emotional expressions (Ekman, 1989), and (b) a more traditional imagery task (relived emotion task), in which emotional memories were recalled and relived. Evidence of emotion-specific ANS activity was found with both tasks, but several questions were raised concerning the generality of the phenomenon and the manner by which the directed facial action task produced emotion-specific activity.

In a series of additional studies using the directed facial action task with young adults (Levenson, Ekman, & Friesen, 1990), we presented evidence that these findings generalized to college students and did not differ between the sexes. Furthermore, we found that the capacity of voluntary facial actions to generate emotion-specific ANS activity (a) did not require that subjects see an emotional facial configuration (on their own face or on the face of an experimenter); (b) could not be explained in terms of differences in facial muscle activity, in nonfacial muscle activity, or in the difficulty of making the different configurations; and (c) was most pronounced when the configurations most closely resembled the associated emotional expression and when subjects reported actually feeling that emotion.

The existence of emotion-specific autonomic activity has long been controversial. However, combining findings from our own work with those of others (e.g., Ax, 1953; Graham, 1962; Roberts & Weerts, 1982; Schwartz, Weinberger, & Singer, 1981), there now appears to be ample evidence for the existence of a limited, but reliable, set of autonomic differences among emotions in young adults, which may be consistent across modes of elicitation.

We are aware of no research that has asked whether these same patterns of autonomic differentiation of emotions exist in very old age, and if they do, whether they are of similar magnitude and can be elicited in similar ways as with young subjects. To these issues can be added questions of the nature of subjective emotional experience and emotional facial behavior associated with the emotion-eliciting tasks and of the existence of gender differences in emotion in old age. We address these questions in this study.

Method

Subjects

Thirty-five subjects, aged 70 years or older, were recruited from the Bloomington, Indiana, community. Subjects were in good health and were sufficiently mobile to travel to the laboratory and participate in a 2-hr experimental session. In a preliminary session, subjects were screened individually by a research assistant for their ability to move voluntarily certain facial muscles by a procedure used in our previous studies with young subjects (Levenson et al., 1990). Nine men and 11 women (mean age = 77; range = 71–83) who manifested good voluntary control of their facial muscles participated in the laboratory experiment, for which they received a payment of $25.

Although we studied only elderly subjects for this investigation, it seemed important to compare the data with data obtained from young subjects who had participated in the same experimental procedures. For this purpose, we used data from a recently published set of three experiments using young subjects (Levenson et al., 1990). One of these experiments was conducted in Bloomington, Indiana, with college students, and the other two were conducted in San Francisco with students and nonstudents. There were 62 young subjects (27 men and 35 women, aged 18–30) in these experiments, all of whom were paid for their participation (payments ranged from $10 to $25).

Apparatus

Physiological. A system consisting of two Lafayette Instruments six-channel polygraphs and a DEC LSI 11/73 microcomputer was used for acquisition and on-line analysis of physiological data. Second-by-second averages were obtained for four measures: (a) heart rate, for which Beckman miniature electrodes with Beckman paste were placed in a bipolar configuration on opposite sides of the subject's chest; (b) skin conductance, for which a constant-voltage device passed a small voltage between Beckman regular electrodes attached to the palmar surface of the middle phalanges of the first and third fingers of the nondominant hand with an electrolyte of sodium chloride in Unibase; (c) finger temperature, for which a thermistor was taped to the palmar surface of the distal phalange of the second finger of the dominant hand; and (d) general somatic activity, for which an electromechanical transducer attached to a platform under the subject's chair generated an electrical signal proportional to the amount of movement in any direction. The resolution of this computer–polygraph system was 1 ms for measures of time and 1 mV for measures of amplitude.

This set of physiological measures was selected to sample from major organ systems (cardiac, vascular, electrodermal, and somatic muscle), to include measures found by us and by other researchers to differentiate among emotions, to allow for continuous measurement, and to be as noninvasive as possible.

Audiovisual. A partially concealed video camera was mounted on the wall opposite the subject. The output of the camera was routed through a video time-code generator that superimposed the elapsed time on the signal, which was recorded on a videocassette recorder. Synchronization between physiological and facial data was achieved at the start of each trial by having the computer start the frame counter at the same time it began timing the physiological data for that trial.

The subject sat alone in the experimental chamber. An experimenter sat in an adjacent room where he or she could view the subject on a television monitor and communicate over an intercom system. Subjects were fully informed concerning the presence of the camera and the video recording.

Procedure

Subjects participated in a 2-hr laboratory experiment in which six emotions (anger, disgust, fear, happiness, sadness, and surprise) were studied with the use of two eliciting tasks (directed facial action and relived emotion). Emotion order was counterbalanced within tasks.

Directed facial action task. The directed facial action task comprised six trials. Each trial commenced with a 30-s rest period, then the experimenter (W. V. Friesen) asked the subject to make a standard nonemotional control configuration (eyes closed, with cheeks puffed out) and hold it for 10 s. After a brief rest, the experimenter began giving the subject the muscle-by-muscle instructions for one of the six emotional facial configurations without mentioning the associated emotion. For example, to construct the facial configuration for anger, the subject would be told to "pull your eyebrows down and together, raise your upper eyelids, and push your lower lip up and press your lips together." The experimenter provided feedback and suggestions as needed to help the subject comply with the instructions (e.g., "that's right," "don't raise your eyebrows, lower them," and "try to raise your eyelids higher"). The final facial configuration was held for 10 s.

Each set of instructions, if followed correctly, resulted in a facial configuration morphologically equivalent to the universal expression for one of the six emotions (Ekman, 1989; Ekman, Sorenson, & Friesen, 1969; Izard, 1971).

Relived emotion task. The relived emotion task comprised six trials. Each trial commenced with a 30-s rest period after which the experimenter (L. L. Carstensen) provided the subject with an antecedent condition (e.g., death of a family member or close friend) and asked him or her to recall such a time when the related emotion (i.e., sadness) was felt strongly. The antecedent conditions for the other emotions were (a) for anger, hitting someone; (b) for disgust, reactions to a noxious stimulus; (c) for fear, anticipating injury; (d) for happiness, an amusing incident; and (e) for surprise, an unexpected event. For each emotion, the subject was asked to describe the situation and was helped in focusing on the moment at which the target emotion was felt with no other emotion. After a 30-s rest period, the subject was instructed to relive the experience and to press a handheld switch when the feeling began. Fifteen seconds after the switch was pressed, the subject was asked to relax.

Our decision to provide subjects with these antecedent conditions was a compromise between two other procedures often described in the imagery literature: (a) using completely standardized images, in which all subjects are provided with the same detailed scenes to imagine, and (b) using completely individualized images, in which subjects are only told to remember a time when they felt a given emotion, with each subject providing his or her own idiosyncratic emotional memory.

Self-report. After each trial on both tasks, subjects were asked whether they experienced any emotions, memories, or physical sensations. If emotions were reported, their intensity was rated on a scale ranging from 0 to 8, with 8 equivalent to the strongest experience of that emotion in the subject's entire life. Subjects were also asked to rate the difficulty of the task on each trial using a 9-point scale.

Results

Data Reduction

Physiological. For the directed facial action task, the video tape recording for each subject was examined to locate the standard control configuration and the target emotional configuration on each trial. While each configuration was being held, the physiological data were extracted and averaged, and a change score was computed for each physiological measure (averaged data during emotional configuration minus control configuration). For the relived emotion task, on each trial the 30-s rest period prior to reliving was averaged, as was a 15-s period commencing 5 s prior to and ending 10 s after the subject's switch press, and a change score was calculated for each physiological measure (reliving period minus rest period).

Some mention should be made of our analytic approach. For physiological data that are obtained from a series of within-subjects tasks and trials, it is important to consider changes in physiological levels that occur over the course of the experiment. The simplest way to accomplish this is to compute change scores for critical experimental periods using reference periods that are temporally proximal. Change scores also have the advantage of preserving both the original metric of the data (in contrast to normalized scores) and their actual observed magnitudes (in contrast to estimated scores derived from covariance or regression approaches). Although there are statistical disadvantages associated with their use (e.g., lower reliability), change scores typically are used in psychophysiological studies as indices of physiological reactivity.

A related analytic issue regarding physiological differences among emotions is whether to compare physiological levels during a task related to one emotion with a baseline level or to compare change scores for one emotion with change scores obtained for another emotion. We adopted the latter strategy, an approach that we had also used in previous studies. This avoids the intractable problem of selecting an appropriate baseline (see Levenson, 1988, for a discussion of the biological implications and advantages and disadvantages of various solutions to this problem).

Facial coding. The facial action coding system (FACS; Ekman & Friesen, 1978) was used to determine which facial muscles were contracted on each trial for both tasks. The FACS is an anatomically based system that enables one to decompose any facial expression into its visually distinguishable muscular actions through repeated slow-motion viewing of the video tape recording. Reliabilities for FACS scoring are typically greater than .80.

On directed facial action task trials, working with the silent video tape recording, a rater assigned a performance score (on a 0–4 scale) to each facial configuration, indicating the extent to which the configuration included all of the muscle contractions specified in the instructions and no others, and whether the configuration was held steadily throughout the 10-s holding period. We previously obtained an intercoder reliability for this performance score of .89 (Levenson et al., 1990).

On relived emotion trials, FACS scores obtained during the reliving period were classified in terms of their likely emotional meaning. This was accomplished by checking each combination of facial actions against a dictionary, which, on the basis of theory and empirical evidence, indicates whether that combination is likely to have emotional meaning and, if so, which emotion or combination of emotions is most likely.

Group Physiological Data

For these initial analyses of group data, verification criteria were adopted similar to those we have used in previous studies. For the directed facial action task, only configurations receiving quality scores of 3 or greater were included (45.8% of trials met this criterion). In the relived emotions task, only trials on which the subject rated the intensity of the target emotion at 4 or greater on the 0–8 scale were included (60.2% of trials met this criterion).

Physiological data were analyzed with 2 × 2 × 6 (Sex × Task × Emotion) split-plot factorial analyses of variance (ANOVAs, with Sex as a between-subjects factor and Task and Emotion as within-subject factors). These ANOVAs revealed evidence of ANS differences among emotions, with significant emotion main effects for all four physiological measures: heart rate, $F(5, 59) = 39.68$, $p < .001$; finger temperature, $F(5, 59) = 42.12$, $p < .001$; skin conductance, $F(5, 59) = 19.61$, $p < .001$; and somatic activity, $F(5, 59) = 197.42$, $p < .001$. When these ANOVAs were repeated for all trials without regard to verification criteria, there was less indication of emotion-specific ANS activity; only the Emotion main effects for heart rate, $F(5, 90) = 2.33$, $p = .048$, and for somatic activity, $F(5, 90) = 2.82$, $p = .020$, remained significant.

The nature of emotion-specific ANS activity was explored with Bonferroni-adjusted t tests, revealing the following significant differences calculated across tasks: Heart rate (beats per minute) increased more in anger and sadness than in disgust (anger: $M = +1.80$, $SE = 0.71$; sadness: $M = +1.81$, $SE = 0.55$; disgust: $M = +0.29$, $SE = 0.56$); finger temperature (degrees Fahrenheit) decreased more in sadness than in disgust (sadness: $M = -0.08$, $SE = 0.05$; disgust: $M = +0.11$, $SE = 0.09$); and somatic activity (arbitrary units) decreased more in fear than in anger, disgust, happiness, or surprise (fear: $M = -0.034$, $SE = 0.030$; anger: $M = +0.003$, $SE = 0.011$; disgust: $M = +0.013$, $SE = 0.008$; happiness: $M = +0.022$, $SE = 0.006$; surprise: $M = +0.006$, $SE = 0.006$). From these differences, we conclude that several autonomic (and somatic) differences among emotions exist in old age.

There was no indication of differences in emotion-specific ANS patterns between the two eliciting tasks for heart rate, skin conductance, and somatic activity (i.e., the Task × Emotion interactions were not significant), but there was for finger temperature (Task × Emotion interaction), $F(5, 59) = 21.26$, $p < .001$. Examination of the data from elderly subjects in Panel 2 of Figures 1 and 2 reveals the basis for this significant interaction. In the directed facial action task, both the anger configuration and the fear configuration were associated with decreases in finger temperature from baseline. In the relived emotion task, the anger configuration was associated with an increase in finger temperature from baseline, whereas the fear configuration was associated with a decrease in temperature.

Gender Differences

There were almost no differences between elderly men and women on our measured variables. They did not differ in the extent of the four autonomic distinctions among negative emotions for either task, in the quality of their facial configurations in the directed facial action task, in the intensity of report of the target emotion in the directed facial action task, or in the frequency of occurrence of emotional facial expressions in the relived emotion task. The only gender difference that was found was in the relived emotion task, where rated intensity of the target affect was higher for women than for men (women, 4.29; men, 3.08), $F(1, 18) = 7.75$, $p = .012$.

Comparison of Results From Older Subjects With Results Obtained in Previous Studies Using Young Subjects

To address the question of whether the autonomic differences among emotions found for elderly subjects are similar to those found for young subjects, we used data obtained from a series of three experiments using 62 young subjects. All 62 subjects participated in the directed facial action task, and 46 also participated in the relived emotion task. Although procedures in these three experiments were essentially identical to those used in this study, they varied as to whether subjects had visual feedback of facial expressions (in a mirror or on the face of the

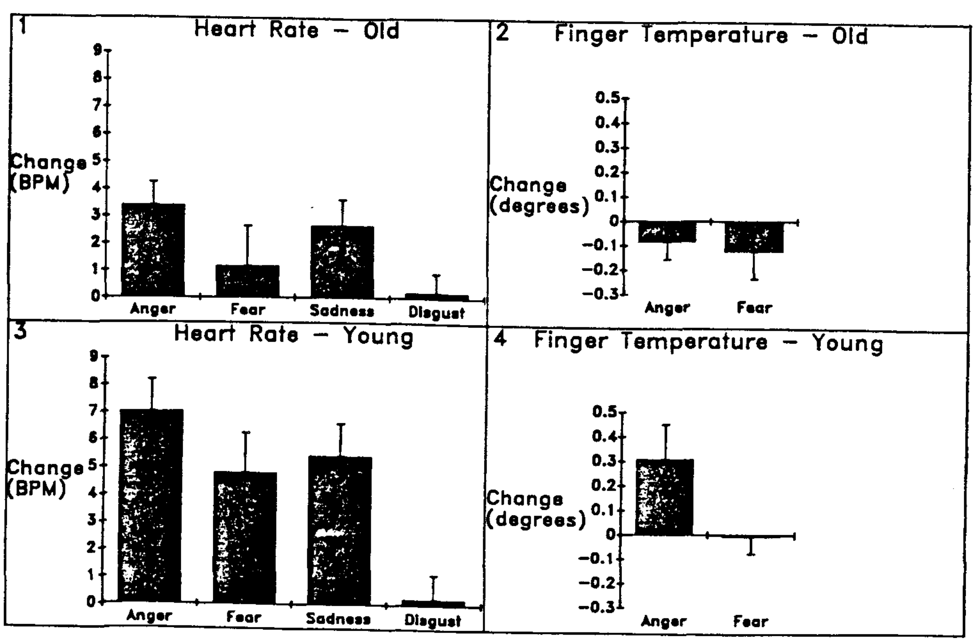

Figure 1. Mean change and standard error for heart rate (in beats per minute [BPM]) and finger temperature (in degrees Fahrenheit) during negative emotional configurations for elderly and young subjects during the directed facial action task.

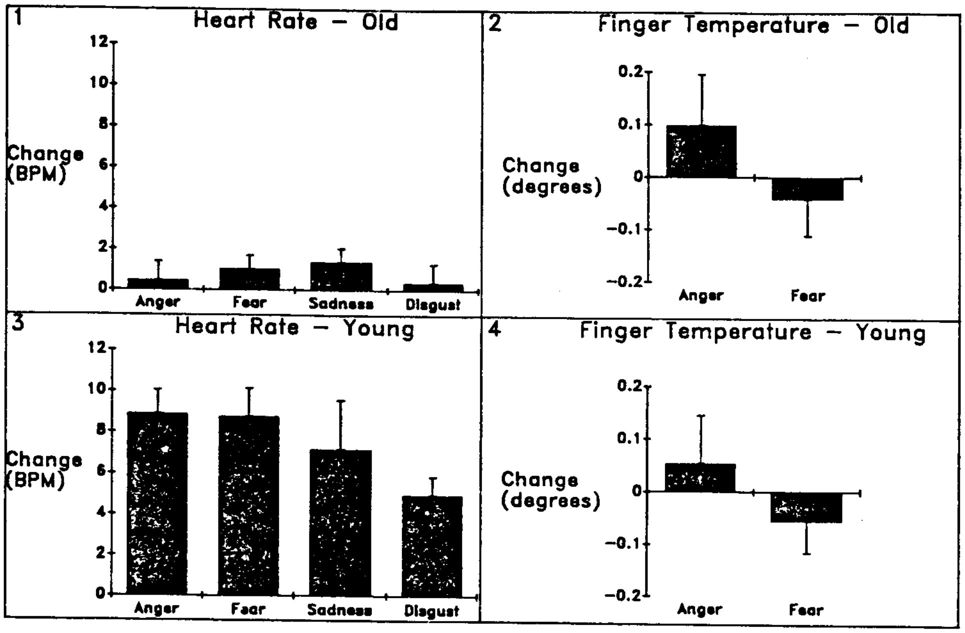

Figure 2. Mean change and standard error for heart rate (in beats per minute [BPM]) and finger temperature (in degrees Fahrenheit) during negative emotional configurations for elderly and young subjects during the relived emotion task.

coach) in the directed facial action task. As indicated in the introduction, the findings generalized across these variations. To provide the broadest basis for comparison and to increase statistical power to detect differences between elderly and young subjects, young subjects' data were pooled across the three experiments.

Group physiological data. In our previous work with young subjects, heart rate was found to enable distinctions among the emotions of anger, fear, sadness, and disgust, whereas finger temperature distinguished between anger and fear. These data are depicted in Figure 1 for the directed facial action task for the 20 elderly subjects in this study and for the 62 young subjects from the previous studies. Similar data from the relived emotions task are presented in Figure 2. For both elderly and young subjects, only trials meeting the verification criteria described earlier were included. These figures reveal similarities between data from elderly and young subjects (e.g., heart rate increases were greater for anger, fear, and sadness than for disgust; finger temperature cooling was greater for fear than for anger). However, the magnitudes of these changes were generally much smaller for the elderly subjects than for the younger subjects.

Idiographic physiological data. In our work with younger subjects (Levenson et al., 1990), we found four distinctions among negative emotions to be the most reliable across multiple experiments: greater heart rate increase in anger than in disgust, greater heart rate increase in sadness than in disgust, greater heart rate increase in fear than in disgust, and greater finger temperature cooling in fear than in anger. The first 2 of these distinctions were among the significant differences presented earlier in the analyses of group data for older subjects.

We carried out an idiographic analysis to determine whether the small autonomic changes shown by elderly subjects were nonetheless as consistent as those shown by young subjects. Hit rates were calculated for each subject for each of the four distinctions among negative emotions. In this analysis, a hit was recorded whenever a distinction was found (e.g., heart rate increase was greater on that subject's anger trial than on the disgust trial), regardless of how small the difference might be. Ties were counted as misses, and nonparametric tests were performed assuming a chance hit rate of 50%.

We first determined that the elderly subjects were not any more likely to show one of the four distinctions among negative emotions than another. Comparisons among hit rates for these distinctions within each task indicated that the elderly subjects had equivalent hit rates for the four distinctions in both the directed facial action task, Cochran's $Q(3) = 1.20$, and in the relived emotion task, Cochran's $Q(3) = 1.29$. Thus, subsequent analyses were conducted by combining hit rates across the four distinctions within each task (which would provide greater statistical power to detect any differences between elderly and young subjects).

These analyses revealed that the elderly subjects consistently showed these ANS distinctions among emotions on both tasks at levels comparable with those of young subjects. On the directed facial action task (using all trials without regard to configuration quality[1]), the elderly subjects had a 67.5% hit rate (54

[1] Because the number of trials on the relived emotions task (for the four negative emotions used in these analyses) that met the verification criterion was small, the reported idiographic analyses for both tasks were conducted with data from all trials. There were, however, sufficient trials in the directed facial action task that met verification criteria to conduct an analysis limited to high-quality configurations. This analysis revealed that elderly subjects had a 78.6% hit rate (11 hits out of

hits out of 80 trials) for the four distinctions among negative emotions, which was significantly greater than chance (50%; $z = 3.13$, $p = .001$) and did not differ significantly from the 68.2% hit rate (161 hits out of 236 trials) shown by young subjects (z of difference = 0.12). On the relived emotions task (using all trials without regard to intensity of reported emotion), elderly subjects had a hit rate of 74.6% (47 hits out of 63 trials), which was significantly greater than chance (50%; $z = 3.91$, $p < .001$) and did not differ significantly from the 65.5% hit rate (95 hits out of 145 trials) shown by young subjects.

Subjective report and facial expressive data. In the directed facial action task, differences were found between elderly and young subjects in both subjective report and facial expression: The mean quality rating of facial configurations was lower for elderly subjects than for young subjects (old, 2.38; young, 2.85), $F(1, 79) = 9.68$, $p = .003$; elderly subjects reported experiencing the target emotion much less often than did the young subjects (old, 1.7% of trials; young, 33.5%; $z = -6.94$, $p < .001$); and subjects' ratings of the difficulty of the task was the same for elderly and young subjects (old, 2.64; young, 2.30), $F(1, 48) = 3.10$.

In the relived emotions task, there were no subjective or expressive differences between elderly and young subjects: (a) The mean rated intensity of the target emotion was the same for both groups (old, 3.77; young, 3.83), $F(1, 64) < 1$; and (b) the rated difficulty of the task was the same for both groups (old, 3.28; young, 2.86), $F(1, 47) = 2.89$. Although not requested in the relived emotions task, subjects sometimes spontaneously displayed facial expressions of the target emotion. Using the emotional dictionary (described earlier) to classify FACS scores, we found the percentage of trials on which emotional expressions occurred was the same for both groups (old, 18.3%; young, 15.6%; $z = 0.63$).

Discussion

The findings from this study indicate that certain emotions retain an association with differentiated ANS activity well into the seventh decade of life and beyond. Especially for the four negative emotions we studied, the characteristics of these ANS differences are consistent with those found previously by us and by others working with young adult populations. We do not yet know how *early* in life these autonomic changes become reliably integrated with the facial expressions, subjective experiences, and behavioral action tendencies that constitute emotions. However, we expect that developmental research will ultimately show that the necessary infrastructure for this integration is hardwired from birth and, on the basis of our findings, designed to last a lifetime.

Emotion-specific ANS activity in old age bears strong resemblance to that seen in youth; however, some differences emerged in our investigation. Most striking, the magnitude of ANS activity was much smaller in old age regardless of the eliciting task used. This reduction in autonomic response could not be explained in terms of medications being taken by subjects (e.g., only 4 of the older subjects were taking beta-blocking drugs, which could decrease the magnitude of heart rate response). Some of the reduction undoubtedly reflects the well-documented diminution in neural reactivity in the ANS that occurs with age (Frolkis, 1977). Unfortunately, we have no empirical basis to determine whether the ANS reactivity associated with emotion is any more diminished with age than is the ANS reactivity associated with nonemotional sources (e.g., exercise and autonomic reflexes). We would not be surprised to find that the magnitude of emotional ANS reactivity is especially hard hit by aging. This would be in keeping with our view that emotion-specific ANS activity has been selected by evolution for its adaptive functions that are critical to survival. These functions may become less important once the primary reproductive period has ended, thus diminishing, albeit not eliminating, the ANS component of emotion.

Beyond the observed similarities, two emotion-specific ANS differences emerged that we had *not* seen previously in our younger subjects. These were a greater decrease in finger temperature for sadness than for disgust and a lower level of somatic activity in fear than for the other emotions. Finger temperature decrease mediated by peripheral vascular constriction is subserved by alpha-adrenergic activation of the sympathetic nervous system. This finding may reflect a relative increase in the arousing quality of sadness in old age. A decrease in somatic activity associated with fear in old age may reflect a transition in the primary behavioral adaptation and related motor program associated with the fear, with "flight" being primary in youth and "freezing" becoming primary in old age. The study of other age groups intermediate between the young adults and very old subjects we have studied to date would be informative in evaluating this possibility.

Of considerable interest to us is the finding that emotion-specific ANS activity can still be elicited in very old age by two quite different means. The first of these is by reliving emotional memories. Folk wisdom and gerontological research are in agreement that reminiscence is an important activity in old age. Our results from the relived emotions task indicated that when old people relive emotional memories, these memories are experienced subjectively just as intensely, are just as likely to recruit emotional facial expressions, and are just as likely to recruit patterned emotion-specific ANS activity (albeit of diminished magnitude) as when young people engage in these activities. For these reasons, it is most difficult to take seriously the assertion that the emotional world of the elderly is barren and desolate by virtue of their loss of the capacity for emotional response.

The second eliciting task, voluntarily constructed representations of emotional facial expressions, although still able to recruit emotion-specific ANS activity, showed definite effects of age. The quality of the facial configurations was significantly lower in elderly subjects than in young subjects, and the capacity of these configurations to recruit subjective emotional experience was almost totally absent in the elderly subjects. This lowered configuration quality could reflect a lessening of voluntary muscular control with age. Another possibility is that this somewhat artificial task was not very engaging for elderly subjects, with attendant lower task involvement and lower motivation leading to reduced configuration quality. Regardless of its

14 trials), which was significantly greater than chance (50%; $z = 2.14$, $p = .016$) and did not differ significantly from the 73.0% hit rate (54 hits out of 74 trials) for high-quality configurations shown by young subjects.

source, on the basis of our findings with younger subjects (Levenson et al., 1990), lowered configuration quality may account for some of the dramatic drop in reported emotional experience among elderly subjects in this task as well. However, further experimentation is required to determine whether there are other age-related changes involved.

In regard to the issue of gender differences, despite much conventional wisdom and reports in the literature concerning differences between the sexes in emotional expressiveness (e.g., Hall, 1984), our findings with the elderly subjects indicate that, for the aspects of emotion we studied, there is much more that is similar than is different. We suspect, however, that rather subtle differences in expressiveness distinguish the sexes in old age. During this experiment, we often noted that the elderly women appeared to be much more emotional than the elderly men, who appeared to be much more stoical. However, the only empirical support for this observation came with the finding that the women reported more intense emotional experiences than the men when they relived emotional memories. Of course, our current tasks and measures could be missing important aspects of emotion for which gender differences exist in old age. Furthermore, the number of male and female subjects in this experiment might not have been large enough to detect gender differences, especially in the analyses of physiological data that used only subjects meeting criteria for configuration quality or intensity of emotional memory. However, in our previous studies of young subjects, which used larger samples, we also failed to find reliable sex differences for the aspects of emotion assayed by these methods (Levenson et al., 1990). Pending the outcome of ongoing studies in our laboratories of more naturalistic social interaction of older married couples (which use larger samples and which might be more sensitive to aspects of emotion for which gender differences are more likely to exist), we consider the issue of gender differences in emotionality in old age to remain an open question.

Although our data suggest that the basic emotion "machinery" is still intact in old age, old people may nonetheless *appear* to be less emotional in the natural environment because of lowered levels of social activity. Carstensen (1987, 1989) has offered selectivity theory as an alternative explanation to existing theories of diminished social activity in late life. According to this selectivity model, reductions in interactions represent an affect regulation strategy that is prominent in old age. A great deal of emotion occurs in the context of social interaction. Limiting social interaction to people and issues of greatest importance to the individual can optimize positive emotional experience and minimize negative emotional experience. This lessening of negative affect could create the appearance of lowered emotionality. Of course, tactics of increasing positive affect and reducing negative affect are surely not the unique province of the elderly, but these tactics may become much more prominent in old age as energy reserves become depleted and the future becomes more limited.

Finally, although the primary rationale for this research was to study emotion in old age, it provided us with a much needed opportunity to begin to obtain data relevant to the issue of whether emotion-specific ANS activity is consistent across different modes of elicitation. Since our initial study (Ekman et al., 1983), we have focused primarily on the directed facial action task and have found several consistent relations between specific emotions and specific patterns of ANS activity. In this study, we used the directed facial action task as well as the relived emotion task in the same sample of subjects. The results, which indicated strong consistency of ANS distinctions among negative emotions across these two tasks, provide our most powerful support to date for the notion that ANS activity is emotion specific, rather than task specific (e.g., Stemmler, 1989). Of course, we need additional research using additional tasks to determine the full extent of this generality across tasks and across emotions. Nonetheless, the level of similarity of findings reported herein between the quite novel directed facial action task and the more conventional relived emotions task supports the hypothesis that autonomic specificity is determined more by the emotion than by the mode of elicitation.

References

Ax, A. F. (1953). The physiological differentiation between fear and anger in humans. *Psychosomatic Medicine, 15,* 433–442.

Berkman, L. F., & Syme, S. L. (1979). Social networks, host resistance and mortality: A nine-year follow-up study of Alameda County residents. *American Journal of Epidemiology, 109,* 186–204.

Blazer, D. (1982). Social support and mortality in an elderly community population. *American Journal of Epidemiology, 115,* 684–694.

Bondareff, W. (1980). Neurobiology of aging. In J. E. Birren & R. B. Sloane (Eds.), *Handbook of mental health and aging* (pp. 75–99). Englewood Cliffs, NJ: Prentice-Hall.

Buhler, C. (1968). The developmental structure of goal setting in group and individual studies. In C. Buhler & F. Massarik (Eds.), *The course of human life* (pp. 27–54). New York: Springer.

Carstensen, L. L. (1987). Age-related changes in social activity. In L. L. Carstensen & B. A. Edelstein (Eds.), *Handbook of clinical gerontology* (pp. 222–237). New York: Pergamon Press.

Carstensen, L. L. (1989, November). *A longitudinal analysis of social and emotional relationships across the life-span.* Paper presented at the meeting of the Gerontological Society of America, Minneapolis, MN.

Costa, P. T., McCrae, R. R., Zonderman, A. B., Barbano, H. E., Lebowitz, B., & Larson, D. M. (1986). Cross-sectional studies of personality in a national sample: 2. Stability in neuroticism, extraversion, and openness. *Psychology and Aging, 1,* 144–149.

Cumming, E., & Henry, W. E. (1961). *Growing old: The process of disengagement.* New York: Basic Books.

Eisdorfer, C. (1970). The implications of research for medical practice. *The Gerontologist, 10,* 62–67.

Ekman, P. (1989). The argument and evidence about universals in facial expressions of emotion. In H. Wagner & A. Manstead (Eds.), *Handbook of psychophysiology: Emotion and social behavior* (pp. 143–164). London: Wiley.

Ekman, P., & Friesen, W. V. (1978). *Facial action coding system.* Palo Alto, CA: Consulting Psychologists Press.

Ekman, P., Levenson, R. W., & Friesen, W. V. (1983). Autonomic nervous system activity distinguishes among emotions. *Science, 221,* 1208–1210.

Ekman, P., Sorenson, E. R., & Friesen, W. (1969). Pan-cultural elements in facial displays of emotion. *Science, 164,* 86–88.

Erikson, E. R. (1959). *Identity and life cycle: Psychological issues I.* New York: International Universities Press.

Fredrickson, B. L., & Carstensen, L. L. (1990). Choosing social partners: How old age and anticipated endings make people more selective. *Psychology and Aging, 5,* 335–347.

Frolkis, V. V. (1977). Aging of the autonomic nervous system. In J. E.

Birren & K. W. Schaie (Eds.), *Handbook of the psychology of aging* (pp. 177–189). New York: Van Nostrand Reinhold.
George, L. K., & Bearon, L. B. (1980). *Quality of life in older people: Meaning and measurement.* New York: Human Sciences Press.
Graham, D. T. (1962). Some research on psychophysiologic specificity and its relation to psychosomatic disease. In R. Roessler & N. S. Greenfield (Eds.), *Physiological correlates of psychological disorder* (pp. 221–238). Madison, WI: University of Wisconsin Press.
Hall, J. A. (1984). *Nonverbal sex differences: Communication accuracy and expressive style.* Baltimore: Johns Hopkins University Press.
Harris, P. L. (1989). *Children and emotion.* New York: Basil Blackwell.
Izard, C. E. (1971). *The face of emotion.* New York: Appleton-Century-Crofts.
Izard, C. E., & Malatesta, C. (1984). *Emotion in adult development.* Beverly Hills, CA: Sage.
Jung, C. C. (1933). *Modern man in search of a soul.* New York: Harcourt, Brace.
Kiecolt-Glaser, J. K., & Glaser, R. (1989). Interpersonal relationships and immune function. In L. L. Carstensen & J. M. Neale (Eds.), *Mechanisms of psychological influence on physical health, with special attention to the elderly* (pp. 43–60). New York: Plenum Press.
Levenson, R. W. (1988). Emotion and the autonomic nervous system: A prospectus for research on autonomic specificity. In H. Wagner (Ed.), *Social psychophysiology and emotion: Theory and clinical applications* (pp. 17–42). London: Wiley.
Levenson, R. W., Ekman, P., & Friesen, W. V. (1990). Voluntary facial action generates emotion-specific autonomic nervous system activity. *Psychophysiology, 27,* 363–384.
Levenson, R. W., & Gottman, J. M. (1983). Marital interaction: Physiological linkage and affective exchange. *Journal of Personality and Social Psychology, 45,* 587–597.
Malatesta, C., & Kalnok, M. (1984). Emotional experience in younger and older adults. *Journal of Gerontology, 39,* 301–308.
Palmore, E. (1981). *Social patterns in normal aging: Findings from the Duke Longitudinal Study.* Durham, NC: Duke University Press.
Powell, A. H., Eisdorfer, C., & Bogdonoff, M. D. (1964). Physiological response patterns observed in a learning task. *Archives of General Psychiatry, 10,* 192–195.
Roberts, R. J., & Weerts, T. C. (1982). Cardiovascular responding during anger and fear imagery. *Psychological Reports, 50,* 219–230.
Schliefer, S. (1989). Bereavement, depression and immunity: The role of age. In L. L. Carstensen & J. M. Neale (Eds.), *Mechanisms of psychological influence on physical health, with special attention to the elderly* (pp. 61–80). New York: Plenum Press.
Schulz, R. (1985). Emotion and affect. In J. E. Birren & K. W. Schaie (Eds.), *The psychology of aging* (pp. 531–543). New York: Van Nostrand Reinhold.
Schwartz, G. E., Weinberger, D. A., & Singer, J. A. (1981). Cardiovascular differentiation of happiness, sadness, and fear following imagery and exercise. *Psychosomatic Medicine, 43,* 343–364.
Stemmler, G. (1989). The autonomic differentiation of emotions revisited: Convergent and discriminant validation. *Psychophysiology, 26,* 617–632.
Thompson, R. A. (in press). Emotion and self-regulation. In R. A. Thompson (Ed.), *Socioemotional development: Nebraska symposium on motivation* (Vol. 33). Lincoln, NE: University of Nebraska Press.

Received January 12, 1990
Revision received July 2, 1990
Accepted July 12, 1990 ■