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Age-Related Differences in Emotion Recognition Ability: A Cross-Sectional Study

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Experimental studies indicate that recognition of emotions, particularly negative emotions, decreases with age. However, there is no consensus at which age the decrease in emotion recognition begins, how selective this is to negative emotions, and whether this applies to both facial and vocal expression. In the current cross-sectional study, 607 participants ranging in age from 18 to 84 years (mean age = 32.6 ± 14.9 years) were asked to recognize emotions expressed either facially or vocally. In general, older participants were found to be less accurate at recognizing emotions, with the most distinctive age difference pertaining to a certain group of negative emotions. Both modalities revealed an age-related decline in the recognition of sadness and—to a lesser degree—anger, starting at about 30 years of age. Although age-related differences in the recognition of expression of emotion were not mediated by personality traits, 2 of the Big 5 traits, openness and conscientiousness, made an independent contribution to emotion-recognition performance. Implications of age-related differences in facial and vocal emotion expression and early onset of the selective decrease in emotion recognition are discussed in terms of previous findings and relevant theoretical models.

Keywords: recognition of emotions, facial and vocal emotion expressions, socioemotional selectivity theory, cognitive aging, age-related changes in brain structures

The expression and recognition of emotion are two of the basic skills on which normal social interaction is based. As people grow older, they may become wiser and more experienced in interacting with other people, but they can also experience memory loss and cognitive slow-down, influencing the quality of relations in their daily routines. Recent discoveries of a significant age-related shift in the ability to identify negative emotions (Calder et al., 2003; Isaacowitz et al., 2007; McDowell, Harrison, & Demaree, 1994; Moreno, Borod, Welkowitz, & Alpert, 1993; Phillips, MacLean, & Allen, 2002; Ruffman, Henry, Livingstone, & Phillips, 2008; Sullivan & Ruffman, 2004a; Suzuki, Hoshino, Shigemasu, & Kawamura, 2007) pose not only a significant scientific but also a societal problem: A growing fraction of the overall aging population may be considerably less accurate in processing emotional signs and cues.

Many studies have consistently demonstrated a negative association between age and the recognition of facially expressed sadness; some research findings also suggest a decrease, and more errors, in recognizing facial anger (MacPherson, Phillips, & Della Sala, 2002; Phillips et al., 2002) as well as fear (Calder et al., 2003). A recent review of the existing relevant literature confirmed that older adults are less accurate at recognizing anger and sadness and, to some extent, fear (Isaacowitz et al., 2007). Some studies also demonstrate an age-related negative association in the recognition of disgust (Sullivan & Ruffman, 2004b), whereas others have not been able to confirm this (Calder et al., 2003; Moreno et al., 1993; L. H. Phillips et al., 2002). Other studies, furthermore, have reported that the decrease relates not only to the recognition of negative but also positive emotions, such as happiness (Brosgole & Weisman, 1995; Isaacowitz et al., 2007). These findings have not been repeated elsewhere, however, where it has been shown that older people are even more adept at recognizing happiness than younger people (Moreno et al., 1993). The difficulties older people experience in recognizing certain emotions, it should be noted, are not influenced by basic face processing skills, as the findings are not related to any overall problems in perception (Calder et al., 2003; Sullivan & Ruffman, 2004a). In addition, the speed of detection of dangerous stimuli is not associated with age given that threatening faces are detected more quickly than other emotional stimuli by both younger and older adults (Mather & Knight, 2006). Most studies, however, rely on the comparison of groups of young and old people, and give no information about possible variation across the age groups of the adult life span. A study by Calder and colleagues (2003) included adults from various age groups and revealed a gradual linear decrease in the recognition of fear from the age of 40 and anger from the age of 50.

There is much less research into the recognition of vocal expression of emotion (Mitchell, 2007; Orbelo, Testa, & Ross, 2003). Impairments in recognizing affective prosody have been observed already at 45 years of age (Brosgole & Weismann, 1995). A

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meta-analysis of 28 data sets by Ruffman and colleagues (2008) examined age differences in emotion recognition across four different modalities: faces, voices, bodies/contexts, and matching of faces to voices. Their findings indicated that older adults are less adept than younger adults at recognizing at least some basic emotions in each modality, but especially anger and sadness. Again, overall perceptual problems can be excluded, as mild to moderate hearing loss has been found not to impair affect comprehension (Orbelo, Grim, Talbot, & Ross, 2005). Impairments in the comprehension of affective prosody also have been found to be largely unrelated to general cognitive decline (Orbelo et al., 2005).

It might be that the task of recognizing different emotions varies in difficulty. In terms of transmission and decoding processes, it has been found that the brain structures involved in the processing of facial expressions are specialized and that different emotions have low correlations with one another (Smith, Cottrell, Gosselin, & Schyns, 2005). Fear has been found to be the most difficult emotion to recognize as it has very few distinctive features and overlaps extensively with the expression of surprise (Smith et al., 2005). For adults with mental retardation, the categories of surprise and fear are the most difficult to recognize (McAlpine, Kendall, & Singh, 1991).

There thus seems to be no doubt that an age-related decrease in the recognition of some negative emotions is a consistent and replicable phenomenon. Results of previous research have been inconsistent in terms of which emotions are recognized poorly and at what age the decrease emerges, however. Also, there is little agreement about whether decreased emotion recognition among older people is limited to the recognition of facial expressions or whether it is a more general phenomenon pertaining also to the processing of prosodic information. And most lacking of all is a comprehensive explanation of this unexpectedly regular decrease in recognition of emotions.

There are essentially four schools of thought concerning the emotion recognition and aging phenomenon, corresponding to the different age categories at which the aging effect in emotion recognition might be expected: (a) the socioemotional selectivity theory (Carstensen, Mikels, & Mather, 2006), (b) the cognitive aging approach (Park, Polk, Mikels, Taylor, & Marshuetz, 2001; Salthouse, 2004), (c) research about neural decline (Adolphs, 2002; Calder et al., 2003; Davidson & Irwin, 1999), and (d) personality studies (McCrae & Costa, 2003). These four approaches are clearly related and supplement each another in their ability to explain the causes and implications of the aging effect in emotion recognition.

The Socioemotional Selectivity Theory

According to the socioemotional selectivity theory, the perceived limited time left in one's life generates what is known as the *positivity effect*, a developmental pattern in which a disproportionate preference for positive information emerges during aging (Carstensen et al., 2006; Carstensen, Fung, & Charles, 2003; Mather & Carstensen, 2003; Mather et al., 2004; Mather & Knight, 2006). This awareness of future mortality is argued to begin in early and middle adulthood, long before old age (Carstensen & Turk-Charles, 1994). Few of the studies in socioemotional selectivity theory that cover the entire adult life span have suggested age-related changes in late midlife. A study by Carstensen and Turk-Charles (1994) on the salience of emotion found a linear increase with age in the recall of emotional material. Focus on opportunities has been found to decline from young adulthood to early middle age and then remain stable during middle age, whereas focus on limitations begins to increase during one's 50s (Cate & John, 2007). However, a recent meta-analytic study by Murphy and Isaacowitz (2008) did not find significant differences between older adults' positivity and negativity preferences; older adults, furthermore, did not show any significantly greater positivity preference than younger adults.

In terms of how this popular theory of aging relates to the domain of emotion recognition, as individuals age, for the sake of emotion regulation, any negative emotion, including others' expressions of emotion, would be avoided. Decreased recognition of negative emotion could be expected for all negative emotions, particularly for sadness, although less so for fear (Mather & Knight, 2006), as these two emotions have different social functions, one to elicit helping behavior, the other to inform about threat (Keltner & Haidt, 1999). As a result of decreased recognition with age, negative emotions would be expected to be perceived as positive or neutral to a greater extent. The preference for positive or neutral expressions could be expressed in emotion-specific response biases revealed by analyses of errors made in emotion recognition. However, there is no clear consensus about the age at which the perception of limited time might start to influence emotion recognition.

Cognitive Aging

The recognition of emotions requires a series of cognitive operations: discrimination of visual or acoustic details, recognition of characteristic patterns, and comparison with prototypes stored in the memory, to name a few, regulated by the interaction of the brain structures involved in emotion recognition (Adolphs, 2006). Any these cognitive faculties separately or in combination can deteriorate with age. Research by Salthouse (2004) suggests that age-related cognitive decline is fairly broad, begins in early adulthood, and is cumulative across the life span. Age-related decreases in cognitive functioning are stronger after the age of 50, but are also significant in the 18- to 50-year age range (Verhaegen & Salthouse, 1997). There is significant linear decline in fluid intelligence, memory, and speed factors during aging, starting after the age of 30 for fluid intelligence and speed factors and after the age of 40 for memory (Salthouse, 1998; Salthouse, Atkinson, & Berish, 2003). Still, for vocabulary-related abilities, such as inductive reasoning, vocabulary, verbal memory, and spatial orientation, peak performance occurs in the early 40s to 60s (Salthouse, 2004; Willis & Schaie, 1999). Thus, if age differences in emotion recognition are related to a decline in general cognitive abilities, the negative trend in recognizing emotions could be expected to emerge at a relatively young age. From the point of cognitive aging, if the age difference is related to general cognitive abilities, we could expect it to be related to IQ. However, Kiss and Ennis (2001) found an age-related negative association in emotion recognition with IQ-matched age groups.

Neural Decline

The third possible explanation is concerned with neural mechanisms as the bases for cognitive performance. The selective

negative age association in emotion recognition might be related to differential aging and degradation of the brain as the recognition of each basic emotion is directed by a complex interplay of brain structures. This is in line with Ruffman and colleagues (2008), who believe that the pattern of age-related change in emotion recognition is most consistent with a neuropsychological model of adult aging, stemming from changes in frontal and temporal volume or changes in neurotransmitters.

Previous research results support heterogenic aging; the frontal and medial temporal lobes are among the brain areas known to show the earliest and most rapid decline in normal adult aging, suggesting that poorer recognition of certain emotions might be associated with faster degradation in some brain areas (Petit-Taboué, Landeau, Desson, Desgranges, & Baron, 1998; Sowell et al., 2003). The results of Walhovd and colleagues (2005) clearly indicate early decline, starting in a person's 40s, in many brain structures including the cortex and amygdala, with a larger decline in the former. The brain neuronal systems regulated by the neurotransmitter dopamine show age-related decline in the density of different dopamine markers; the decline proceeds in a gradual fashion after its onset (see Bäckman, Nyberg, Lindeberger, Li, & Farde, 2006, for a review).

Studies suggest the involvement of a distributed neural system in the perception of emotionally salient information, with ventral prefrontal cortical regions having a general role in emotion processing, with at least partially distinct processing of individual emotions (Adolphs, Damasio, Tranel, & Damasio, 1996; Lawrence, Goerendt, & Brooks, 2007). Specific neural regions such as the amygdala and the anterior insula have been highlighted as particularly important for the identification of emotional stimuli (Calder, Lawrence, & Young, 2001). The amygdala has, in particular, been found to be involved in processing emotion-related information from facial and vocal expressions (Ochsner, 2004), especially the expression of fear (Adams, Gordon, Baird, Ambady, & Kleck, 2003; Adolphs, Russell, & Tranel, 1999; Calder et al., 1996; Morris et al., 1996; Phan et al., 2004; M. L. Phillips et al., 1998), surprise (Kim, Somerville, Johnstone, Alexander, & Whalen, 2003; Phelps et al., 2001), sadness (Blair, Morris, Frith, Perrett, & Dolan, 1999; Schneider, Habel, Kessler, Salloum, & Posse, 2000), happiness (Breiter et al., 1996), as well as other negative stimuli (Irwin et al., 1996; Lane, Reiman, Ahem, Schwartz, & Davidson, 1997). The insula has been found to mediate the identification of displays of disgust (M. L. Phillips et al., 1997; Calder et al., 2001), as well as anger, fear, happiness (Damasio et al., 2000), and sadness (Eugène et al., 2003).

Personality Dimensions

Emotion recognition could depend on multiple cognitive factors and be related to changes in personality dimensions during aging, or it could be a separate ability. Previous studies have demonstrated reliable correlations between the ability to recognize emotions and personality dimensions. In particular, individuals who score high on openness to experience are more successful in recognizing emotional expressions (Matsumoto et al., 2000; Realo et al., 2003). In most studied countries, agreeableness and conscientiousness tend to increase, whereas extraversion and openness tend to decrease with age (McCrae & Costa, 2003; see also Allik, Laidra, Realo, & Pullmann, 2004). Consequently, it is possible that age differences in the ability to recognize emotions are mediated by an age-related decline in openness to experience: With advancing age, individuals become less aware or spend less time analyzing their own and others' feelings; as a result, they become less discriminating in the processing of emotional information.

Aims of the Present Study

The main goal of the current study was to investigate age differences in recognizing facial and vocal emotion expression by using cross-sectional data covering the whole adult life span. More specifically, the aim was to replicate and extend previous research by examining for which emotions, between which age groups, and in which direction the age differences in emotion recognition emerge. Very few previous studies on age differences in emotion recognition have used samples larger than 300 participants and, most commonly, groups of young and older adults have been compared (e.g., Brosgole & Weisman, 1995; Isaacowitz et al., 2007). To obtain more detailed information about age-related differences in emotion recognition, a sufficiently large sample is required. Our goal was to collect data from at least 600 participants, ensuring a sufficient number of individuals in each age group.

Unlike many previous studies, we used all six basic facial emotion expressions, the expression of contempt, and the neutral state (Matsumoto & Ekman, 2004) to see how selective or general age differences in the ability to recognize emotional expression are. Very few studies have examined age differences in the recognition of neutral emotion expression (Borod et al., 2004; Isaacowitz et al., 2007; McDowell et al., 1994). However, the ability to correctly identify the absence of emotion is as important as the ability to identify its presence (Isaacowitz et al., 2007); it was also important to examine the recognition of neutral emotion as it permitted the control of response biases. In addition, we also included faces expressing contempt as contempt has many properties of basic expressions (Matsumoto & Ekman, 2004).

Although the age differences in the accuracy of emotion recognition from posed facial expressions is relatively well documented, there is no certainty as to whether this is in fact a more general phenomenon in processing emotional information. Furthermore, there are only a few studies examining the recognition of emotion in more than one modality. For example, Sullivan and Ruffman (2004b) asked participants to match emotion sounds to angry, sad, and disgusted faces. Isaacowitz and colleagues (2007) presented sentences describing emotional situations (e.g., "An older man looks at the picture of his recently departed wife") asking which emotion corresponds best to the described situation. Our goal was to use a test that measured accuracy of emotion recognition from acoustic information very similar in its general logic to emotion recognition from facial expressions. With this in mind, an audio test (Realo et al., 2003) was administered, with sentences that were spoken in either a neutral, happy, sad, or angry manner, and the listeners' task was to recognize the vocal expression of the respective emotion. The facial emotion recognition measure consisted of widely used set of standardized faces from the Japanese and Caucasian Facial Expressions of Emotion (JACFEE) and the Japanese and Caucasian Neutral Faces (JACNeuF; Matsumoto & Ekman, 1988). Simultaneous assessment of both modalities gives the possibility of excluding modality-specific age differences; if a

negative age-related difference in both facial and vocal emotion recognition emerges, it clearly indicates more general problems in the accumulating, processing, and interpretation of emotional information.

To explore the relationship between personality dimensions and the ability to recognize emotions, we also asked all participants to evaluate themselves on the Big Five—neuroticism, extraversion, openness to experience, agreeableness, and conscientiousness—personality traits.

Hypotheses regarding emotion recognition in facial and vocal emotion recognition tasks were postulated on the basis of prior literature and existing theoretical perspectives. Specifically, it was predicted that (a) age differences in emotion recognition will emerge for different basic emotions and the neutral expression, with negative emotions showing the largest age differences; (b) the age difference will emerge at midlife at the earliest given that the age of 40 has been found to be the earliest onset of the decrease in previous studies (Calder et al., 2003); (c) the age difference will be expressed in both facial and vocal modalities as has been revealed by studies of each modality independently, although they have not previously been tested in combination; and (d) the age effects in emotion recognition will not be mediated by personality traits. Although previous studies have revealed correlations between personality dimensions and emotion recognition, the mediation analyses have not been tested.

Method

Participants

A total of 607 individuals (431 women and 176 men) participated in this study. The mean age of the participants was 32.6 years ($SD = 14.9$), ranging from 18 to 84 years. Fifteen percent of the participants were students ($n = 94$), and the rest consisted of people with different educational and social backgrounds. Participants were recruited through newspaper and radio advertisements, fliers, and referrals from other participants. Most of the participants were recruited without financial compensation; however, they could choose between a small honorarium in the amount of 50 EEK (approximately 4 euros) or feedback (the results of their tests). Students participated in the experiment as a part of their class requirements. Participants were classified into six age groups: 18–20 ($n = 147$; 99 women and 48 men; education: 9% elementary school, 91% secondary school), 21–30 ($n = 208$; 149 women and 59 men; education: 3% elementary school, 75% secondary school, 22% higher education), 31–40, ($n = 93$; 69 women and 24 men; education: 56% secondary school, 42% higher education), 41–50 ($n = 71$; 48 women and 23 men; education: 1% elementary school, 54% secondary school, 45% higher education), 51–60 ($n = 51$; 39 women and 12 men; education: 9% elementary school, 46% secondary school, 45% higher education), and 61–84 ($n = 37$; 27 women and 10 men; education: 21% elementary school, 41% secondary school, 33% higher education). The number of participants may vary in different analyses because of missing data.

Measures

Facial expression measure. The facial expression measure consisted of thirty-two 35-mm slides from the slide sets JACFEE and JACNeuF (Matsumoto & Ekman, 1988), each slide portraying one of the seven basic emotions (anger, contempt, disgust, fear, happiness, sadness, and surprise) or a neutral expression. All slides were coded by Ekman and Friesen's (1978) Facial Action Coding System to ensure the validity of the slides in portraying the intended emotion and comparability of expression intensity levels. In this study, every emotion was represented in four slides. The expressions were represented by models of two visibly different racial backgrounds—two photos of each emotion depicted posers of either Caucasian or Japanese descent (two males and two females, equally representing the two races). Each slide was shown to the respondents for 10 s, and they were asked to check on their answer sheets one of the seven emotion terms (anger, contempt, disgust, fear, happiness, sadness, and surprise) or the neutral expression, as best described the emotion portrayed. The correlation between facial White and Japanese expressions was .61 ($p < .001$). The facial expression measure has been used in several previous studies (see Ruffman et al., 2008, for a review).

Voice expression measure (VEM). To measure the recognition of emotions in speech, an audio test from a study by Realo and colleagues (2003) was used in which two speakers, a male and a female, recited four sentences (with a neutral meaning) either in a neutral, happy, sad, or angry manner. Each sentence was repeated twice. Thus, altogether the stimulus material consisted of 64 sentences (i.e., 8 twice-repeated sentences $\times$ 4 emotions $\times$ 2 speakers). Participants were asked to tick on their answer sheets one of the three emotion terms (anger, happiness, and sadness) or a neutral expression to indicate which emotion the speaker was trying to express. A preliminary rating study demonstrated that the intended emotion category was always the most frequent answer.

Personality traits. All the participants were asked to complete the Estonian NEO-FFI (Allik et al., 2004), which consists of 60 items, with each of the five major personality dimensions—neuroticism (N), extraversion (E), openness to experience (O), agreeableness (A), and conscientiousness (C)—being represented by 12 items each. The responses were given on a 5-point Likert-type scale ranging from 0 (*strongly disagree*) to 4 (*strongly agree*). The internal consistency reliability coefficients (Cronbach alphas) were .89, .83, .82, .72, and .87 for N, E, O, A, and C subscales, respectively.

Procedure

Data were collected during several years between 1999 and 2005. Subjects were mainly tested in groups ranging from 6 to 47 persons. Because it was more complicated to recruit older participants, their number is underrepresented. All experiments had the same protocol. First, the emotion recognition tasks were conducted (first the facial expression measure and then VEM); thereafter, different questionnaires were administered to participants.

Results

Emotion Recognition by Age Group

The mean recognition rate of facial expressions was 70%, which is less than the corresponding percentage (90%) for the same set of faces in the U.S. sample (Biehl et al., 1997). However, the correlation between the Estonian and the North American percentages

for the correct recognition for the 32 facial expressions was reasonably high ($r = .82$, $p = .000$), which indicates that the same emotions that were difficult or easy to recognize in the Estonian sample were similarly perceived in the U.S. sample. Previous studies have also found the Estonian sample to have lower recognition rates than U.S. sample (Ekman et al., 1987).

The mean facial and vocal recognition scores were moderately correlated ($r = .39$, $p < .001$), indicating that individuals who were more successful in recognizing facial expressions were also more successful in recognizing vocally expressed emotions.

Figure 1 shows the proportion of correct classifications of facial expressions for different age groups. For better readability, the expression categories were split between two otherwise identical panels. Unlike other facial expressions, the probability of recognition of sadness and anger was highest in the youngest group of participants (18–20 years) and steadily decreased in older age groups (see Figure 1). Recognition of sadness and anger demonstrated a significant negative linear correlation with age, $r(598) = -.35$ and $r(597) = -.42$, respectively (both significant at $p < .0001$). In all other expression categories, including the neutral expression, recognition ability remained at approximately the same level until 60 years of age. The recognition of all other emotions, except for neutral faces, demonstrated a considerable drop in the oldest age group.

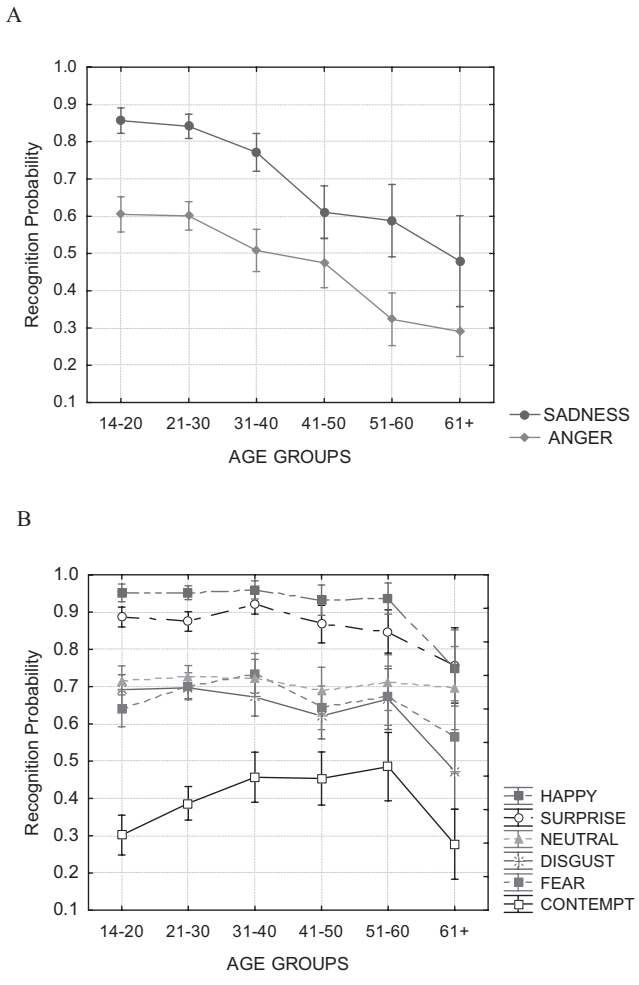

Figure 1. Mean emotion recognition of facial emotion expression by age group and stimulus emotions of sadness and anger (A), happy, surprise, neutral, disgust, fear, and contempt (B).

Figure 2 shows the probability of recognizing vocal expressions of emotion in the different age groups. Like recognition of facial sadness, the probability of correct identification of vocally expressed sadness was negatively associated with age, $r(600) = -.60$, $p < .0001$. The decrease in the probability of anger recognition across age groups was more modest but still significant, $r(590) = -.19$, $p < .0001$. Happiness also demonstrated a negative association with age in recognition performance, especially for the age groups in the second half of the adult life span, $r(594) = -.20$, $p < .0001$. The correlation between recognition of neutral expressions and age was $r(605) = -.11$, $p < .05$.

Separate analyses of variance (ANOVAs) were conducted for the facial and vocal emotion recognition tasks. The statistical design was a Stimulus Type (eight facial expressions or four vocal expressions) × Age Group (six age groups) factorial design, with stimulus type as a within-group variable and age group as a between-groups variable. Correct classification for each stimulus emotion was treated as a dependent variable. The results of the ANOVA are presented in Table 1. An overall Facial Emotion × Age ANOVA revealed an emotion recognition difference across age groups, $F(8, 599) = 29.64$, $p < .001$. For more specific comparisons, we performed a post hoc comparison of means with the Scheffé test to examine the breakpoint at which age differences in emotion recognition emerge. For sadness, significantly better performance for age groups until age 40 years ($p < .001$ for all groups) was revealed. For anger, younger groups (18–40 years) showed significantly better performance ($p < .01$ for all groups) than groups over 50 years of age. In recognizing fear, the oldest group (ages 61+) showed poorer performance than groups 21–40 years of age ($p < .05$). The recognition pattern was similar for disgust; the performance of younger age groups (18–60 years) was significantly better than the performance of the oldest 61+ group ($p < .05$ for all groups). For contempt, on the contrary, the performance of the youngest age group (18–20 years) was poorer than for the groups 31–50 years of age ($p < .05$). In terms of positive emotions, for happiness, a slight decrease emerged at age 61 ($p < .001$ for all groups). For surprise, the decrease emerged for the age group of 61+ compared with groups 18–40 years of age ($p < .01$). For the facial neutral expression, there were no differences between groups ($p > .05$ for all groups).

An overall Vocal Emotion × Age ANOVA revealed an emotion recognition difference across the age groups, $F(4, 600) = 89.58$, $p < .001$. A post hoc comparison of means with the Scheffé test revealed no significant differences between age groups in recognizing the vocal neutral expression ($p > .05$ for all groups). For happiness, the oldest age group had the lowest performance of all groups ($p < .05$). For sadness, the decrease in emotion recognition emerged at the age of 31 years ($p < .001$ for all groups). For anger, the two youngest groups performed better than the oldest group ($p < .05$ for both).

Both quadratic and linear age effects were tested. There was a significant negative quadratic age coefficient for facial disgust ($\beta = -1.08$, $p < .05$), fear ($\beta = -0.75$, $p < .001$), surprise ($\beta = -0.62$, $p < .01$), happiness ($\beta = -1.20$, $p < .001$), contempt ($\beta = -1.08$, $p < .001$), and vocal sadness ($\beta = -0.35$, $p < .05$).

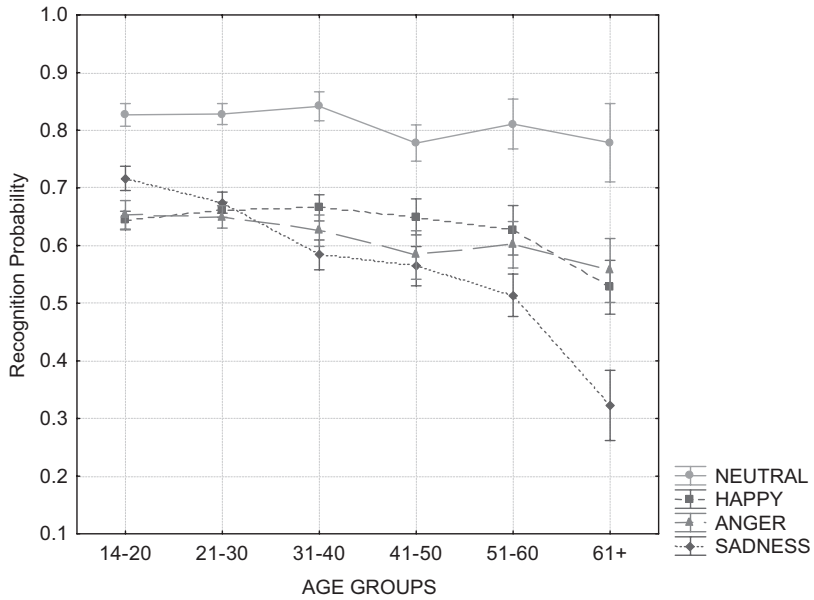

Figure 2. Mean emotion recognition of vocal emotion expression by age group and stimulus emotion.

Generally, adding a quadratic term improved only slightly the quality of approximation. Only in the case of happiness and facial contempt did the adjusted R^2 from a quadratic model account for an additional 5% of the total variance compared with R^2 of the simple linear model.

Confusion Matrices

To examine emotion-specific response biases, we performed an analysis of confusion matrices on the basis of the pattern of errors. Participants were categorized into two age groups and, following previous studies, age 40 was marked as the breakpoint between younger and older individuals (midlife and old age; Isaacowitz et al., 2007; MacPherson et al., 2002). Table 2 shows the percentage of each emotion category as a response to the particular facial expression presented. The main diagonal corresponds to correct recognition, and all other cells represent the percentage of incorrect answers by emotion category. The last column gives the percentage of each response category for all responses. Assuming unbiased responses, all eight response categories should have been selected with equal probability, that is 12.5%. Comparison of the upper matrix (younger participants) with the lower one (older participants) reveals quite a similar response pattern. The element-by-element comparison of these two matrices showed that they are highly correlated, $r(64) = .97$, $p < .0001$. Because the correlation between confusion matrices was very high (.97), it was possible to conclude that younger and older samples confused emotion categories in a similar way. Because we were interested only in the general pattern, we did not think that more sophisticated statistical tests were needed. Of course, it would be possible to search for the optimal breakpoint that could give the largest difference between younger and older samples. Nevertheless, we did not follow this approach mainly because the clearest observed trends were close to linear. This means that a breakpoint close to 40 years very likely maximizes expected differences between younger and older samples. Thus, the structure of the response pattern did not differ considerably between younger and older adults. The response biases (the last column) also had quite similar structures among age groups: Happiness and surprise were the most frequent and anger was the least frequent of response categories in both age group sets. Nevertheless, older participants were more likely than younger participants to perceive faces as expressing contempt (a difference of 2.8%) and less frequently as angry (1.9%).

Table 3 shows the response matrix from the VEM experiment. Although the older participants made more mistakes, the patterns of confusion were quite similar. The correlation across all corresponding elements was very high, $r(16) = .98$, $p < .0001$. Again, the older participants used the anger response category more frequently than younger participants (the difference was 3.6%). Although sadness was the most frequent response in both age groups, older participants used it only 1.5% more frequently than

Table 1
ANOVA Summary of Emotion Recognition Across Age Groups

Stimulus emotion	*df* effect	*df* error	*F*	*p*	η_p^2 (%)
Facial expression					
Disgust	5	603	5.98	.000	4.72
Fear	5	603	3.51	.004	2.83
Anger	5	603	16.95	.000	12.32
Sadness	5	603	25.81	.000	17.63
Surprise	5	603	4.33	.001	3.46
Happiness	5	603	11.64	.000	8.80
Contempt	5	603	5.36	.000	4.26
Neutral	5	603	0.28	.925	0.23
Vocal expression					
Neutral	5	600	2.77	.017	2.26
Happiness	5	600	9.97	.000	7.67
Sadness	5	600	67.33	.000	35.94
Anger	5	600	4.96	.000	3.97

Table 2
Response Matrices (Emotion-Specific Response Biases) for Facial Expression in Younger and Older Groups of Participants

Labeled emotion	Presented emotion								% of all answers
	Fear	Sadness	Contempt	Happiness	Disgust	Anger	Surprise	Neutral	
Younger group (<40 years), n = 448									
Fear	69.0[a]	3.3	0.3	0.3	0.2	0.7	7.0	2.9	10.5
Sadness	3.8	82.0[a]	2.3	0.7	0.6	1.5	0.4	7.1	12.3
Contempt	2.4	4.0	42.5[a]	2.7	17.8	20.7	0.9	7.2	12.3
Happiness	0.2	0.5	16.7	89.3[a]	6.1	0.2	0.9	9.9	15.5
Disgust	7.6	1.1	4.9	0.7	68.6[a]	16.7	2.7	3.3	13.2
Anger	1.5	0.9	3.6	0.5	3.2	59.0[a]	0.4	1.5	8.8
Surprise	14.9	1.6	5.1	1.1	0.8	0.6	87.3[a]	3.1	14.3
Neutral	0.6	6.5	24.7	4.6	2.7	0.7	0.4	65.1[a]	13.2
Older group (≥40 years), n = 159									
Fear	63.6[a]	3.7	1.6	0.2	1.4	1.3	7.9	0.3	10.0
Sadness	2.9	59.0[a]	3.0	0.0	0.8	2.2	0.6	12.8	10.2
Contempt	3.8	8.1	47.4[a]	0.9	24.4	31.6	0.8	3.5	15.1
Happiness	0.6	0.8	12.5	93.4[a]	0.6	0.5	1.6	8.5	14.8
Disgust	8.5	3.7	7.6	0.5	67.1[a]	20.0	2.2	1.0	13.8
Anger	3.6	4.4	3.6	0.0	2.7	39.9[a]	0.3	0.8	6.9
Surprise	16.3	5.9	9.0	2.4	2.5	2.8	85.4[a]	1.3	15.7
Neutral	0.6	14.6	15.3	2.7	0.5	1.7	1.3	71.8[a]	13.6

[a] The values in the diagonal cells represent the percentage of correct recognitions.

younger participants. A relatively high correlation, $r(606) = .37$, $p < .0001$, demonstrated that those who were proficient at recognizing sadness in faces were also good at recognizing sadness in prosody.

Taken together, the confusion matrices do not reveal any systematic preference for positive or neutral expression in older adults. The similarity of confusion matrices suggests that, with aging, perception patterns remain the same; however, more mistakes emerge.

The Role of Personality, Gender, and Education in the Recognition of Emotional Expression

Finally, we were interested in whether personality traits have an effect on emotion recognition as these have been shown to follow a clear pattern of change during aging. Because of the sample size, the alpha level was adjusted to 0.1%. In this sample, as with previous reports from Estonia (Allik et al., 2004; Costa et al., 2000), conscientiousness, $r(598) = .15$, $p < .001$, increased, whereas extraversion, $r(598) = -.19$, $p < .001$, and openness, $r(599) = -.18$, $p < .001$, decreased, with age. There was also a slight but statistically insignificant increase in agreeableness, $r(598) = .10$, $p = .011$. Typically for Estonians, the level of neuroticism remained at the same level across the whole life span, $r(599) = -.03$, $p = .502$ (cf. Allik et al., 2004). The explained variances were 0.07% for neuroticism, 3.48% for extraversion, 3.18% for openness, 1.09% for agreeableness, and 2.19% for conscientiousness.

Besides other aspects of openness, the NEO-FFI also measures receptiveness to one's own and others' feelings as well as the ability to differentiate between emotional states. Thus, it is possible that the gradual decrease in recognition ability is caused by the decline in openness. The results of a series of forward stepwise

Table 3
Response Matrices for Vocally Expressed Emotions in Younger and Older Groups of Participants

Labeled emotion	Presented emotion				% of all answers
	Sadness	Happiness	Anger	Neutral	
Younger group (<40 years), n = 448					
Sadness	83.2[a]	24.0	22.9	10.3	35.1
Happiness	1.6	65.9[a]	7.0	24.5	24.8
Anger	14.6	1.4	67.2[a]	0.5	20.9
Neutral	0.5	8.7	2.9	64.7[a]	19.2
Older group (≥40 years), n = 159					
Sadness	78.5[a]	23.4	32.7	10.4	36.3
Happiness	4.0	60.9[a]	14.1	29.7	27.2
Anger	16.1	2.6	49.1[a]	1.6	17.4
Neutral	1.4	13.2	4.2	58.3[a]	19.3

[a] The values in the diagonal cells represent the percentage of correct recognitions.

multiple regressions are given in Table 4. With the exception of the contempt and neutral facial expressions, the multiple R was only .03–.04 points higher than the single correlation between age and the probability of recognition. However, contempt and neutral facial expressions were the only ones demonstrating no correlation with age. This means that education, sex, and personality traits added very little to the recognition of facial and vocal expression.

In general, women performed better than men in the identification of emotions (in 8 cases of 12, sex was a predictor of recognition probability). Education was also a significant predictor of emotion recognition performance (in 11 cases of 12, education was a predictor of recognition probability). Of the Big Five personality traits, openness was the most pervasive predictor of emotion recognition: Participants who scored higher in the openness dimension had a tendency to recognize emotional expressions more accurately. Openness, agreeableness, and conscientiousness also played some role in the ability to identify facial or vocal expressions.

To determine whether age differences in personality traits accounted for age differences in emotion recognition, we performed a mediation analysis, using age and recognition of emotions as independent and dependent variables and personality traits as mediators. The results of a Sobel z test (Sobel, 1982) indicated that personality traits were not significant mediators of age-related effects in emotion recognition. The largest mediating effect, extraversion for the recognition of facial sadness, $z = 0.22$ $p = .83$, did not attain significance.

Discussion

The goal of this study was to investigate cross-sectional age trends in emotion recognition across both facial and vocal modalities. Consistent with our predictions, the largest age differences were found for negative emotions. Age differences in the recognition of emotion were expected to emerge at midlife; however, linear and quadratic cross-sectional age trends were found to start already in the decade of the 30s. Age differences were revealed in both vocal and facial modalities and were not mediated by personality traits.

We have identified the following seven issues of significance from the results:

1. The trajectories of recognition performance across the age groups are not similar for different emotions: The probability with which contempt is recognized increased continually until 60 years of age; neutral faces were almost equally recognizable at all ages; and the identification of sadness, expressed either facially or vocally, decreased progressively with age. Consistent with previous studies (cf. Isaacowitz et al., 2007, Table 1), the results of this study indicate that older participants were less accurate at recognizing two negative emotions: sadness and anger. The difference in accuracy was quite substantial. For example, younger participants were 23% more accurate than older participants in recognizing sadness in faces and 5.7% more in speech. At the same time, there was very little change in the detection of the absence of emotion: The recognition of neutral expressions, both facially and vocally, remained almost constant across the whole life span. Taken together, these findings suggest that the age-related decrease in the recognition of facial expressions and prosody is restricted to certain emotion categories. Although older participants were in general less accurate at recognizing emotions, the most distinctive age difference was constrained to a certain group of negative emotions. In accordance with a recent meta-analysis (Isaacowitz et al., 2007), the largest difference between younger and older participants was in the recognition of anger and sadness. Several other studies have found a similar negative association with age in the recognition of fear (Calder et al., 2003; McDowell et al., 1994; Isaacowitz et al., 2007), but not in the recognition of disgust, which, according to

Table 4
Correlations and Results of Multiple Forward Stepwise Regression Analysis Predicting the Recognition of Emotion Expressions From Age, Sex, and Personality Traits

Emotion	Linear adj. R^2	Quadratic adj. R^2	Forward stepwise multiple regression: Coefficients: Age	Sex[a]	Education	N	E	O	A	C	R	$F(df)$	p
Facial expression													
Disgust	.04	.04	−.21	.16	.10						.25	13.27 (3, 592)	.00
Fear	.01	.03	−.09		.06			.08			.13	3.06 (3, 592)	.03
Anger	.12	.12	−.33*	.14*			.07*		−.06		.38	23.88 (4, 591)	.00
Sad	.19	.19	−.44*	.06	.10*			.08*	.08*		.45	24.09 (5, 590)	.00
Surprise	.01	.03	−.16*		.16*			.04		.05	.20	6.21 (4, 591)	.00
Happy	.06	.11	−.26*	.09*	.15*	.06	−.05	.09*		.08	.30	7.92 (7, 588)	.00
Contempt	.00	.05	.05	.11*	.17*			.11*	−.06		.25	7.45 (5, 590)	.00
Neutral	.00	.00	−.07	.08	.13*	−.06				.05	.18	3.80 (5, 590)	.00
Vocal expression													
Neutral	.01	.01	−.14*		.15*			.12*			.22	9.90 (3, 589)	.00
Happy	.04	.09	−.21*	.12*	.12*			.08		.07	.27	9.12 (5, 587)	.00
Sad	.36	.36	−.60*		.07*			.08*	.08*	−.04	.61	68.07 (5, 587)	.00
Anger	.03	.03	−.21*	.09*	.06		−.04	.07			.23	6.70 (5, 587)	.00

Note. N = neuroticism; E = extraversion; O = openness to experience; A = agreeableness; C = conscientiousness; adj. = adjusted.
[a] Positive coefficients mean female superiority over males in recognition.
* Significant at $p < .05$.

some studies, can even show some improvement (Calder et al., 2003; Suzuki et al., 2007). Because the recognition of contempt, disgust, and fear in facial expressions did not show any progressive negative association with age, only a slight negative shift for the oldest age group, it is impossible to argue that there is any generalized age-related reduction applicable to all negative emotions. The ability to recognize contempt increased gradually across age groups until the seventh decade and only then began to decrease.

2. These results do not seem to support the socioemotional selectivity theory, according to which people try to maximize emotional rewards in the context of social interaction as they get older and therefore concentrate on more positive social interaction. This could also mean that older people unconsciously select positive emotional clues as more meaningful and ones that require attention and therefore understand these better. They learn to ignore negative information, making them insensitive to negative expression of emotion. It might be that sadness and anger are the most avoided emotions. However, the shift toward a positive outlook was not confirmed by the analysis of confusion matrices as there was no age-related shift toward positive or neutral emotions.

3. It was particularly surprising to find that the selective negative age effect in the recognition of sadness both facially and vocally starts at a young adult age and increases across the entire life span. The recognition of an angry voice was less dependent on the listener's age, but this may be more a reflection of the stimulus material rather than of a general superiority in the recognition of vocal anger. There is no consensus in the existing literature about the point in the adult life span at which age-related differences in emotion recognition emerge. Brosgole and Weisman (1995), for example, found that a progressive negative association between age and emotion recognition starts at age 45 and is caused primarily by problems in recognizing angry faces. Isaacowitz and colleagues (2007) found differences in emotion-recognition performance between a young group (18–39 years) and a middle-age one (40–59 years), yet fewer or no differences between middle-age and older adults (60–85 years). Because of the sufficiently large sample, we were able to show that a systematic decrease in the recognition probability of sadness and anger starts earlier than was assumed. Already 21- to 30-year-old participants were slightly less efficient in the identification of sadness and anger than younger participants, but the decline was much more pronounced in 31- to 40-year-olds. This result is similar to that of age-related decline in fluid intelligence and speed factors (Salthouse et al., 2003). In addition, more recent evidence from research on the neurotransmitter dopamine clearly demonstrates its important role in the decline of cognitive abilities due to aging where the decline in the dopaminergic system begins at the age of 20 (Bäckman et al., 2006). This pattern clearly resembles the negative age trend in recognizing sadness and anger found in the current study, meaning that there is a specific biological marker behaving in a similar way to the trends in emotion recognition found. Among other cognitive functions, dopamine transfer density has been found to be related to face recognition (Erixon-Lindroth et al., 2005).

To the best of our knowledge, however, there is no evidence that the recognition of sadness and fear requires a significantly different cognitive apparatus than, say, the recognition of fear and disgust. It might be that the recognition task itself is inherently more difficult in the case of expressions of sadness and anger. Still, identifying contempt appeared to be the most difficult task for both younger and older people, as it was the most frequently misidentified emotion. Smith and colleagues (2005) found happy, surprised, fearful, and disgusted expressions to be positively correlated with each other, as were sadness and anger. This suggests the existence of different perceptual characteristics for these emotions, which may depend on different cognitive abilities compared with other emotion expressions. Through cognitive tasks, it has been shown that fluid intelligence, perceptual speed, and memory show an early onset of age-related decline, whereas for vocabulary and verbal memory, peak performance is reached in midlife (Martin & Zimprich, 2005; Salthouse, 2004; Willis & Schaie, 1999). However, there were no time constraints in the emotion recognition test. Furthermore, age remained the principal influencing factor after controlling for education, which reflects cognitive abilities (Kaufman, Kaufman, Liu, & Johnson, 2009). Therefore, age differences in emotion recognition cannot be considered to be a reflection of decline in cognitive abilities.

4. The age-related decrease in the ability to identify emotions was not modality-specific, limited to neither vocal nor facial expressions alone. Like the recognition of facial sadness, the ability to identify sadness in the voice started to show a negative association with the early adulthood age group and continued to decrease across the adult life span. Previous reports on age-related ability to decode emotions from verbal material are not consistent. For example, some studies have found specific age-related deficits in identifying emotions from faces, but no age effects in the understanding of emotions from verbal descriptions (L. H. Phillips et al., 2002). To the contrary, Isaacowitz and colleagues (2007) found that lexical tasks showed stronger age differences than facial tasks. There is an important difference between the current study and many previous ones. Unlike earlier research, we did not use lexical or semantic tasks. The content of the verbal material was neutral and identical across all emotion categories. All potential emotion cues were contained in the speech prosody alone. The similarity of results seems to suggest that the extraction of emotion information from speech prosody is indeed similar to the extraction of emotion information from facial expressions.

5. The cognitive mechanisms involved in the extraction of emotion information from faces and speech were very similar in both groups of participants. An examination of the pattern of confusions revealed that despite some differences in average recognition performance, these differences were not significant. For example, both younger and older participants mistook facial contempt for happiness in 16.7% and 12.5% of cases, respectively. The reverse error, however, was committed very seldom, only on 2.7% and 0.9% of occasions, respectively. Because the patterns of confusions were quite similar in younger and older participants, it can be claimed that the process of extracting information from faces and prosody is basically identical in both cases. Of course, this is not a foregone conclusion: One can readily imagine that older people process faces and prosody differently, extracting different information from that which younger participants rely on in making their judgments. One possibility is that age-related decrease in the recognition of emotions is caused by changes in cognitive functions that are vulnerable to decline in aging. For example, older participants may have a different eye movement strategy (fewer fixations and looking mainly at the lower halves of faces) that is less optimal in terms of extraction of information

related to facial expression (Wong, Cronin-Golomb, & Neargarder, 2005). Still, it is quite doubtful as to whether the observed age differences in recognition performance can be explained by any general, all-purpose cognitive mechanism—not only because this mechanism would need to operate identically in visual and acoustic domains, but also, and principally, because the age differences in recognition performance were restricted to only a few emotion categories (i.e., sadness and anger). In contrast, the ability to determine the absence of emotional information, both in face and prosody, remained intact throughout the entire life span. This stability is not caused by the response bias because the probability that younger and older participants used the neutral response category was almost exactly the same. It is even more complicated to find a cognitive mechanism that would explain the deterioration of the recognition of sadness while the recognition of contempt improves even until relatively old age. In principle, the selective negative age association of sadness and anger recognition can be interpreted in terms of neural decline. However, it would be necessary to demonstrate that, first, there are distinct brain structures specialized in processing sadness and perhaps anger and, second, that these structures are vulnerable to deterioration from a relatively early age. Indeed, there is evidence for specific impairment of negative emotions with intact processing of positive ones. For example, it seems that bilateral damage of the amygdala leads to a specific impairment in assessing sad faces, yet an almost intact ability to assess happy faces (Adolphs & Tranel, 2004). However, it is more likely that patients with amygdala damage have impaired processing of many negative emotions, including fear and anger (Graham, Devinsky, & LaBar, 2007; Sato et al., 2002). Thus, although the results of the present study do not contradict the neuronal decline explanation, there is no convincing evidence that sadness and anger are processed by a neuronal mechanism separate from other negative emotions.

6. In accordance with popular belief, women were generally more accurate than men in the recognition of facial and vocal expressions. This superior performance cannot be explained by the fact that women are more conscientious and open to feelings than men. The effect of sex remained, even after age and personality differences were taken into account. Evolutionary psychologists are eager to explain the observed female superiority in the perception of emotion through selectional pressure over the course of human history. The two versions of the child-rearing hypothesis predict either across-the-board female superiority in the discrimination of emotional expressions (the "attachment promotion" hypothesis) or a female superiority that is restricted to expressions of negative emotion ("fitness threat" hypothesis; Hampson, van Anders, & Mullin, 2006). Although sex differences were accentuated for negative emotions, women were generally better than men in emotion recognition. In spite of the fact that this pattern of results seems to support the attachment promotion hypothesis, we are very reluctant to commit to any hypotheses that do not have sufficiently high standards of both verification and falsification.

7. Finally, in addition to age, education, and sex, personality traits have their own independent contribution to emotion recognition. Individuals who are conservative and closed to new experiences tend not to be very good at extracting emotion information from either faces or prosody, irrespective of their age. Yet, age-related changes in the recognition of emotion expression are not mediated by personality traits. Although individuals become more closed, agreeable, and conscientious with age, these changes seem to have little effect on the recognition of emotions.

Limitations and Conclusions

The present study has several serious limitations. Like most of the previous studies, we used convenience samples, not a random selection from the general population. It is possible that an age-related selection bias in some way favored older participants who experienced greater than average difficulty in the identification of facial and vocal expressions. Furthermore, different age groups were not equally represented. Older adults were significantly underrepresented compared with younger participants. Atypically for these types of studies, the large number of participants may counterbalance, to some extent, this shortcoming. Another shortcoming was the use of VEM. Unlike the posed facial expressions (Matsumoto & Ekman, 1988), which have international standards for this type of research, the feigned vocal expressions were less thoroughly calibrated. Although all psychoacoustical parameters for all speech stimuli were established, we still know rather little about the relevance of these parameters. For instance, it is possible that the relative age-related stability in the recognition of anger can be attributed to somewhat unrealistic psychoacoustical features.

In spite of these limitations, this study advances our knowledge about age differences in the ability to recognize emotions. Whereas most emotions demonstrated fairly sound age-related stability, the ability to recognize sadness and anger decreased gradually with age. This decrease started at an unprecedentedly early age, that is, in the fourth decade, and gradually progressed with increasing of age. This specific and progressive loss of recognition ability was not limited to one modality as the incorrect identification of sadness advanced with age identically in visual and acoustical domains alike. For the first time, the association among emotion recognition, personality dimensions, and age was studied, demonstrating that changes in the recognition of emotion expression were not mediated by personality traits.

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