Recognition of Facial, Auditory, and Bodily Emotions in Older Adults

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Understanding older adults' social functioning difficulties requires insight into their recognition of emotion processing in voices and bodies, not just faces, the focus of most prior research. We examined 60 young and 61 older adults' recognition of basic emotions in facial, vocal, and bodily expressions, and when matching faces and bodies to voices, using 120 emotion items. Older adults were worse than young adults in 17 of 30 comparisons, with consistent difficulties in recognizing both positive (happy) and negative (angry and sad) vocal and bodily expressions. Nearly three quarters of older adults functioned at a level similar to the lowest one fourth of young adults, suggesting that age-related changes are common. In addition, we found that older adults' difficulty in matching emotions was not explained by difficulty on the component sources (i.e., faces or voices on their own), suggesting an additional problem of integration.

Key Words: Bodily expressions—Emotion recognition—Facial expressions—Older adults—Vocal expressions.

OLDER adults find certain facial expressions more difficult to identify than younger adults. A recent meta-analysis of 17 studies indicated that older adults (60+ years) are consistently worse than young adults at identifying facial expressions of anger, sadness, fear, and, to a lesser extent, happiness and surprise (Ruffman, Henry, Livingstone, & Phillips, 2008). Difficulties with emotion recognition are associated with specific types of social impairment, including reduced social competence and interest, poor interpersonal functioning and communication, reduced quality of life, and inappropriate social behavior (e.g., Spell & Frank, 2000).

However, facial expressions are only one source of emotional information. In real social situations, other sources—namely, from the communicator's voice and body—may be available, with or without facial cues. For instance, it is sometimes necessary to evaluate a voice on its own in the dark or a body on its own when the face is obscured. Furthermore, even when facial expression information is available, it may or may not be consistent with vocal and bodily affect, and detecting such incongruities may be a critical part of determining the genuineness of an expression or of an individual's intentions. Therefore, recognition of emotion in voices and bodies is key to understanding how social functioning changes over the life span.

In addition, young–old differences in recognizing emotions in voices and bodies can provide insight into the reasons for older adults' difficulties in recognizing facial expressions. It is possible, for example, that difficulty in determining emotion in a face stems from visual perceptual difficulties, such as an inability to discern fine movements in facial muscles or to determine the spatial relations among facial features. Importantly, such difficulties are irrelevant for discerning emotion in bodily displays, where emotion is conveyed through gross movements. Alternatively, worse recognition of angry, sad, and fearful facial expressions by older adults could stem from attentional differences, such as a tendency to look more at mouths than eyes (Sullivan, Ruffman, & Hutton, 2007; Wong, Cronin-Golomb, & Neargarder, 2005), but similar difficulties on auditory and bodily expressions would demonstrate that young–old differences are not likely due solely to facial scanning strategies.

In addition, Williams et al. (2006) have argued for a positivity bias, such that older adults are motivated to attend more to positive than to negative social information (Carstensen, Mikels, & Mather, 2006), resulting in selective sparing of the perception of positive emotions. However, studies on facial expressions are difficult to interpret because of a ceiling effect on happy expressions (in Ruffman et al.'s [2008] meta-analysis, young adults were correct 98% of the time). Whereas happy facial expressions are very easy to identify, happy auditory and bodily expressions have the potential to be more difficult, and as such, might help resolve claims regarding a positivity bias in emotion recognition.

Thus, the first aim of the present study was to provide more information about young–old differences in recognition of auditory and bodily emotional expressions, and in so doing shed light on the mechanisms of emotional impairment generally. Ruffman et al.'s (2008) meta-analysis did identify several data sets relevant to these questions that suggested that older adults are worse at recognizing angry, sad, and happy vocal expressions and angry, sad, and fearful bodily expressions, and at matching vocal expressions to facial expressions on all emotions. However, the evidence is quite limited; there are only four published studies examining auditory expressions (Brosgole & Weisman, 1995; Isaacowitz et al., 2007; Ryan, Murray, & Ruffman, in press; Wong

et al., 2005), and one of these studies used descriptions of situations rather than changes in prosody. Furthermore, none of the studies examining bodily expressions had been published; there are only two published studies examining matching of faces to voices (Ryan et al., in press; Sullivan & Ruffman, 2004a), and no studies have examined matching of bodies to voices.

The second aim of the current study was to understand why older adults have difficulty in matching vocal expressions of emotions to their corresponding facial (or bodily) expressions. Ruffman et al.'s (2008) meta-analysis reported difficulties in matching faces to voices on all emotions, and the effect sizes were much larger (*M* across all emotions = 0.36) compared with those for identifying faces or voices on their own (both *M*s = 0.17). A simple explanation, the *component* view, is that difficulties with either component (faces or voices on their own) create difficulty when matching faces to voices. However, no study has been able to test this hypothesis because no study has included both recognition and matching tasks employing the same stimuli. Furthermore, a difficulty with this simple explanation is that in the case of disgust, older adults tended to be better than young adults in one source, yet were substantially worse on the matching task.

Another possibility is that older adults suffer from additional difficulties in integrating input from two emotion sources (the *integration* view), independent of their accuracy in any single source, possibly due to brain volume reductions in areas that integrate visual and auditory emotion. Research indicates that processing of auditory and visual emotional expressions results in additional activation in a number of brain areas compared with either expression on its own. The brain areas involved in integration include frontal areas (Pourtois, de Gelder, Bol, & Crommelinck, 2005) and the temporal lobe, including the superior temporal sulcus (Ethofer, Anders, et al., 2006; Kreifelts, Ethofer, Grodd, Erb, & Wildgruber, 2007), the superior and middle temporal gyri (Pourtois et al.), the amygdala (Ethofer, Anders, et al., 2006; Ethofer, Pourtois, & Wildgruber, 2006), and the fusiform gyrus (Ethofer, Anders, et al., 2006; Pourtois et al.).

An age-related increase in activation in frontal areas on a range of tasks (including nonemotional tasks) has been related to older adults' greater difficulty in suspending non-task-related "default mode" neural activity (Grady, 2002; Grady, Springer, Hongwanishkul, McIntosh, & Winocur, 2006). Nevertheless, Kreifelts et al. (2007) found that activation in temporal integration areas is positively correlated with better emotion recognition in young adults. Little is known about whether there are young–old differences in activation when presented with emotion stimuli in the majority of the integration areas, with the exception that older adults have less amygdala activation (Fischer et al., 2005; Gunning-Dixon et al., 2003; Iidaka et al., 2001; Mather et al., 2004; Tessitore et al., 2005), an area implicated previously in integration of visual and auditory emotions stimuli. It may be that older adults have a reduced capacity for experiencing the increase in activation essential for correct performance in face–voice matching tasks and that body–voice integration is similar in this regard.

In the present study, our matching tasks required integration of two emotion sources (determining which facial expression goes with an auditory expression or which bodily expression goes with an auditory expression), allowing us to examine the relation between performance on three single source tasks (recognition of facial, auditory, and bodily expressions) and performance on two matching tasks. Again, we hypothesized that matching would create an additional difficulty over and above the difficulty experienced on component tasks because the additional activation needed for correct matching might be reduced in older adults relative to young adults.

In sum, the current study comprehensively compares, for the first time, young and older adults' recognition of emotion (anger, sadness, fear, disgust, surprise, and happiness) expressed in faces, voices, and bodies, along with the same participants' ability to match the emotions across different modes of expression. In all, there were 120 emotion items, with an equal number of stimuli in each task for each emotion—to our knowledge, the most comprehensive battery ever used to examine young–old differences in emotion recognition.

PILOT STUDY

Emotion items used in most previous research (including the widely used faces developed by Ekman & Friesen, 1976, and Matsumoto & Ekman, 1988) have been created or normed based on ratings of young and middle-aged adults. In the present study, stimuli were developed in a pretest in which young and older adults were equally represented. The pretest was also designed to reduce ceiling and floor effects that previous researchers (e.g., Isaacowitz et al., 2007; Ruffman et al., 2008) have argued could obscure differences in emotion recognition because the items are either too easy or too difficult and not representative of their category.

Consequently, for each stimulus in each basic emotion category (angry, sad, fearful, disgusted, surprised, and happy) in each source (faces, voices, and bodies), we calculated the proportion of the participants (collapsed over age) who identified that stimulus as expressing its intended emotion. We then selected for use in the main study only items with intermediate proportion scores, excluding the highest and lowest scoring items within each emotion category. To choose the 24 faces used in the main experiment, we initially administered 10 faces in each basic emotion category, then removed the three items, averaged across participants, that were at or closest to ceiling, and the three items that were at or closest to floor. Similarly, we selected the two middle-scoring items of the four vocal expressions, and the four middle-scoring items of the six bodily expressions, in each case eliminating one higher and one lower item.

Methods

Participants.—The participants were 20 young adults (7 men and 13 women) ranging from 18 to 24 years (*M* = 20.6 years) and 20 healthy older adults (6 men and 14 women) ranging from 64 to 84 years (*M* = 72.3 years). The older adults were recruited through a university participant database and had volunteered through newspaper advertisements. The young adults were psychology undergraduate students who satisfied a small portion of a course requirement by completing a worksheet based on the experiment. All participants spoke English as their first language, and none of the older adults had previously suffered from a stroke or cognitive impairment. All participants' eyesight was assessed using Snellen's 3-m visual acuity chart, and all had uncorrected or corrected vision falling within the normal range (i.e., 20/20 to 20/30).

Materials.—Faces used in the pilot study were 60 black and white images of five men and five women expressing each of six basic emotions, drawn from the "Facial Expressions of Emotion: Stimuli and Test" stimulus set (Young, Perrett, Calder, Sprengelmeyer, & Ekman, 2002).

The auditory expressions included 24 stimuli, 4 representing each basic emotion, drawn from four different stimulus sets. The first two sets consisted of a male and a female actor's nonverbal, emotionally expressive sounds—a happy humming sound, sad sighs and groans, gasps and high-pitched tones of fear, angry snorts and "grr" sounds, light and high-pitched gasps of surprise, and "ughh" sounds of disgust. The male sounds were taken from Sullivan and Ruffman (2004a), and the female sounds were created for this experiment. The third set, taken from Sullivan and Ruffman, featured an actress who read the same passage conveying each of the six basic emotions in her tone of voice. The passage was, "I was walking down the road yesterday, when I saw a large red car in front of me. It stopped and a small man in a blue coat got out." The fourth set, new to this experiment, involved a woman who mumbled incoherently, conveying each of the basic emotions through her tone of voice. Stimuli were played over headphones and all participants adjusted the volume until they were sure they could hear. Prior research shows that older adults' difficulties on auditory expressions of emotion are not reducible to general hearing difficulties in this type of paradigm (Mitchell, 2007; Orbelo, Grim, Talbott, & Ross, 2005).

The bodily expressions included 36 color pictures, 6 images representing each of the six basic emotions, via different bodily poses (i.e., anger was depicted by a man leaning forward, pointing his finger; sadness by a woman peering out of a window; fear by a seated man recoiling with his hands in front of his face/body; disgust by a woman recoiling from a man who is trying to kiss her; surprise by a man with one hand on the side of his head; and happiness by a girl jumping in the air while holding someone's hand). In all photos, faces were either not visible or were digitally "smudged." We obtained these photos from various Internet sources and presented them on a computer monitor at a size of 12 × 14 cm.

Procedure.—Face, voice, and body stimuli were presented individually on the computer in three separate, counterbalanced blocks, with individual items randomized. On each trial, we asked participants to identify the emotion by pressing a key beneath one of six emotion labels situated at the top of the keyboard.

Results and Discussion

The mean proportion scores for selected and excluded items appear in Table 1. Among selected items, the best performance over young and older adults was recorded for happy faces (*M* = 0.99) and the worst for surprised bodies (*M* = 0.65). Generally, the data are comparable to previous findings, of which the most well established are for faces. For example, in Ruffman et al.'s (2008) meta-analysis, the percentages of young adults correctly identifying faces for angry, sadness, fear, disgust, surprise, and happiness were 86%, 89%, 79%, 81%, 87%, and 98%, respectively. For items in the "selected" column of Table 1, we compared the level of agreement that an item represented a particular emotion with chance (1/6 = .17). All selected items were above chance, *p* < .01.

Main Study

In the main study, we gave the face, voice, and body stimuli selected from the pilot study to an independent group of

Table 1. Pilot Study: Mean Proportion of Correct Responses for Selected, Rejected Low, and Rejected High Items

	Selected items		Rejected high		Rejected low	
	Young	Old	Young	Old	Young	Old
Faces	*n* = 4	*n* = 4	*n* = 3	*n* = 3	*n* = 3	*n* = 3
Anger	.88	.75	.93	.97	.65	.67
Sadness	.96	.88	1.00	.97	.73	.58
Fear	.75	.61	.82	.75	.48	.42
Disgust	.80	.90	.92	1.00	.67	.72
Surprise	.90	.95	1.00	1.00	.77	.90
Happiness	1.00	.98	1.00	1.00	1.00	.93
Voices	*n* = 2	*n* = 2	*n* = 1	*n* = 1	*n* = 1	*n* = 1
Anger	.90	.73	.95	.90	.80	.35
Sadness	.80	.73	.95	.95	.65	.65
Fear	.68	.83	.95	.90	.55	.65
Disgust	.75	.83	1.00	1.00	.55	.55
Surprise	.75	.83	.90	1.00	.45	.60
Happiness	.88	.75	1.00	1.00	.70	.45
Bodies	*n* = 4	*n* = 4	*n* = 1	*n* = 1	*n* = 1	*n* = 1
Anger	.98	.89	1.00	1.00	.85	.55
Sadness	.93	.90	1.00	1.00	.80	.75
Fear	.80	.86	.95	1.00	.20	.50
Disgust	.66	.70	.85	.95	.30	.25
Surprise	.65	.65	.90	.75	.10	.35
Happiness	.96	.89	1.00	.95	.95	.75

Figure 1. Young and older adults' performance on the faces task. *Note.* Asterisk indicates significant young–old difference.
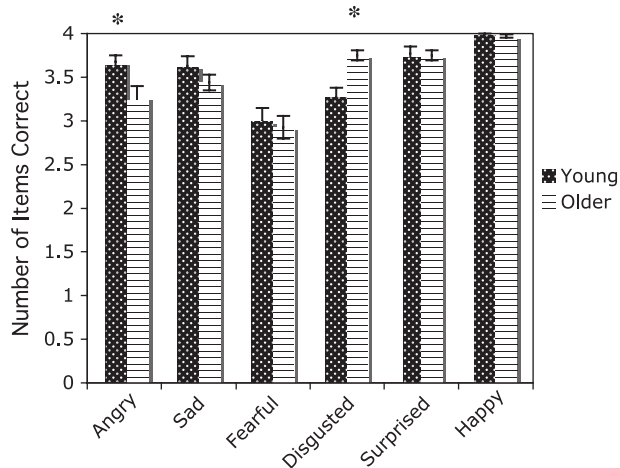

Figure 2. Young and older adults' performance on the voices task. *Note.* Asterisk indicates significant young–old difference.

young and older adults. In addition, we used the face, voice, and body stimuli to create two matching tests: matching faces to voices and matching bodies to voices.

Methods

Participants.—The participants were 60 young adults (26 men and 34 women) ranging from 18 to 35 years ($M = 20.5$ years) and 61 healthy older adults (25 men and 36 women) ranging from 60 to 85 years ($M = 70.5$ years). The older adults were recruited through the same university participant database as those from the pilot study, but none had taken part in that study. The young adults were psychology undergraduate students who satisfied a small portion of a course requirement by completing a worksheet based on the experiment. All participants spoke English as their first language, and none of the older adults had previously suffered from a stroke or cognitive impairment. All participants' eyesight was assessed using Snellen's 3-m visual acuity chart, and all had corrected or uncorrected vision falling within the normal range (i.e., 20/20 to 20/30).

Materials.—The three emotion identification tasks used the 24 emotional faces, 12 emotional vocal expressions, and 24 emotional bodies selected in the pilot study (with the voices presented twice to make 24 items). The face–voice matching task used the 24 faces from the facial expression task, plus the 12 sounds (presented twice) from the vocal expression task. For each of the 24 items of the face–voice matching task, participants observed six faces (one for each of the six basic emotion categories) on a computer monitor and listened to one emotion sound. Participants listened to the sound for 10 s and chose the matching emotion face. Each face served as the correct answer once and as a distracter five times across the 24 trials. The order of correct
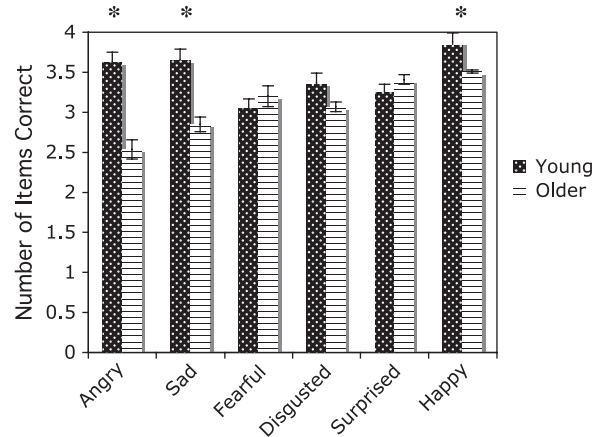
items (e.g., angry, sad) was randomized, as was the order of incorrect distracter faces, with the proviso that every trial included one correct face (e.g., angry) and five incorrect faces (i.e., sad, fearful, disgusted, surprised, and happy). The body–voice matching task was created similarly using the 24 bodies from the body task and the 12 sounds (presented twice) from the voice task. As in the pilot study, items for each of the five tasks were presented in separate, counterbalanced blocks on a computer, with items randomized for each participant.

Previous research has demonstrated some independence between declines in fluid intelligence (which typically declines in old age; Salthouse, 2000) and emotion recognition (Keightley, Winocur, Burianova, Hongwanishkul, & Grady, 2006; Ryan et al., in press; Sullivan & Ruffman, 2004a, 2004b). Participants were given a test of fluid and crystallized intelligence to examine relations with emotion recognition. Two subtests of the Culture Fair Intelligence Test (Series Completion and Odd One Out; Cattell & Cattell, 1959) were used to measure fluid intelligence. The Peabody Picture Vocabulary Test was used to measure crystallized intelligence.

Results

Performance on individual emotion recognition tasks.—Performance on each emotion in each task is shown in Figures 1–5. For each task, performance was examined with a 2 (age group) × 6 (emotion) mixed-model analysis of variance, with the second factor treated as a repeated measure. In analyses where the assumption of sphericity was violated, Huynh-Feldt corrected *p* values and *MSE*s are reported. For each task, our a priori interest was in whether there were age differences on specific emotions. Accordingly, *t* tests were used to compare young and old on each of the six emotions, employing Holm's correction to ensure that the family-wise
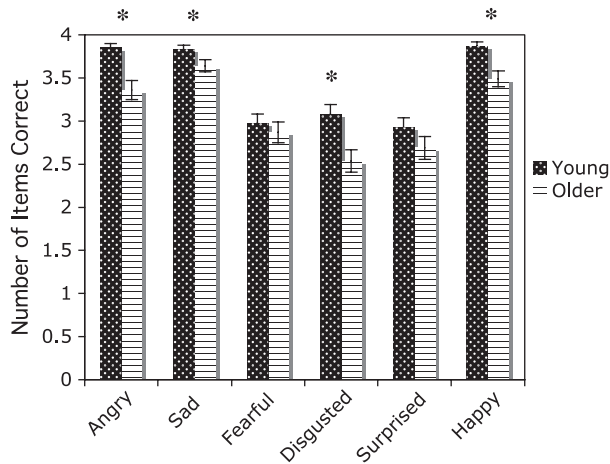
Figure 3. Young and older adults' performance on the bodies task. *Note.* Asterisk indicates significant young–old difference.
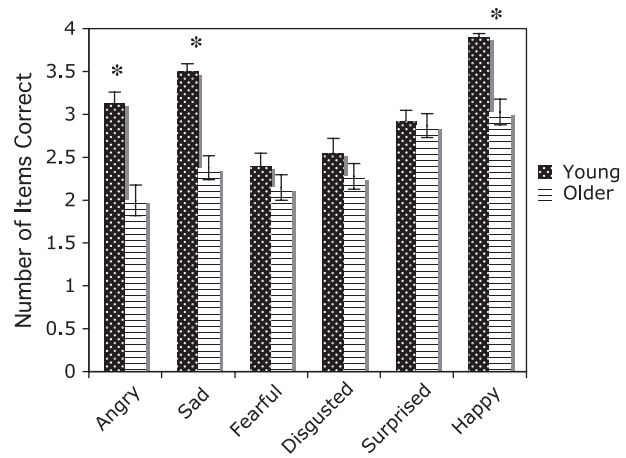

Figure 4. Young and older adults' performance on the face–voice task. *Note.* Asterisk indicates significant young–old difference.

error rate was kept to $p < .05$. Where Levene's test indicated significantly different variances, we applied a correction factor for unequal variance. Asterisks in each figure indicate emotions on which young and old significantly differed.

On the face task (see Figure 1), there was a main effect for emotion, $F(5, 595) = 28.07$, $p < .001$, $MSE = 19.31$, $\eta_p^2 = .19$, and an interaction between emotion and age group, $F(5, 595) = 5.36$, $p < .001$, $MSE = 3.69$, $\eta_p^2 = .04$. The main effect for age group was not significant, $F(1, 119) = 0.29$, $p = .59$, $MSE = 0.21$, $\eta_p^2 = 0$. Older adults attained a lower score when recognizing anger, $t(119) = 2.93$, $p < .01$, and a higher score when recognizing disgust, $t(119) = -4.00$, $p < .001$, with no difference on the other four emotions.

On the voice task (see Figure 2), there was an effect for emotion, $F(5, 595) = 9.98$, $p < .001$, $MSE = 5.85$, $\eta_p^2 = .08$, an effect for age group, $F(1, 119) = 19.28$, $p < .001$, $MSE = 25.74$, $\eta_p^2 = .14$, and an interaction between emotion and age group, $F(5, 595) = 12.96$, $p < .001$, $MSE = 7.60$, $\eta_p^2 = .10$. Older adults attained a lower score on anger, $t(119) = 7.49$, $p < .001$, sadness, $t(119) = 4.87$, $p < .001$, and happiness, $t(119) = 3.10$, $p < .001$, with no difference on the other three emotions.

On the body task (see Figure 3), there was an effect for emotion, $F(5, 595) = 48.54$, $p < .001$, $MSE = 29.12$, $\eta_p^2 = .29$, and an effect for age group, $F(1, 119) = 17.51$, $p < .001$, $MSE = 19.36$, $\eta_p^2 = .13$. The interaction between emotion and age group was not significant, $F(5, 595) = 1.70$, $p = .15$, $MSE = 1.02$, $\eta_p^2 = .01$. Older adults attained a lower score on anger, $t(119) = 3.89$, $p < .001$, sadness, $t(119) = 2.19$, $p = .03$, happiness, $t(119) = 3.56$, $p < .001$, and disgust, $t(119) = 3.17$, $p < .001$, with no difference on fear or surprise.

On the face–voice matching task (see Figure 4), there was an effect for emotion, $F(5, 595) = 26.43$, $p < .001$, $MSE = 23.87$, $\eta_p^2 = .18$, an effect for age group, $F(1, 119) = 24.88$, $p < .001$, $MSE = 68.83$, $\eta_p^2 = .17$, and an interaction between emotion and age group, $F(5, 595) = 8.15$, $p < .001$, $MSE =$

7.36, $\eta_p^2 = .06$. Older adults attained a lower score on anger, $t(119) = 5.01$, $p < .001$, sadness, $t(119) = 6.71$, $p < .001$, and happiness, $t(119) = 5.74$, $p < .001$, with no difference on the other three emotions.

On the body–voice task (see Figure 5), there was an effect for emotion, $F(5, 595) = 71.99$, $p < .001$, $MSE = 60.85$, $\eta_p^2 = .38$, an effect for age group, $F(1, 119) = 45.06$, $p < .001$, $MSE = 150.34$, $\eta_p^2 = .28$, and an interaction between emotion and age group, $F(5, 595) = 4.95$, $p < .001$, $MSE = 4.19$, $\eta_p^2 = .04$. Older adults attained a lower score on all emotions: anger, $t(119) = 6.67$, $p < .001$, sadness, $t(119) = 6.71$, $p < .001$, fear, $t(119) = 2.24$, $p < .03$, disgust, $t(119) = 4.84$, $p < .001$, surprise, $t(119) = 2.45$, $p < .02$, and happiness, $t(119) = 4.36$, $p < .001$. The interaction appears to stem from particularly low scores on anger, sadness, disgust, and happiness.

Interestingly, although our item selection process in the pilot study did not create a bias to favor young or old, age differences on particular emotions of particular tasks in the
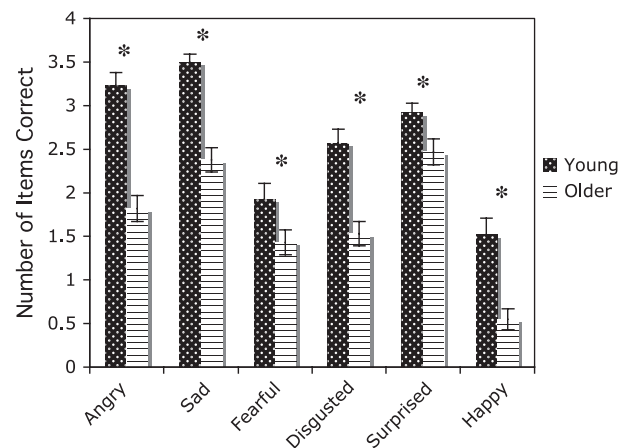

Figure 5. Young and older adults' performance on the body–voice task. *Note.* Asterisk indicates significant young–old difference.

main study were paralleled by differences in the pilot test. To examine this correspondence, we computed difference scores for each emotion on each task for the items chosen in the pilot test and for the main test ([young score − old score]/ number of items chosen). Consistency would be indicated if the difference between young and old was roughly the same for the 18 pilot and 18 main study difference scores. The correlation between these difference scores was significant, $r = .60$, $p < .01$, one-tailed. We then computed a similar difference score for the pilot items *not* chosen (i.e., the high and low items). Although these items were not given in the main study, the difference scores for non-chosen pilot items correlated significantly with those for the chosen main study items, $r = .43$, $p < .05$, one-tailed. Thus, although our selection process did not introduce bias into the selection process, it seems that similar young–old differences will exist regardless of the items used.

Role of individual emotion sources in matching performance.—A second goal of the current study was to examine whether older adults had difficulty on matching tasks independently of their ability to identify the emotions in the components of the task. To test this idea, we first carried out six analyses of covariance for the body–voice task, one for each emotion. For instance, in one analysis the dependent variable was performance on anger in the body–voice task, age group was the lone factor, and the covariates were performance on anger in the body task and anger in the voice task. For all six emotions in the body–voice task, older adults attained a lower score than young adults after accounting for performance on the component tasks, Fs range = 4.87–23.69, ps range <.03 to <.001. We then carried out analogous analyses for the face–voice task. In this case, older adults attained a lower score than young adults on anger, sadness, and happiness (Fs range = 9.41–24.99, ps range <.01 to <.001) but not on fear, disgust, or surprise (Fs range = 0.27–2.62, ps range >.10 to >.60).

Relation to general cognitive ability.—Consistent with typical cognitive aging data, older adults scored higher than young adults on the vocabulary test, $t(119) = −6.06$, $p < .001$, whereas young adults scored higher on the fluid test, $t(119) = 9.29$, $p < .001$. Older adults' performance on all emotion recognition items correlated with both vocabulary test performance, $r = .48$, $p < .001$, and fluid task performance, $r = .41$, $p = .001$. To examine whether age group differences were independent of vocabulary and fluid ability, we carried out a one-way analysis of covariance with age group as the independent variable, total emotion score as the dependent variable, and vocabulary and fluid ability as the covariates. The effect for age group was still significant, $F(1, 117) = 12.68$, $p = .001$.

Declines within the older group.—As a secondary analysis, we were able to explore age effects *within* the older age group, an analysis precluded in most previous work due to prohibitively small samples. Indeed, within the older age group, age correlated significantly with overall emotion performance, $r = −.26$, $p < .05$, such that the oldest older adults attained a lower score than younger older adults. However, this lower score can be explained by general cognitive declines. When fluid ability was accounted for, the partial correlation between age and total emotion score in the older age group was no longer significant, $r = −.16$, $p = .21$.

Overall performance and distributions.—Young adults' mean score across all 120 emotion items was 96.78 ($SD = 10.73$), and older adults' mean score was 83.05 ($SD = 13.13$), a difference of 13.73%. In order to appreciate the magnitude of this effect, we examined how many older adults' recognition scores fell into each quartile of young adults' recognition scores. Due to our relatively large sample and range of emotion tasks, this analysis also provides unique insight into whether emotion recognition decline is inevitable in old age. A Mann–Whitney test confirmed that significantly more older adults were in the lowest quartile and fewer in the upper quartiles, $Z = −5.31$, $p < .001$. Furthermore, the percentages of young and old in the quartiles, and in particular the lowest scoring quartile, were strikingly different. These percentages were as follows—lowest quartile: 23% of young, 71% of old; second quartile: 25% of young, 15% of old; third quartile: 25% of young, 10% of old; and highest quartile: 27% of young, 5% of old.

General Discussion

The current study fills an important empirical gap because although a number of studies have examined age-related recognition of facial expressions of emotion, very few have examined vocal expressions and the links between faces and voices, and there are no published studies examining older adults' recognition of bodily expressions or their ability to match bodies to voices. Young–old differences across faces, voices, and bodies are of interest because it is often necessary to detect emotions in voices and bodies on their own and because patterns of difficulties across these tasks can provide unique insight into their cause. With so few studies examining young–old differences in recognition of auditory expressions and bodily expressions and when matching faces to voices or bodies to voices, it is difficult to determine whether older adults obtain consistently lower scores across different modalities of expression, and whether they do so with similar expressions across different modalities. Nevertheless, these issues are important for the reasons given at the outset.

As in previous research on facial expressions (Ruffman et al., 2008), young adults scored higher than older adults when detecting anger, but lower when detecting disgust. That older adults did not obtain lower scores when recognizing sad or fearful facial expressions is not surprising,

given that this effect has not been obtained in every study (see Isaacowitz et al., 2007, for a summary). Older adults' lower scores when recognizing vocal expressions of anger, sadness, and happiness (but not other emotions) in the present study are consistent with young–old differences in the five studies included in Ruffman et al.'s (2008) meta-analysis. Regarding bodily expressions, older adults obtained lower scores than young adults on four of the six emotions tested, namely anger, sadness, happiness, and disgust. Older adults' consistently lower scores on bodily expressions, and on anger and sadness across faces, bodies, and voices, suggest that lower scores on facial expressions are not due solely to an inability to discern the fine movements in facial muscles or to a tendency to look at the mouth instead of the eyes.

When matching faces to voices, individual studies have obtained significant young–old differences on a subset of the basic emotions, although in Ruffman et al.'s (2008) meta-analysis, data pooling resulted in significant differences on all emotions. The present study was similar to previous individual studies (Ryan et al., in press; Sullivan & Ruffman, 2004a) in indicating that age differences are obtained on a subset of emotions—namely anger and sadness. In addition, consistent with Ryan et al. (in press), we obtained age differences on happiness. No studies have previously examined older adults' matching of bodies to voices; in our examination, this was the most difficult task for older adults, with age differences on all emotions.

The current study, unique in its scope of tasks and stimuli, provides a picture of relatively generalized emotion recognition differences between young and older adults. Age differences were obtained on 17 of 30 comparisons, with 71% of older adults and only 23% of young adults scoring in the lowest young adult quartile. These findings suggest that age differences cannot be reduced to a cause such as a failure to attend to eyes. Furthermore, older adults' lower scores when recognizing happy auditory and bodily expressions are inconsistent with the notion of a positivity bias in emotion recognition (Williams et al., 2006), although one limitation is that relatively few auditory expressions were used. Our data indicate that older adults sometimes but not always obtain lower scores than young adults when recognizing negative expressions, but equally, they sometimes obtain higher scores when recognizing positive expressions.

What, then, causes the pattern of young–old differences? The explanation most often given is neurological change. The orbitofrontal cortex, anterior cingulate cortex, and amygdala are involved in recognizing facial expressions of anger, and the cingulate cortex, amygdala, and fusiform cortex are involved in sadness recognition (for a summary, see Ruffman et al., 2008). The orbitofrontal cortex has also been implicated in processing auditory expressions of anger and sadness and, along with the amygdala, the cingulate cortex, and the fusiform cortex, in processing bodily expressions. Thus, there are brain regions that are common to

anger and sadness recognition across faces, voices, and bodies, and consistent declines in the volume of such areas with age (Ruffman et al., 2008) help explain the consistent declines in anger and sadness recognition across faces, voices, and bodies. Nevertheless, we note that rather than *decline*, older adults' pervasive tendency to label some items differently than young adults (e.g., in our pilot test) means that we cannot rule out the possibility that young and old are simply different rather than older adults being worse.

The second aim of our study was to examine why a face–voice matching task or a body–voice matching task might be more difficult than a task tapping recognition of faces, voices, or bodies on their own. Problems could ensue from difficulties with individual components or from additional difficulties in integrating information. Because no study has included both component and matching tasks, these two alternatives could not previously be distinguished. The current study showed that age effects often persist after accounting for component tasks, consistent with the idea that there are additional difficulties in integrating emotion information from two sources that transcend the difficulty on individual sources.

What causes the additional difficulty in the matching task? Although we do not provide direct neurological evidence to support a neurological argument, as discussed previously, simultaneous processing of emotion expressions in faces and voices results in more activation in emotion-processing areas than expressions in one source only, and increased activation is associated with better emotion recognition (Kreifelts et al., 2007). If so, then age-related declines in the volume of emotion centers could result in a reduced capacity for experiencing the increase in activation essential for correct performance in matching tasks. Despite the plausibility of this account, we note a difference between the matching and component tasks. The face, voice, and body tasks required labeling of each expression, whereas the matching tasks required only matching of a face and voice or body and voice. In practice, we think that matching might frequently be done through labeling each expression as "angry," "sad," and so on, but we note that this difference in tasks is a limitation of the present study.

In sum, the present study indicates that older adults' worse emotion recognition extends from faces to vocal and bodily expressions and to matching faces to voices and bodies to voices. We also found that difficulties when matching emotional expressions in two sources cannot be reduced simply to difficulties in component sources. Finally, our results suggest that nearly three quarters of older adults function at the level of the lowest group of young adults when it comes to recognizing emotions across facial, auditory, and bodily expressions.

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