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Effects of age and mood on emotional face processing differ depending on the intensity of the facial expression

Kelly A. Durbin¹, Sarah Rastegar¹, Bob G. Knight^{1,2}

¹Department of Psychology, University of Southern California ²School of Psychology and Counseling, University of Southern Queensland

Abstract

Prior research suggests that mood and the intensity of emotion can moderate age differences in recognizing emotion in facial expressions. Moreover, situations that increase physiological arousal, such as high cognitive demand or increased anxiety, may magnify age differences in emotional face processing. In the current study, we examined how an anxious versus calm mood state affected younger and older adults' processing of emotional facial expressions that portrayed emotions at either low or high intensity levels. Consistent with previous findings, older adults had greater difficulty identifying negative emotions in faces, particularly when emotions were displayed at a low intensity. Individuals in a calm mood state showed better recognition of sad faces, yet an anxious mood state did not increase recognition of threat-based emotion. There was no interaction between age and mood in identifying emotional facial expressions. In contrast, age, intensity of emotion, and participants' current mood state all affected the perceived intensity of emotion. For low intensity faces, younger adults perceived threatening emotions (i.e., fear, anger) as more emotionally intense when in an anxious mood state, whereas anxious older adults perceived anger and happiness as more intense. Older adults perceived certain emotions as more emotionally intense than younger adults did; however, this was dependent on the mood induction condition. Mood had no impact on the perceived intensity of highly intense emotional expressions. These findings emphasize the need for future research to consider both internal and external factors as potential moderators when investigating the effects of age on emotional face processing.

Keywords

aging; anxiety; emotional face processing; intensity; facial expressions

Facial expressions are a key component of nonverbal communication and the ability to correctly perceive what emotion is being depicted by a facial expression is essential for social and emotional functioning. For example, perceiving anger in faces allows individuals to detect possible threat in their environment, while difficulty identifying emotional facial expressions can lead to misinterpretation and increased conflict with others. As such, interpreting emotional facial expressions is important for all stages of life; however, this skill

may be particularly advantageous in older age given that older adults prioritize social goals and interpersonal relationships to a greater extent than younger adults (Carstensen, Isaacowitz, & Charles, 1999). Yet, despite the importance of emotional well-being in later life, the ability to correctly identify emotions being depicted in facial expressions seems to worsen with age (for meta-analyses, see Gonçalves et al., 2018; Ruffman, Henry, Livingstone, & Phillips, 2008), with older adults showing a particular deficit for faces portraying negative emotion such as anger, fear, and sadness (Calder et al., 2003; Isaacowitz et al., 2007; Mill, Allik, Realo, & Valk, 2009; Orgeta & Phillips, 2008; Phillips, MacLean, & Allen, 2002; West et al., 2012). However, this age-related impairment in emotional face identification has not been consistently replicated. Other studies have found that older adults only show a deficit in recognizing angry faces (Holland, Ebner, Lin, & Samanez-Larkin, 2019) and that the ability to detect fear in facial expressions remains intact in older age (e.g., Sullivan & Ruffman, 2004, Experiment 1; Suzuki, Hoshino, Shigemasa, & Kawamura, 2007).

The heterogeneity of findings in the literature suggests that there may be circumstances in which age differences are more likely to emerge. Thus, it is plausible that there are both internal and external factors that moderate older adults' ability to correctly perceive facial emotion. With regard to external factors, several studies have investigated whether stimulus characteristics can affect age differences in emotion recognition. For example, most studies examining age-related deficits in emotional face processing have used static images of facial expressions. Yet, recent research suggests that age differences are actually attenuated when dynamic facial expressions are used (Grainger, Henry, Phillips, Vanman, & Allen, 2017; Holland et al., 2019). Other evidence suggests that younger and older adults' facial recognition ability can vary depending on the age of the person making the facial expression (for reviews, see Fölster, Hess, & Werheid, 2014; Rhodes & Anastasi, 2012; Wiese, Komes, & Schweinberger, 2013). In addition, the level of emotional intensity also plays an important role in the emergence of age differences in emotion identification. In two studies, researchers presented faces that displayed emotions at 25%, 50%, 75%, and 100% intensity and then asked participants to identify the emotion that was being depicted (Orgeta & Phillips, 2008; West et al., 2012). Both studies found an age-related deficit in recognizing fear, anger, and sadness at all intensity levels, but found that the largest age discrepancy occurred at a lower intensity level (i.e., 50%). The results of these studies suggest that age differences in emotional face recognition are magnified when the emotion is subtly being portrayed.

Expanding upon these findings, two additional studies found that age differences in emotion recognition were greater at lower intensity levels (Mienaltowski et al., 2013; Mienaltowski, Lemerise, Greer, & Burke, 2019); however, in contrast to prior work, these researchers did not observe an age-related impairment when emotions were displayed at high intensity levels. One possible reason for these discrepant findings is the methodology that was used to assess emotion recognition. Unlike prior research in which participants were presented with six response options (i.e., fear, anger, sadness, disgust, happiness, and surprise), Mienaltowski and colleagues (2013, 2019) used two-alternative forced-choice tasks. In the first study, participants saw emotional facial expressions and chose which of two emotion labels best described that emotion (Mienaltowski et al., 2013). In the second paradigm, an

emotional face was shown at the top of the computer screen and participants had to choose which of two facial expressions represented the same emotion as the stimulus picture (Mienaltowski et al., 2019). Evidence suggests that identifying emotions in facial expressions is a cognitively demanding task that requires working memory; however, lowering the number of response options can reduce the cognitive burden that is placed on participants (Phillips, Channon, Tunstall, Hedenstrom, & Lyons, 2008). Given that working memory declines in older age (Hasher & Zacks, 1988), it is not surprising that age differences for highly intense facial expressions were more likely to occur under greater cognitive demands.

When people view threatening facial and body expressions, the diameter of their pupil, a measure of physiological arousal, increases (Kret, Roelofs, Stekelenburg, & de Gelder, 2013). Interestingly, individuals with high anxiety show a greater increase in pupil dilation in response to angry facial expressions than people with lower anxiety levels (Kret, Stekelenburg, Roelofs, & de Gelder, 2013). Therefore, it is plausible that circumstances that increase physiological arousal, such as anxiety, could also influence the effects of age on emotion identification. Prior evidence has shown that internal mood states do affect emotional face processing. For example, low levels of positive mood can decrease the ability to correctly identify happiness in facial expressions, whereas a negative mood state can increase identification of disgust in faces (Coupland et al., 2004). Likewise, participants induced into a sad mood state had better recognition for sad than happy faces (Schmid & Mast, 2010). This mood congruency effect in emotional face processing has also been observed in older adults. Studies have shown that an age-related decrease in negative affect can explain older adults' deficit in identifying sadness in faces (Suzuki et al., 2007), and that older adults' current mood state influences their perception of happiness in faces (Voelkle, Ebner, Lindenberger, & Riediger, 2014). Thus, it is possible that individuals induced into an anxious or highly arousing mood state will demonstrate mood congruent effects by showing an increased ability to identify threat-based emotions in faces, such as fear and anger. Supporting this notion, research has found that younger adults with high anxiety were better at identifying fear in facial expressions and perceived greater fear in ambiguous faces than those with low levels of anxiety (Richards et al., 2002; Surcinelli, Codispoti, Montebanocci, Rossi, & Baldaro, 2006; but see Cooper, Rowe, & Penton-Voak, 2008). In addition, younger adults with high anxiety show an attentional bias towards angry and fearful facial expressions (Bradley, Mogg, Falla, & Hamilton, 1998; Fox, 2002). Together, these results clearly support the idea that an anxious mood state can affect emotional face processing. However, it is unclear if both younger and older adults induced into an anxious mood state would show an enhancement in recognizing threat-based emotion in facial expressions and if the magnitude of this effect would differ between age groups.

In addition to identifying the emotion being depicted in faces, accurate interpretation of an emotional facial expression also requires individuals to correctly perceive the intensity of that emotion. Thus, it is important to determine if the perception of emotional intensity also changes across the lifespan. Research suggests that the ability to accurately perceive and detect the intensity of negative facial expressions, such as anger and fear, declines in older age (Rutter et al., 2019). Yet, there is evidence suggesting that participants' internal mood state can moderate age differences in perceiving the intensity of emotions. Phillips and Allen

(2004) showed that older adults rated both sad and happy faces as less emotionally intense than younger adults did; however, this age difference was eliminated when participants' self-reported ratings of depression and anxiety were entered in as covariates. In line with this research, a recent study induced younger and older adults into a sad mood state and then asked participants to rate the strength of emotions that were depicted in morphed facial expressions (Lawrie, Jackson, & Phillips, 2019). Findings showed that both younger and older adults induced into a sad mood state perceived greater levels of sadness in facial expressions than individuals in a neutral mood state. In addition, older adults perceived happy faces as less emotionally intense when in a sad mood compared to a neutral mood, whereas this pattern was not observed in younger adults. These findings suggest that the perceived intensity of facial emotion can differ between younger and older adults depending on the type of emotion being assessed and participants' current mood state.

The Present Study

Here, we examined how age, emotional intensity, and participants' internal mood state can affect emotional face processing for faces depicting angry, sad, fearful, and happy facial expressions. By using an autobiographical memory task and mood congruent music, we induced younger and older adults into either an anxious or calm mood state. Once participants were successfully induced into their assigned mood state, they were shown static images of emotional facial expressions and asked to identify the emotion being depicted and rate the intensity of that emotion on a 9-point scale.

Recognition of emotional facial expressions.

With regard to accuracy, we hypothesized that older adults would be less accurate at identifying emotional facial expressions than younger adults, especially since our task offered multiple response options, thereby increasing the cognitive demand placed on participants. However, we expected that this age difference would be magnified when emotions were depicted at low intensity levels, replicating findings from previous research (Mienaltowski et al., 2013, 2019; Orgeta & Phillips, 2008; West et al., 2012). In addition, we predicted that younger adults in an anxious mood state would be more accurate at identifying threatening and highly arousing facial expressions, such as anger and fear, whereas younger adults in a calm mood state would show greater recognition for sad facial expressions since sadness is characterized as a low arousal emotion (Russell, 1980). We also investigated whether mood congruency effects on emotion recognition would differ depending on the intensity of the emotional facial expression. Novel to this study, we explored whether there was an interactive effect between participants' age and current mood state on emotional face identification and if the intensity of facial emotion moderated these effects. Specifically, we investigated if older adults in an anxious mood state would also show increased accuracy for threatening faces and whether the size of this effect would differ between the two age groups.

Perceived intensity of emotional facial expressions.

Regarding perceptions of emotional intensity, we anticipated that age differences in perceived intensity would be moderated by participants' current mood state. Given that prior

research found that age differences were eliminated when participants' anxiety levels were covariates in the analyses (Phillips & Allen, 2004), we hypothesized that older adults would perceive emotions as less intense than younger adults when individuals were in a calm mood state, but this age difference would be attenuated, if not eliminated, when participants were induced into an anxious mood state. Lastly, we explored if the effects of age and internal mood state on the perceived intensity of emotional faces would differ based on the intensity of the emotional expression.

Method

Participants

Seventy-six undergraduates from the University of Southern California ($M_{\text{age}} = 19.7$ years, $SD = 1.2$ years, range = 18–23; 66 females) and 66 older adults living in the Greater Los Angeles area ($M_{\text{age}} = 71.4$ years, $SD = 6.9$ years, range = 60–95; 46 females) were recruited and randomly assigned to be induced into either an anxious or calm mood state. Older adults were screened for possible dementia using a telephone-screening instrument and all scored above the recommended cutoff score of 16 (Gatz et al., 2002). Three younger adults and two older adults were excluded for reporting a recent psychiatric diagnosis or the use of psychotropic medication. Of the remaining participants, 11 younger adults and 10 older adults were excluded for an inability to be induced into the proper mood state (see Method for mood induction criteria). Thus, 62 younger adults ($n_{\text{anxious}} = 30$; $n_{\text{calm}} = 32$) and 54 older adults ($n_{\text{anxious}} = 26$; $n_{\text{calm}} = 28$) were included in the final analyses. As shown in Table 1, younger adults reported higher baseline levels of depressive symptomatology, trait anxiety, and worry than older adults did. However, these baseline age differences in mood and anxiety levels are consistent with prior research that has found that older adults often report better emotional well-being and lower levels of negative affect and anxiety relative to younger adults (Carstensen, Pasupathi, Mayr, & Nesselroade, 2000; Carstensen et al., 2011; Phillips & Allen, 2004). Participants received either course credit or monetary compensation for their participation. All participants provided written informed consent in accordance with a protocol approved by the University of Southern California's Institutional Review Board.

Materials and Procedure

Assessment of mood.—Participants' mood was assessed at different times throughout the experiment using an abbreviated version of State-Trait Anxiety Inventory – State Anxiety Scale (STAI-S; Spielberger, 1983). The STAI-S consists of a list of 10 positive and 10 negative statements (e.g., “I feel calm”, “I feel tense”) and participants indicate the extent to which their current feelings match these statements using a 4-point scale (1 = not at all, 2 = somewhat, 3 = moderately so, 4 = very much so). This shortened 10-item version of the STAI-S was derived using the procedure described in Fox and Knight (2005) in which five positively-worded items and five negatively-worded items were randomly selected from the original STAI-S. Participants also completed a visual analog scale (VAS) in which they rated their current level of anxiety on a 0 (no anxiety/worry) to 10 (the most anxiety you have ever felt) scale. Unlike the STAI-S, which provides an estimation of state anxiety by asking participants about symptoms that are often related to anxiety (e.g., feeling calm, tense, jittery, etc.), the VAS explicitly asks participants to rate their current anxiety level. Thus, we

chose to include both the VAS and STAI-S to have a direct and indirect measure of state anxiety, respectively. Participants' mood was assessed before the mood induction (i.e., at baseline), after the mood induction, and then again after the facial identification task.¹

Mood induction.—Participants were induced into either an anxious or calm mood state using an autobiographical memory task. In this task, participants were instructed to spend three minutes thinking in as much detail as possible about a recent situation that made them feel either worried and anxious or relaxed and calm, depending on the assigned mood condition. Mood congruent music played while participants recalled this situation and the music continued to play throughout the duration of the facial identification task in an effort to sustain the assigned mood state. The music selected for the anxious and calm mood inductions were Dmitri Shostakovich's String Quartet No. 8 in C Minor (Op. 110), Allegro Molto movement and Claude Debussy's Clair de Lune, respectively.

After the mood induction, scores on the STAI-S and VAS were highly correlated ($r = 0.85$, $p < .001$); however, the criteria for determining whether an individual was successfully induced into their assigned mood state was established using only the STAI-S. This criterion was chosen since the VAS is a single-item measure, whereas the STAI-S provides a total composite score derived from 10 items. Moreover, the STAI-S has been shown to be effective at capturing changes in mood following a similar mood induction procedure (Fox & Knight, 2005). For individuals assigned to the anxious mood condition, the mood induction was considered successful if their score on the STAI-S increased following the mood induction. Conversely, for those in the calm mood condition, the mood induction was deemed effective if their individual score on the STAI-S did not increase. As reported earlier, 11 younger adults ($n_{\text{anxious}} = 6$, $n_{\text{calm}} = 5$) and 10 older adults ($n_{\text{anxious}} = 7$, $n_{\text{calm}} = 3$) were unable to be induced into the proper mood state using these criteria. The proportion of individuals in our sample who were unable to be successfully induced into the proper mood state is comparable to studies using similar mood induction procedures (Mienaltowski & Blanchard-Fields, 2005; Scheibe & Blanchard-Fields, 2009). In addition, the discrepancy between the anxious and calm mood induction conditions is similar to prior research that has induced participants into negative and neutral mood states (e.g., Scheibe & Blanchard-Fields, 2009).

Facial identification task.—Stimuli were taken from the Penn Emotion Recognition Task (ER-40; Gur et al., 2002). The ER-40 contains 40 color photographs of human faces displaying emotional (anger, fear, happiness, sadness) and neutral facial expressions; eight photographs for each facial expression category. Neutral facial expressions were only included as filler items to serve as a contrast for emotional faces and thus will not be included in the analyses. Within each emotional category (e.g., anger), half of the photographs depicted a mild level of intensity for that emotion while the other half displayed an extreme level of intensity. During the facial identification task, facial expressions were presented in a pseudorandomized order. Each face was presented on the computer screen for

¹After the facial identification task, participants underwent a "booster" mood induction using a similar methodology as the described mood induction procedure. Participants then completed an attention task and an executive control task. These tasks were part of a separate study and beyond the scope of the current study so they will not be discussed further.

five seconds and participants were asked to identify the emotion being depicted (i.e., anger, fear, happiness, sadness, neutral). Participants were also asked to rate how confident they were in their response on a scale from 1 (low) to 9 (high) and rate the emotional intensity of each facial expression on the same 9-point scale.²

Results

Efficacy of Mood Induction

State anxiety levels were assessed using scores on the STAI-S and VAS (mean scores as a function of age group and mood induction condition are reported in Table 2). A series of univariate ANOVAs were conducted on STAI-S and VAS scores at each time point (i.e., at baseline, after the mood induction, and after the facial identification task) with age (younger, older) and mood induction condition (anxious, calm) as between-subjects factors. At baseline, there was only a main effect of age, with younger adults reporting higher levels of anxiety than older adults (STAI-S, $F(1, 112) = 29.19, p < .001, \eta_p^2 = .21$; VAS, $F(1, 112) = 23.59, p < .001, \eta_p^2 = .17$). Baseline anxiety levels did not differ between participants in the anxious and calm mood conditions and the interaction was also not significant ($F_s = 2.66, p_s = .11$). Anxiety scores immediately after the mood induction procedure indicated that participants induced into an anxious mood state were significantly more anxious than individuals induced into a calm mood state (STAI-S, $F(1, 112) = 119.30, p < .001, \eta_p^2 = .52$; VAS, $F(1, 112) = 169.14, p < .001, \eta_p^2 = .60$). Younger adults continued to report higher anxiety levels than older adults (STAI-S, $F(1, 112) = 19.86, p < .001, \eta_p^2 = .15$; VAS, $F(1, 112) = 20.88, p < .001, \eta_p^2 = .16$); however, the interaction between age group and mood induction condition was not significant ($F_s = 0.92, p_s = .34$). To confirm that the mood induction was effective for each age group, we compared anxiety scores before and after the mood induction. Both younger and older adults induced into an anxious mood state showed a significant increase in anxiety on both the STAI-S and the VAS (for younger adults: STAI-S, $t(29) = 9.28, p < .001, d = 1.69$, and VAS, $t(29) = 5.54, p < .001, d = 1.01$; for older adults: STAI-S, $t(25) = 8.00, p < .001, d = 1.57$, and VAS, $t(25) = 3.84, p = .001, d = 0.75$), whereas both age groups in the calm mood condition showed a significant decrease on these anxiety measures (for younger adults: STAI-S, $t(31) = 7.68, p < .001, d = 1.36$, and VAS, $t(31) = 7.56, p < .001, d = 1.34$; for older adults: STAI-S, $t(27) = 3.54, p = .001, d = 0.67$, and VAS, $t(27) = 3.78, p = .001, d = 0.71$). To verify that the induced mood state was maintained throughout the experimental task, we assessed anxiety scores after the facial identification task. After the experimental task, participants in the anxious mood condition continued to report greater levels of anxiety than those induced into a calm mood state (STAI-S, $F(1, 112) = 28.09, p < .001, \eta_p^2 = .20$; VAS, $F(1, 112) = 20.80, p < .001, \eta_p^2 = .16$). Younger adults endorsed higher anxiety levels than older adults (STAI-S, $F(1, 112) = 27.33, p < .001, \eta_p^2 = .20$; VAS, $F(1, 112) = 7.86, p = .006, \eta_p^2 = .07$); however, the interaction on the VAS and STAI-S was only marginally significant (STAI-S, $F(1, 112) = 3.45, p = .066, \eta_p^2 = .03$; VAS, $F(1, 112) = 3.50, p = .064, \eta_p^2 = .03$).

²Even though neutral facial expressions are, by definition, low in emotional intensity, participants were still asked to rate the emotional intensity of neutral faces to standardize the procedure across facial expressions.

Accuracy of Identifying Emotions

Accuracy was calculated as the proportion of correctly identified facial expressions within an emotional category (e.g., anger). We conducted separate 2 (Age: younger, older) $\times$ 2 (Mood Induction: anxious, calm) $\times$ 4 (Emotion: anger, fear, sadness, happiness) repeated-measures ANOVAs on these accuracy scores for low and high intensity faces (see Table 3 for mean accuracy scores).

For facial expressions that were of low emotional intensity, there was a main effect of Age, $F(1, 112) = 38.50, p < .001, \eta_p^2 = .26$, that was qualified a significant Age $\times$ Emotion interaction, $F(3, 336) = 4.01, p = .008, \eta_p^2 = .04$. Follow-up t -tests showed that younger adults were more accurate at identifying negative facial expressions than older adults (anger: $t(114) = 4.19, p < .001, d = 0.78$; fear: $t(91.95) = 2.72, p = .008, d = 0.51$; sadness: $t(98.97) = 4.05, p < .001, d = 0.76$)³; however, the ability to accurately identify happiness in faces was only marginally significant between age groups ($p = .08$). The main effect of Emotion was also significant, $F(3, 336) = 89.95, p < .001, \eta_p^2 = .45$. Bonferroni-corrected pairwise comparisons indicated that individuals were more likely to correctly identify happiness in faces relative to all other emotions ($ps < .001$). Fear was more likely to be accurately identified than sadness or anger ($ps < .001$) and individuals were more accurate at identifying sadness than anger in faces ($p < .001$). No other main effects or interactions were significant ($Fs = 1.31, ps = .27$).

For faces that displayed highly intense emotions, there was a main effect of Age, $F(1, 112) = 17.69, p < .001, \eta_p^2 = .14$, that was qualified by a significant Age $\times$ Emotion interaction, $F(3, 336) = 3.80, p = .011, \eta_p^2 = .03$. Younger adults were better than older adults at identifying fearful, $t(88.09) = 4.13, p < .001, d = 0.78$, and sad facial expressions, $t(103.49) = 2.45, p = .016, d = 0.46$, whereas there was only a marginal age difference in the accuracy of identifying angry faces ($p = .09$) and there was no difference between age groups in identifying happiness in faces ($p = .88$). The main effect of Emotion was also significant, $F(3, 336) = 22.83, p < .001, \eta_p^2 = .17$. Bonferroni-corrected pairwise comparisons demonstrated that happiness was more likely to be correctly identified than any other emotion ($ps < .001$). In addition, sadness was more likely to be accurately identified than anger ($p = .013$); no other comparisons were significant ($ps > .16$). For high intensity faces, there was a significant Mood Induction $\times$ Emotion interaction, $F(3, 336) = 3.24, p = .022, \eta_p^2 = .03$, that was not observed for low intensity faces. Participants in a calm mood state were more accurate at identifying sadness in faces than individuals induced into an anxious mood state, $t(89.05) = 2.50, p = .014, d = 0.47$; the difference between the two induction groups for all other emotions was not significant ($ts = 1.40, ps = .17$).

Intensity of Emotions

Separate 2 (Age: younger, older) $\times$ 2 (Mood Induction: anxious, calm) $\times$ 4 (Emotion: anger, fear, sadness, happiness) repeated-measures ANOVAs were conducted on the perceived

³Levene's test for equality of variances revealed that the variance between age groups was not always equal. In those instances, the reported degrees of freedom, t statistic, and p value are those in which equal variances was not assumed.

intensity of low and high intensity faces, regardless of accuracy (see Table 3 for mean intensity ratings).

For low intensity facial expressions, there were main effects of Age, $F(1, 112) = 5.95$, $p = .016$, $\eta_p^2 = .05$, and Mood Induction, $F(1, 112) = 6.18$, $p = .014$, $\eta_p^2 = .05$, in which older adults and individuals induced into an anxious mood state perceived facial expressions to be more emotionally intense than younger adults and participants in a calm mood state, respectively. A main effect of Emotion was also observed, $F(3, 336) = 46.79$, $p < .001$, $\eta_p^2 = .30$. Bonferroni-corrected pairwise comparisons indicated that individuals perceived happiness and fear to be more emotionally intense than sadness or anger (all $ps < .001$); no difference was observed for the perceived intensity between happiness and fear or sadness and anger ($ps > .81$). The Age $\times$ Emotion interaction, $F(3, 336) = 10.49$, $p < .001$, $\eta_p^2 = .09$, and Mood Induction $\times$ Emotion interaction, $F(3, 336) = 3.55$, $p = .015$, $\eta_p^2 = .03$, were qualified by a significant three-way interaction between Age, Mood Induction, and Emotion, $F(3, 336) = 3.34$, $p = .020$, $\eta_p^2 = .03$. In younger adults, those who were induced into an anxious mood state perceived angry, $t(60) = 3.36$, $p = .001$, $d = 0.85$, and fearful, $t(51.71) = 2.10$, $p = .041$, $d = 0.54$, faces to be more emotionally intense than individuals in a calm mood state. However, the perceived intensity of sad or happy facial expressions did not differ between younger adults in the two induction groups ($ts < 1.17$, $ps > .25$). Among older adults, participants in an anxious mood state perceived angry, $t(52) = 2.16$, $p = .035$, $d = 0.59$, and happy, $t(52) = 2.21$, $p = .031$, $d = 0.61$, faces to be more emotionally intense than those who were induced into a calm mood state. Perceived intensity of sad and fearful faces did not differ between older adults in the two induction conditions ($ts < 1.14$, $ps > .26$). Among individuals induced into an anxious mood state, older adults perceived sad, $t(54) = 2.21$, $p = .031$, $d = 0.59$, and happy, $t(54) = 3.88$, $p < .001$, $d = 1.03$, faces as more emotionally intense than younger adults did; however, the difference between the two age groups for angry faces was only marginally significant ($p = .06$) and the difference for fearful faces was not significant ($p = .27$). When participants were in a calm mood state, older adults perceived sad, $t(58) = 2.91$, $p = .005$, $d = 0.75$, and angry, $t(58) = 2.24$, $p = .029$, $d = 0.57$, faces as more emotionally intense than younger adults did. The difference in perceived intensity of fearful and happy faces did not differ between the two age groups ($ts < 0.78$, $ps > .44$).

For high intensity facial expressions, there was a significant main effect of Emotion, $F(3, 336) = 112.58$, $p < .001$, $\eta_p^2 = .50$. Bonferroni-corrected pairwise comparisons revealed that happy and angry faces were rated as more emotionally intense than sad faces ($ps < .001$) and all emotional faces were perceived as more emotionally intense than fearful faces ($ps < .001$). A significant Age $\times$ Emotion interaction was also observed, $F(3, 336) = 5.50$, $p = .001$, $\eta_p^2 = .05$. Follow-up t -tests showed that older adults perceived happy faces to be more emotionally intense than younger adults did, $t(114) = 2.65$, $p = .009$, $d = 0.49$, whereas the perceived intensity for angry, sad, or fearful facial expressions did not differ between the two age groups ($ts < 1.40$, $ps > .16$). There was a marginal main effect of Mood Induction, $F(1, 112) = 3.01$, $p = .086$, $\eta_p^2 = .03$, and a marginal interaction between Mood Induction and Emotion, $F(3, 336) = 2.33$, $p = .074$, $\eta_p^2 = .02$. No other main effects or interactions were significant ($Fs < 0.22$, $ps > .64$).

Discussion

In the current study, we evaluated how age, intensity of emotion, and an anxious versus calm mood state affected both the recognition and perceived intensity of anger, fear, sadness, and happiness in static facial expressions. As expected, younger adults outperformed older adults in the ability to accurately identify negative facial expressions, replicating numerous studies (Gonçalves et al., 2018; Mill et al., 2009; Orgeta & Phillips, 2008; Phillips et al., 2002; Ruffman et al., 2008; West et al., 2012). Supporting our prediction, we found that the intensity of emotion moderated this age difference. When emotions were displayed at a lower intensity level, older adults had greater difficulty identifying all types of negative emotions (i.e., anger, fear, sadness); however, at high intensity levels, age differences were only observed for fear and sadness. These findings fit nicely with prior research showing that age deficits are more pronounced when emotions are displayed at lower intensity levels (Mienaltowski et al., 2013, 2019; Orgeta & Phillips, 2008; West et al., 2012). For some emotions, such as anger, the emergence of age differences in emotion recognition may be dependent on how intensely the emotion is portrayed. The age-related impairment for identifying fear and sadness at high intensity levels is consistent with several studies (Orgeta & Phillips, 2008; West et al., 2012), but inconsistent with other research (Mienaltowski et al., 2013, 2019). As discussed earlier, it is likely that methodological differences can account for discrepancies at high intensity levels. Our findings replicated studies that also provided participants with multiple response options during the emotion recognition task (Orgeta & Phillips, 2008; West et al., 2012). Thus, it likely that age differences in identifying emotional expressions will emerge at high intensity levels unless the cognitive demands of the task are reduced (e.g., by simplifying the number of response options; Mienaltowski et al., 2013, 2019).

Notably, we did not observe an age-related deficit in identifying happiness in facial expressions, regardless of the intensity level, a finding that has also been demonstrated in prior research (Murphy & Isaacowitz, 2010; Orgeta & Phillips, 2008; West et al., 2012). There are several possible explanations as to why an age difference in recognizing happiness did not occur. First, it is possible that ceiling effects in younger and older adults' recognition of happiness make it difficult to detect age differences (cf. Ebner, He, & Johnson, 2011; Ruffman et al., 2008). Consistent with this possibility, participants in our study were more accurate at identifying happiness in faces relative to all other emotions and when happiness was displayed at a high intensity level, recognition performance was at ceiling. However, at low intensity levels, younger adults were marginally more accurate than older adults at recognizing happiness, but this trend did not reach significance. Notably, happiness was the only positive facial expression used in this study, so it is plausible that the inclusion of other positive facial expressions (e.g., excitement, surprise) would reduce this ceiling effect and allow for any potential age differences in the recognition of positive facial expressions to emerge. Alternatively, the absence of an age-related impairment in the identification of happiness in facial expressions could reflect older adults' bias and prioritization of positive information to optimize their emotional well-being, a well-established finding that has been consistently replicated throughout the literature (Carstensen et al., 1999; Mather & Carstensen, 2003; Reed & Carstensen, 2012).

With regard to participants' internal mood state, individuals induced into a calm mood were more accurate at identifying sadness in high intensity facial expressions than individuals in an anxious mood state. Sadness is characterized as a state of low arousal (Russell, 1980), so the enhanced ability to identify sadness when in a calm mood state does provide further evidence for mood congruence effects in emotional face processing, extending prior research on how younger and older adults' current mood can influence the recognition of sadness in faces (Schmid & Mast, 2010; Suzuki et al., 2007). However, it should be noted that this mood congruency effect was only observed when sadness was displayed at a high intensity level, underscoring the importance of taking emotional intensity into account when investigating factors that can influence emotional face processing. Contrary to our prediction, an anxious mood state did not increase recognition of threatening emotions (e.g., fear, anger), regardless of the intensity level. One possible explanation for this unexpected finding is the type of anxiety that is being assessed. Studies showing greater sensitivity and recognition of fear among anxious individuals have recruited participants with high levels of trait anxiety (Richards et al., 2002; Surcinelli et al., 2006). In contrast, we did not recruit participants with high levels of trait anxiety and our mood induction procedure manipulated levels of state anxiety. It is possible that chronic levels of high anxiety (i.e., trait anxiety) are required for anxiety to have a deleterious effect on emotional face identification, rather than a temporary increase in state anxiety. Regardless, it should be noted that other research has also failed to find an anxiety-related impairment in recognizing facial emotion, even when recruiting participants with high levels of trait anxiety (e.g., Cooper et al., 2008). Thus, it also plausible that the effects of anxiety on identifying threat-based emotion (e.g., fear) in facial expressions are not as robust as other cognitive processes (e.g., attentional biases to threat) and are sensitive to methodological differences.

Given that we did not observe enhanced recognition for threat-based emotion among anxious individuals, it continues to remain an open question as to whether or not older adults would demonstrate greater recognition for threatening facial expressions in situations where anxious younger adults do show increased identification for threat, and if the magnitude of this effect would differ between the two age groups. We did not observe any interactions between age and mood induction condition on accuracy scores, suggesting that induction into an anxious or calm mood state did not differentially affect younger and older adults' recognition of emotional facial expressions, regardless of the intensity level. However, future work should compare younger and older adults with high levels of trait anxiety to determine if trait anxiety would moderate age differences in emotional face identification.

Although an anxious mood state did not enhance recognition of threat-based emotion in faces, we did find that age, intensity of emotion, and current mood state all influenced participants' perceived intensity of emotional facial expressions. For low intensity facial expressions, individuals in an anxious mood state did perceive certain types of emotions as more emotionally intense than individuals in a calm mood state; however, the emotions that were perceived as more intense differed between younger and older adults. Anxious younger adults perceived threat-based emotions (i.e., fear and anger) as more emotionally intense than their counterparts in a calm mood state. Likewise, older adults induced into an anxious mood perceived angry faces to be more emotionally intense than those in a calm mood, but the perceived intensity of fearful facial expressions did not differ between these two groups.

These findings extend previous findings with anxious younger adults (Richards et al., 2002; Surcinelli et al., 2006), and provides novel evidence that older adults in an anxious mood state can also show mood congruent effects for certain types of threat-based emotion (i.e., anger). In addition, anxious older adults also perceived happiness as more emotionally intense than older adults induced into a calm mood state, whereas this effect was not observed in younger adults. Moreover, older adults induced into an anxious mood perceived happy faces as more emotionally intense than younger adults in an anxious mood state did. Happiness is a highly arousing positive emotion, so it is possible that the increased physiological arousal levels that accompany anxiety will prompt older adults to indiscriminately perceive any highly arousing emotion as more intense, regardless of whether it is a positive or negative emotion. In contrast, anxious younger adults might interpret the increased arousal from anxiety as negative and threatening leading them to perceive only threat-based emotions with greater intensity. Future research is needed to explore these possibilities.

We also found that older adults perceived emotional facial expressions to be more emotionally intense than younger adults did; however, participants' current mood state also influenced this pattern of results. When individuals were induced into an anxious mood state, older adults perceived sad and happy faces as more emotionally intense than younger adults did. In contrast, older adults in a calm mood state perceived sad and angry faces to be more emotionally intense than their younger counterparts. Taken together, these results emphasize how age differences in emotional face processing can vary depending on internal factors, such as participants' current mood state. Contrary to our prediction, we found that older adults perceived certain types of emotions as more emotionally intense than younger adults did. This finding is incongruent with previous work showing that older adults rated sad and happy faces as less emotionally intense than younger adults did (Phillips & Allen, 2004). However, in that study, this age difference was eliminated when anxiety and depression scores were entered in as covariates in the analyses. Thus, it is plausible that mood states play a key factor in the type of age difference that is observed. Lastly, for high intensity facial expressions, older adults rated happy faces as more emotionally intense than younger adults did, whereas there was no age difference in the perceived intensity of any other emotion. As discussed earlier, research has consistently shown that older adults show a bias towards positive information in both attention and memory tasks (Carstensen et al., 1999; Mather & Carstensen, 2003; Reed & Carstensen, 2012). Thus, it is likely that this finding reflects older adults' preference for positive information.

It should be noted that although our study induced participants into either an anxious or calm mood state, which we believe was sufficient to investigate how low versus highly arousing mood states affect emotional face processing, we did not include a neutral condition (i.e., a group that did not undergo a mood induction procedure). Thus, we are unable to speculate how our findings would compare to younger and older adults' naturally occurring mood states. Future research is needed to directly compare how individuals induced into an anxious or calm mood state compare to younger and older adults' naturally occurring mood states. Another limitation is the fact that younger adults reported greater anxiety levels than older adults throughout the duration of this study (i.e., at baseline, after the mood induction, and after the experimental task). Although this age difference did not interact with mood

induction conditions, it is still worth noting that younger adults' increased anxiety make it impossible for us to determine the extent to which the observed age differences were due to age or differences in self-reported anxiety between the two age groups. It may be beneficial for future research to equate anxiety levels using mood induction procedures; however, this option presents two major concerns. First, given that younger adults' baseline anxiety level is higher than older adults, the mood induction procedure itself would have to differ between age groups to equate post-induction anxiety levels, which could present methodological issues. Second, the magnitude of increased anxiety from pre- to post-induction would have to differ between the two age groups, which could be more problematic than having post-induction anxiety levels differ between younger and older adults.

Nevertheless, it is important to note that age differences observed in our study may not strictly be due to differences in age, per se.

In summary, the current research highlights how age, intensity of emotion, and participants' current anxiety level can affect the processing of emotional facial expressions, especially perceiving the intensity of facial emotion. Supporting prior research, these findings challenge the assumption that the ability to recognize facial emotion worsens with age. Instead, we showed that age-related deficits for identifying certain types of emotion (i.e., anger) can vary depending on how intensely that emotion is being portrayed. In addition, we showed that the effects of age on the perceived intensity of facial emotion is fairly complex. The emergence of age differences on perceptions of emotional intensity is dependent not only on the emotion that is being depicted, but also the intensity to which it is displayed and participants' internal mood state. These findings, along with prior research, underscore the need for future research to consider both internal and external factors as potential moderators when investigating the effects of age on emotional face processing.

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Mean scores and tests of significance for subjective health and self-reported mood by age group

Table 1.

	Younger adults		Older adults		<i>t</i>	<i>df</i>	<i>d</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>			
Subjective health rating	4.0	0.8	4.0	0.8	0.20	112	0.04
Depressive symptoms	13.4	9.2	6.1	5.4	5.20***	98.84	0.97
Trait anxiety	8.6	7.4	5.5	5.1	2.52*	113	0.49
Worry	53.0	13.4	35.3	10.9	7.74***	114	1.45

Note. Subjective health was rated on a scale from 1 (poor) to 5 (excellent). Depressive symptoms were measured by the Center for Epidemiological Studies Depression Scale (Radloff, 1977). Baseline levels of trait anxiety were measured by the Beck Anxiety Inventory (Kohn, Kantor, DeCicco, & Beck, 2008) and baseline worry levels were measured using the Penn State Worry Questionnaire (Meyer, Miller, Metzger, & Borkovec, 1990). Degrees of freedom (*df*) vary due to several participants' failure to complete all mood measures and also because Levene's test for equality of variances indicated that the variance between age groups for depressive symptoms was not equal. In that instance, the reported *t* statistic and *p* value are when equal variances were not assumed.

* $p < .05$;

** $p < .01$;

*** $p < .001$.

Table 2.

Mean scores on state mood measures as a function of age group and mood induction condition

	STAI-S		VAS	
	Anxious	Calm	Anxious	Calm
Baseline				
Younger	17.3 (6.2)	19.4 (5.9)	3.9 (3.0)	4.1 (2.5)
Older	13.7 (3.6)	12.7 (4.1)	2.1 (2.5)	1.4 (1.5)
Post Mood Induction				
Younger	25.7 (6.6)	15.2 (4.5)	6.4 (1.7)	1.6 (1.7)
Older	21.4 (6.0)	11.0 (2.2)	4.5 (2.7)	0.4 (0.7)
Post Facial Identification Task				
Younger	23.1 (6.0)	16.9 (4.0)	4.8 (2.5)	2.1 (2.0)
Older	17.0 (4.3)	14.0 (3.9)	2.9 (2.2)	1.7 (2.3)

Note. Standard deviations are given in parentheses. STAI-S = State-Trait Anxiety Inventory – State Anxiety Scale (abbreviated 10-item version); VAS = Visual Analog Scale.

Table 3.

Mean accuracy and subjective intensity ratings as a function of age group, mood induction condition, and the emotional intensity of facial expressions

	Anxious		Calm	
	Younger	Older	Younger	Older
<i>Accuracy – Low Intensity Faces</i>				
Anger	.62 (.24)	.48 (.31)	.68 (.24)	.41 (.27)
Fear	.92 (.12)	.81 (.20)	.89 (.14)	.83 (.18)
Sadness	.81 (.21)	.67 (.24)	.88 (.16)	.69 (.25)
Happiness	.96 (.12)	.90 (.17)	.98 (.07)	.94 (.15)
<i>Accuracy – High Intensity Faces</i>				
Anger	.83 (.21)	.83 (.27)	.88 (.17)	.73 (.27)
Fear	.94 (.13)	.80 (.22)	.91 (.16)	.75 (.24)
Sadness	.91 (.20)	.81 (.20)	.97 (.08)	.91 (.16)
Happiness	.99 (.05)	1.00 (.00)	.98 (.09)	.99 (.05)
<i>Intensity – Low Intensity Faces</i>				
Anger	5.31 (0.99)	5.85 (1.09)	4.46 (1.00)	5.13 (1.32)
Fear	6.43 (1.12)	6.08 (1.22)	5.91 (0.79)	5.69 (1.26)
Sadness	5.05 (1.08)	5.70 (1.12)	4.72 (1.14)	5.69 (1.45)
Happiness	5.84 (0.81)	6.74 (0.92)	6.05 (1.16)	6.08 (1.23)
<i>Intensity – High Intensity Faces</i>				
Anger	7.25 (0.92)	7.29 (0.90)	7.07 (0.85)	7.10 (1.09)
Fear	6.12 (1.00)	5.76 (1.34)	5.50 (0.82)	5.25 (1.26)
Sadness	6.68 (0.87)	6.72 (0.94)	6.48 (1.10)	6.59 (1.21)
Happiness	7.05 (0.75)	7.38 (0.91)	6.79 (1.07)	7.39 (1.04)

Note. Standard deviations are given in parentheses.