Facial age cues and emotional expression interact asymmetrically: age cues moderate emotion categorisation

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Facial Age Cues and Emotional Expression Interact Asymmetrically: Age Cues Moderate Emotion Categorisation

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Abstract

Facial attributes such as race, sex, and age can interact with emotional expressions; however, only a couple of studies have investigated the nature of the interaction between facial age cues and emotional expressions and these have produced inconsistent results. Additionally, these studies have not addressed the mechanism/s driving the influence of facial age cues on emotional expression or vice versa. In the current study participants categorised young and older adult faces expressing happiness and anger (Experiment 1) or sadness (Experiment 2) by their age and their emotional expression. Age cues moderated categorisation of happiness vs. anger and sadness in the absence of an influence of emotional expression on age categorisation times. This asymmetrical interaction suggests that facial age cues are obligatorily processed prior to emotional expressions. Finding a categorisation advantage for happiness expressed on young faces relative to both anger and sadness which are negative in valence but different in their congruence with old age stereotypes or structural overlap with age cues suggests that the observed influence of facial age cues on emotion perception is due to the congruence between relatively positive evaluations of young faces and happy expressions.

Keywords: Emotion Recognition, Emotional Expression, Face perception, Age, Person Construal

All it takes is a quick glimpse of a face to gather a range of information about a person. Not only can a person's sex, race, and age be identified, but we can also get an idea of how the person may be feeling from their facial expressions. Extracting these multiple sources of social information can occur quickly and effortlessly (Karnadewi & Lipp, 2011; Tracy & Robins, 2008), but it is less clear how this information is integrated to form an overall impression. Early models of face processing (e.g., Bruce & Young, 1986) proposed that facial attributes such as race, sex, and age were processed independently from emotional expressions and eye gaze. This meant that recognising someone's emotional state would not be influenced by their race, sex, or age and vice versa; however, a growing body of evidence suggests that these facial attributes can interact (e.g., Aguado, Garcia-Gutierrez, & Serrano-Pedraza, 2009; Atkinson, Tipples, Burt, & Young, 2005; Becker, Kenrick, Neuberg, Blackwell, & Smith, 2007; Craig, Lipp, & Mallan, 2014; Hess, Adams, Grammer, & Kleck, 2009; Karnadewi & Lipp, 2011; Lipp, Craig, Frost, Terry, & Smith, 2014, Lipp, Karnadewi, Craig, & Cronin, 2015). The majority of studies investigating these interactions have focussed on the interaction of race or sex with emotional expression (e.g., Ackerman et al., 2006; Bijlstra, Holland, & Wigboldus, 2010; Craig, Mallan, & Lipp, 2012; Hugenberg, 2005; Hugenberg & Bodenhausen, 2003, 2004; Hugenberg & Sczesny, 2006; Hutchings & Haddock, 2008). Few studies have looked at the interaction of facial age cues and emotional expression and most have only looked at the interaction in one direction. Some found evidence that age cues influence emotion perception (e.g., Sacco & Hugenberg, 2009). Others found that emotional expressions influenced age perception (e.g., Völkle, Ebner, Lindenberger, & Riediger, 2012); however, the manner in which age cues influence emotion perception or vice versa differed across studies.

Studies looking at the influence of age cues on emotional expression recognition by measuring labelling accuracy for a range of emotional expressions, have found emotion identification to be poorer when the face is old than when it is young (Borod et al., 2004; Ebner, Johnson & Fischer, 2012; Richter, Dietzel, & Kunzmann, 2011). However, this deficit in

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recognising expressions on older adult faces is not always uniform across all emotional expressions. Some studies have found poorer accuracy for only negative expressions on older adult faces (Ebner, He, & Johnson, 2011; Ebner & Johnson, 2009), while others have found poorer recognition for happiness, sadness, disgust, and anger, but not fear (Ebner, Riediger, & Lindenberger, 2010), or a recognition deficit for sadness (Hühnel, Fölster, Werheid, & Hess, 2014). Some studies found comparable performance for young adult (age range across studies: 18-31) and older adult participants (age range across studies: 61-94; Borod et al., 2004; Ebner et al., 2012; Ebner et al., 2011) whereas others found poorer performance in older adults, though the expressions recognised with less accuracy differed across studies (Ebner & Johnson, 2009; Ebner et al., 2010; Hühnel et al., 2014, Richter et al., 2011). Beyond measuring recognition accuracy, Hass, Schneider, and Lim (2015), reported a bias in the perception of emotional expressions on old faces. College aged participants rated emotionally ambiguous older adult faces as happier and less angry than young adult faces. Further, Sacco and Hugenberg (2009) demonstrated that cues of youth (faces manipulated to have larger eyes or a rounder face shape) facilitated the categorisation of fear expressions and cues of maturity (faces manipulated to have smaller eyes and a narrower face shape) facilitated the categorisation of facial expressions of anger.

Only a few studies have looked at the influence of emotional expressions on age perception. Völkle et al. (2012), asked participants aged 20-31, 44-55, and 70-81 to estimate the age of a range of male and female faces (aged 19-80) displaying a range of emotional expressions. Participants' age estimates were lower when the faces expressed happiness than when they expressed negative emotions. This pattern was observed for participants across all age groups. A few other studies with college aged samples have found similar results. More intense smiles were found to be correlated with lower age estimates (Wang, He, & Liu, 2015) and Hass, Wester, and Lim (2016), found that participants were more likely to label computer generated faces ranging in apparent age from 30-65 years as young when expressing happiness rather than a neutral expression and as old when expressing sadness rather than a neutral expression. Further to this, Marsh, Adams, and Kleck

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(2005), found that expressions of anger increased participants' ratings of facial maturity. In contrast with these findings, however, Ganel (2015) found that faces were estimated to be older when displaying happiness rather than a neutral expression.

Although there is some evidence for an influence of facial age cues on emotional expression recognition or vice versa in separate investigations, past studies have used different methods and stimuli limiting our ability to aggregate the findings across studies to determine the nature of the interaction between different facial attributes. Studies looking at the interaction of two facial attributes in both directions using comparable methods and identical stimuli with the same participants are required to determine the nature of the interaction. In these investigations, participants complete two comparable tasks using the same facial stimuli varying along two dimensions; however, in each task only one of the dimensions is task relevant. For example, the same happy and angry older and young adult faces would be presented within an age categorisation task and again in an emotion categorisation task (for examples of this approach see Aguado et al., 2009, Lipp, Karnadewi et al., 2015). Using this method, it can be determined whether facial attributes like age and emotional expression are processed independently – i.e., the age of the face does not influence emotion categorisation and emotional expressions do not influence age categorisation, asymmetrically – i.e., cues of age influence emotion categorisation in absence of an influence of emotional expression on the categorisation of age or vice versa, or symmetrically – age cues influence emotion categorisation and cues of emotion reciprocally influence age categorisation. Studies investigating the nature of the interaction between variant and invariant facial attributes are important as they provide a means for refining and extending face processing models. An early influential model proposed independence in processing between variant cues like emotional expression and invariant aspects of the face like age (Bruce & Young, 1986). A subsequent model proposed that variant and invariant aspects of the face were processed by separate dedicated neural systems but that face processing was achieved through multiple neural systems working in concert. This model highlighted the potential for interactions between different facial

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attributes but did not make specific predictions about the nature of these interactions (Haxby, Hoffman, & Gobbini, 2000, 2002).

To our knowledge, only two studies (both testing young adult samples) have utilised such an approach to investigate the nature of the interaction between age cues and emotional expression. Using the Garner paradigm, Karnadewi and Lipp (2011) found evidence of an asymmetrical interaction. Participants were slower to categorise emotional expressions when the age of the faces was varied within the task rather than held constant but no influence of emotional expression was observed in the age categorisation task. On the other hand, using the affective priming method, Craig and colleagues (2014), concluded independence in the processing of age cues and emotional expression. When participants focused on the emotional expression present on the faces, implicit evaluations were only influenced by emotional expression. When participants focused on the age of the faces, implicit evaluations were only influenced by age and not emotional expression.

Studies investigating the interaction of age cues and emotion are not the only ones to draw inconsistent conclusions regarding the nature of the interaction between variant and invariant facial cues. Studies looking at the interaction of race or sex and emotion have also produced inconsistent results. For example, studies assessing the processing of race and emotion have found evidence for independent processing in speeded categorisation tasks and ERPs (Kubota & Ito, 2007), whereas asymmetrical interactions have been observed in one direction in the Garner paradigm (Karnadewi & Lipp, 2011) and in the other direction in visual search (Lipp et al., 2014) and affective priming (Craig et al., 2014). These findings suggest that the nature of the interaction between social category cues and emotional expressions may differ as a function of the psychological processes engaged by the task necessitating research investigating the nature of the interaction age and emotion using a range of different methods.

As such, the first aim of the current investigation was to determine the nature of the interaction between age cues and emotional expression (independent, asymmetrical, or symmetrical) using speeded categorisation tasks. Consistent with previous research investigating

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the interaction of race or sex cues and emotional expression, participants categorised young and older adult faces expressing happiness and anger (Experiment 1) or sadness (Experiment 2) by their age and their emotional expression. Based on the most similar previous study investigating the interaction of age cues and emotional expression (Karnadewi & Lipp, 2011), an asymmetrical interaction was predicted. It was expected that age cues would influence emotion categorisation in the absence of an influence of emotion on age categorisation.

Beyond examining the nature of the Age × Emotion interaction using a different method, the second aim of the study was to identify the mechanism underlying the influence of age cues on emotional expression perception or vice versa should an interaction be observed. Past research has proposed a number of mechanisms to explain the influence of age on emotion recognition (see Fölster, Hess, & Werheid, 2014 for a review) and other studies have described possible mechanisms to explain a reciprocal influence of emotional expressions on age perception (e.g., Miller et al., 2010; Sacco & Hugenberg, 2009).

The speeded categorisation method, and in particular, comparing the influence of age cues on categorisation of happiness vs. anger, and happiness vs. sadness allows us to distinguish between a number of mechanisms that may underlie an influence of age on emotion categorisation or vice versa (see Becker et al., 2007; Craig, Koch, & Lipp, 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006; Miller, Maner, & Becker, 2010 for use of this approach). The evaluative congruence account proposes that participants first spontaneously categorise and evaluate faces based on their age and young adult faces are evaluated as positive relative to older adult faces (Craig et al., 2014; Nosek, Greenwald, & Banaji, 2005). This positive evaluation facilitates the categorisation of positive expression but can slow the categorisation of negative expressions. As such, young happy faces should be categorised faster than old happy faces and/or young angry and sad faces (see Craig et al., 2017; Hugenberg & Sczesny, 2006 for comparable influences of race and sex cues on emotion categorisation). There may also be evidence for an old angry advantage; however this has not typically been observed in other studies where race and sex based evaluations have been found

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to influence emotion categorisation (Craig et al., 2017; Hugenberg & Sczesny, 2006). This is perhaps because a small default happy advantage exists for all faces that is accentuated or reduced in size by the positive or negative evaluation of the social category. This would make a reversal of the small happy advantage less likely. If the influence of age cues on emotion recognition is driven by overlapping facial structural information, a categorisation advantage for old vs. young angry and old vs. young sad faces should emerge as facial maturity cues (i.e., small eyes and narrow faces) have been structurally associated with anger (Sacco & Hugenberg, 2009) and age related facial wrinkles have been structurally associated with sadness (Malatesta & Izard, 1984). Under this account, no young happy advantage should be observed as cues of youth have not been found to improve recognition of happiness (Hass et al., 2015). If the influence of age on emotion categorisation is driven by age related stereotypes, an advantage for categorising old sad vs. young sad faces, but an advantage for categorising young angry vs. old angry faces should be observed as sadness is more stereotypically associated with older adults than young adults but anger is more stereotypically associated with young adults than older adults (Montepare & Dobish, 2014).

Based on previous research, it was predicted that the congruence between implicit age based evaluations and the valence of emotional expressions would best explain the influence of age cues on the categorisation of emotional expressions (Craig et al., 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006). Young happy faces should be categorised faster than old happy faces and/or young angry and sad faces. In the age categorisation tasks, it was predicted that older adult faces (an age out group) would be categorised faster than young adult faces (Johnston, Kanazawa, Kato, & Oda, 1997). The prediction of an asymmetrical interaction meant that no influence of emotional expression on age categorisation was expected.

Experiment 1

Methods

Participants. Previous studies investigating the influence of social category cues like race or sex on emotion categorisation and vice versa have typically recruited around 28-32 participants

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(e.g., Aguado et al., 2009; Lipp, Craig, & Dat, 2015); as such, 32 undergraduate volunteers at The University of Queensland (5 Males, $M = 19.31$, $SD = 4.86$) participated in Experiment 1. Participants were compensated with partial course credit.

Stimuli. All stimuli were gathered from the FACES database (Ebner et al., 2010). Both the happy and the angry expression displayed on eight older and eight young adult male faces were selected (older adult posers 004, 015, 033, 042, 053, 059, 065, 076, young adult posers 008, 013, 016, 031, 037, 049, 057, 072). These images were edited to remove the neck and clothing so just the head remained. They were then converted to greyscale and placed on a grey background 340 × 390 pixels in size.

Procedure. The experiment took place in a group computer laboratory with no more than six participants taking part within a testing session. Each participant was seated in front of a 17" CRT monitor (screen resolution: 1024 × 786 pixels, refresh rate: 85 Hz). Participants completed two categorisation tasks which were executed by DMDX (Forster & Forster, 2003). They were instructed that faces would appear on the screen one at a time. For the age categorisation task, participants were instructed to categorise the face as 'old' or 'young'. No further instructions were provided to participants to indicate how old or young the faces in each age group would be; however, high accuracy in the age categorisation task suggests that participants accurately distinguished the faces in the manner intended. In the emotion categorisation task, participants were instructed to categorise the faces as 'happy' or 'angry'. They were asked to respond as quickly and accurately as possible. Instructions were presented on the computer screen in writing and also given verbally. Responses were made using the right and left shift keys on a standard keyboard and response mapping and task order were counterbalanced across participants.

On each trial, a white fixation cross was presented on a black background in the centre of the screen for 1000ms. This was replaced by a single face which was presented until a response was made or for 3000ms. Response times were measured from the onset of the stimulus until a response was made. In both the emotion and the age categorisation task, participants were presented with all

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16 individuals (eight older adult and eight young adult) expressing happiness and anger. Each poser was presented expressing happiness and anger four times resulting in 128 trials in each task.

Data reduction and analysis. Responses faster than 100ms or faster or slower than three standard deviations from each participant's mean response time were identified as outliers and excluded from analysis along with incorrect responses. Average response times and error rates were then submitted to separate 2 (Age: young, old) × 2 (Emotion: happy, angry) repeated measures ANOVAs, for the emotion and the age categorisation tasks. As previous research in our lab (Craig & Lipp, 2017) has indicated that performance on tasks of this nature can be influenced by recently completed tasks, we analysed for task sequence effects in each experiment. The results of these analyses were reported only if task sequence affected the pattern of results.

Results

Emotion categorisation.

Response times. As seen in Figure 1a, participants were faster to categorise emotional expressions on young than older adult faces, $F(1, 31) = 56.56$, $p < .001$, $\eta_p^2 = .65$. There was no main effect of emotion, $F(1, 31) = 0.90$, $p = .350$, $\eta_p^2 = .03$; however, a significant Age × Emotion interaction emerged, $F(1, 31) = 6.80$, $p = .014$, $\eta_p^2 = .18$[1]. Participants were faster to categorise happiness on young than on older adult faces, $t(31) = 5.11$, $p < .001$, but this difference was not observed when categorising anger, $t(31) = 1.42$, $p = .166$. Following up the interaction the other way, participants were faster to categorise happiness than anger on young faces, $t(31) = 2.46$, $p = .020$, but not on old faces, $t(31) = 1.23$, $p = .229$.

[1] Task sequence influenced performance in the emotion task (Task sequence × Emotion interaction, $F(1, 30) = 8.54$, $p = .007$, $\eta_p^2 = .22$, as well as a marginally significant Task sequence × Age × Emotion interaction, $F(1, 30) = 3.55$, $p = .069$, $\eta_p^2 = .11$). This marginal three way interaction was followed up by looking at the pattern of results separately for the two task sequences. Those who completed the emotion categorisation task first, were significantly faster to categorise expression on young than older adult faces, $F(1, 15) = 22.55$, $p < .001$, $\eta_p^2 = .60$. The Age × Emotion interaction was also significant, $F(1, 15) = 6.81$, $p = .020$, $\eta_p^2 = .31$, indicating faster recognition of happiness on young than on older adult faces, $t(15) = 3.76$, $p = .002$, but no difference in the speed of recognising anger as a function of the age of the face, $t(15) = 0.19$, $p = .853$. Those who completed the age categorisation task first were significantly faster to categorise happiness than anger regardless of the age of the face, $F(1, 15) = 10.02$, $p = .006$, $\eta_p^2 = .40$, and were significantly faster to categorise expressions displayed by young adults than older adults, $F(1, 15) = 38.70$, $p < .001$, $\eta_p^2 = .72$. There was, however, no significant interaction of face age and emotional expression, $F(1, 15) = 0.77$, $p = .395$, $\eta_p^2 = .05$.

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Accuracy. As can be seen in Table 1, participants were significantly more accurate when categorising expressions on young than on older adult faces, $F(1, 31) = 4.74$, $p = .037$, $\eta_p^2 = .13$. There was no difference in how accurately happy and angry expressions were categorised and the interaction of age and emotion was not significant, Fs < 0.92, ps > .345, suggesting the pattern of categorisation times was not due to a speed accuracy trade off.

Age categorisation.

Response times. As can be seen in Figure 1b, participants were significantly faster to categorise faces as old than as young, $F(1, 31) = 8.19$, $p = .007$, $\eta_p^2 = .21$. The main effect of emotion and the Age × Emotion interaction were not significant, Fs < 0.06, ps > .815.

Accuracy. There were no significant main effects and no interaction of age and emotional expression, all Fs < 2.51, ps > .123. Inspection of error rates suggests a numerical trend for fewer errors made categorising the age of older adult than young adult faces.[2]

Discussion

As predicted, consistent with Karnadewi and Lipp (2011), an asymmetrical interaction was observed. The results from Experiments 1 and the replication described in the footnote demonstrate that facial age cues moderate emotion categorisation performance in the absence of an influence of emotional expression on age categorisation. This finding suggests that age cues are obligatorily processed in emotion labelling tasks but emotional expressions are not obligatorily processed prior to age judgements. Specifically, a young happy advantage emerged. Young happy faces were

[2] Previous research has demonstrated that the number of stimuli used in a task can influence the interaction between emotional expression and sex cues (Lipp, Karnadewi, et al. 2015). To determine whether stimulus set size influenced the nature of the Age × Emotion interaction, 61 participants (15 Males, $M = 24.43$, $SD = 4.89$) took part in a replication of Experiment 1; however only two young and two older adult faces were used and participants saw only one older adult and one young adult face in each task. As in Experiment 1, participants were, faster to categorise emotional expressions on young than older adult faces, $F(1, 60) = 12.25$, $p = .001$, $\eta_p^2 = .17$. There was, overall, no difference in categorisation times for happy and angry expressions, $F(1, 60) = 0.01$, $p = .943$, $\eta_p^2 < .01$. However, there was an Age × Emotion interaction, $F(1, 60) = 4.39$, $p = .040$, $\eta_p^2 = .07$. Participants were significantly faster to categorise happiness on young ($M = 548.68$, $SD = 87.30$) than older adult faces ($M = 580.78$, $SD = 121.62$), $t(60) = 4.65$, $p < .001$, but the age of the face did not affect categorisation of anger, $t(60) = 1.69$, $p = .097$ (young adult $M = 558.58$, $SD = 93.56$, older adult $M = 570.22$, $SD = 103.73$). In the age categorisation task, data from one participant were not included in analysis as their error rate approached chance. Participants were significantly faster to categorise old ($M = 466.32$, $SD = 69.50$) than young faces ($M = 480.23$, $SD = 88.20$), $F(1, 59) = 7.92$, $p = .007$, $\eta_p^2 = .12$. The main effect of emotion as well as the Age × Emotion interaction were not significant, Fs < 1.60, ps > .211.

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categorised faster than young angry faces and/or old happy faces. No evidence for an old angry advantage was observed as old angry expressions were not categorised faster than old happy expressions or young angry expressions. The evaluative congruence between relatively positive evaluations of young relative to old faces and the valence of happy compared with angry expressions facilitating categorisation provides the most likely explanation for these results and this explanation is consistent with the mechanism proposed to explain very similar influences of race and sex cues on emotion categorisation (e.g., Craig et al., 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006). It is unlikely that the overlap between facial structure cues indicating old age and anger explains the moderating influence of age cues on emotion categorisation as the old angry advantage predicted under this account was not observed. Age related emotion stereotypes also seem unlikely to explain the pattern observed as previous research suggests that anger is stereotypically more associated with young adults than older adults (Montepare & Dobish, 2014) but no evidence for a young angry advantage was observed. Despite this preliminary evidence for the evaluative congruence account, Experiment 2 aimed to more directly test the potential influence of stereotypes using sadness rather than anger: a negative expression stereotypically associated with older adults (Montepare & Dobish, 2014). If age based stereotypes drive the influence of age on emotion categorisation, an old sad advantage should be observed. This additional experiment can also confirm whether the asymmetrical interaction of age and emotional expression observed in Experiment 1 will generalise to a task using a different negative expression.

Experiment 2

Method

Participants. As in Experiment 1, we aimed to sample 28-32 participants. This resulted in a sample of 28 undergraduate students at Curtin University (12 Males, $M = 21.56$, $SD = 5.78$) who received partial course credit in return for their participation.

Stimuli. Photographs of the same young and old posers used in Experiment 1 expressing sadness were selected from the FACES database (Ebner et al., 2010) and edited in the same manner

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described above. These sad expressions were presented along with the happy expressions presented in Experiment 1.

Procedure, data reduction and analysis. The experiment took place in a testing laboratory with participants seated in separate enclosable cubicles. The experiment was presented on a 22" LED monitor (screen resolution: 1680 × 1050 pixels, refresh rate: 60Hz). As in Experiment 1, participants completed the age and the emotion categorisation tasks in a counterbalanced order. In the emotion categorisation task, participants were asked to categorise the faces as 'happy' or 'sad' rather than 'angry'. Apart from these differences, the experiment proceeded in the same way as Experiment 1.

Results

Emotion categorisation.

Response times. As seen in Figure 2a, participants were faster to categorise expressions on young adult faces than on older adult faces, $F(1, 27) = 17.\ 24$, $p < .001$, $\eta_p^2 = .39$. They were also significantly faster to categorise happy than sad expressions, $F(1, 27) = 15.73$, $p < .001$, $\eta_p^2 = .37$. These main effects were moderated by a significant Age × Emotion interaction, $F(1, 27) = 4.67$, $p = .040$, $\eta_p^2 = .15$. Participants were significantly faster to categorise happiness on young than on old faces, $t(27) = 3.57$, $p = .001$, but were no faster to categorise sad expressions on young or old faces, $t(27) = 0.52$, $p = .611$. Following up the interaction the other way, participants were faster to categorise happiness than sadness on young faces, $t(27) = 4.78$, $p < .001$, but there was no happiness or sadness advantage for older adult faces, $t(27) = 1.42$, $p = .167$.

Accuracy. The main effects of age and emotion and the Age × Emotion interaction were not significant Fs < 1.97, $p > .172$. However, the pattern of errors (see Table 1) was generally consistent with response times.

Age categorisation.

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Response times. Participants were marginally faster to categorise old than young faces by their age, $F(1, 27) = 3.68$, $p = .066$, $\eta_p^2 = .12$. There was no significant emotion main effect or Age × Emotion interaction, Fs < .01, ps > .926, (see Figure 2b).

Accuracy. No significant effects emerged in error rates, Fs < 2.28, $p > .143$, as can be seen in Table 1.

Discussion

Again, an asymmetrical interaction of age and emotion was observed. Age cues influenced how quickly emotional expressions were categorised in the absence of a moderating influence of emotional expressions on age categorisation. The way age cues influenced emotion categorisation was consistent with the evaluative congruence account (Craig et al., 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006). Participants were faster to categorise happiness on young adult faces than on older adult faces, and faster to categorise happiness than sadness on young faces. There was no indication of an influence of stereotypes or overlapping structural cues as no association between old age and sadness was observed in response times. Sad expressions were not categorised faster on older adult than on young adult faces, and there was no indication that sadness was categorised faster than happiness on old faces.

General Discussion

The aim of the current study was to investigate the nature of the interaction between facial age cues and emotional expressions within the speeded categorisation paradigm, and to identify the mechanism underlying the influence of age cues on emotional expression or vice versa if an interaction was observed. The results of each experiment suggested that age cues and emotion interact asymmetrically when young and older adult faces expressing happiness and anger or sadness were presented within the speeded categorisation paradigm. Age cues moderated the speed of categorising happiness vs. anger and sadness in the absence of an influence of emotional expression on age categorisation. Finally, older adult faces tended to be categorised by age faster than young adult faces.

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Finding an asymmetrical interaction where age cues moderate emotion categorisation in the absence of an influence of emotional expression on age perception is consistent with the findings of Karnadewi and Lipp (2011). It is also similar to the results of a study by Atkinson et al. (2005), who found an asymmetrical interaction of sex and emotional expression in the Garner paradigm. Together these studies provide a body of evidence to suggest that social category cues interact asymmetrically with emotional expression in categorisation type tasks such that social category cues influence emotion perception but not vice versa (but see Aguado et al., 2009; Lipp, Karnadewi, et al., 2015 for evidence of a symmetrical interaction between sex and emotion in speeded categorization tasks under some circumstances).

This finding of an asymmetrical interaction of social category cues and emotional expressions is not consistent some influential models of face processing. Bruce and Young's (1986) proposal that invariant aspects of the face like social category cues are processed independently from variant aspects of the face like emotional expression was not supported in the current findings. The findings were more consistent with Haxby et al.'s (2000, 2002) proposal that different aspects of the face could interact; however, the Haxby et al. model remained agnostic as to the nature (symmetrical or asymmetrical) or direction of these interactions. As such, the current study and recent research (Atkinson et al., 2005; Lipp, Karnadewi, et al., 2015; Karnadewi & Lipp, 2011) can extend our understanding of face processing beyond this model.

Finding that social category cues influence emotion processing in the absence of an influence of emotional expression information on social category processing in the current study and in previous investigations suggests that social category cues are processed obligatorily prior to the emotion judgement. Emotional expressions, on the other hand, are not obligatorily processed in tasks of this nature or are not processed quickly enough to influence age judgements. These finding highlight the need for future face processing models to consider the time course of processing different aspects of the face or the degree to which different facial cues are prioritised to fully account for the asymmetrical interactions observed.

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It is also interesting to note here that the majority of studies finding an influence of emotional expression particularly on race and age perception observed this influence when the race or age of the target stimulus was ambiguous (e.g., Hugenberg & Bodenhausen, 2004; Hutchings & Haddock, 2008; Völkle et al., 2012). For example, Hugenberg and Bodenhausen (2004) and Hutchings and Haddock (2008) found an influence of emotion on race perception when the faces used were racially ambiguous rather than clearly representative of one racial group. Similarly, Völkle et al. (2012), found an influence of emotion on age perception when participants had to estimate the age of the individual in years, a judgement with a degree of uncertainty, rather than classifying faces that were clearly distinct in age as was the case in the current study. Finding an influence of age cues on emotion perception, but not vice versa, may occur as emotional expressions are expected to vary from moment to moment and gaining a nuanced understanding of a person's internal states often requires the observer to incorporate further information like surrounding context and bodily cues (e.g., Aviezer et al., 2008), as well as the other social information on the face. On the other hand, social categories like race, sex, and age, are relatively invariant and additional contextual information is not routinely required to make accurate social categorisations.

Potential Mechanisms

Beyond merely documenting the nature of the interaction between age cues and emotional expression, the categorisation paradigm allowed us to identify a potential mechanism underlying the observed influence of age on emotion perception from a number of candidates that have been proposed (see Fölster et al., 2014 for a review). As eye-tracking was not used in the current study, it could not be determined whether differences in scan patterns for older and young adult faces mediated the effects of age cues on emotion perception (Ebner et al., 2011). However, it is unlikely that the current results reflect age dependent differences in emotional expressiveness of the posers (Borod et al., 2004) or differences in participants' expertise processing young and older faces (Ebner & Johnson, 2009; Rhodes & Anastasi, 2012). Firstly, the faces used in all experiments were

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from the FACES database which only contains expressions that were rated as highly intense (Ebner et al., 2010) removing any differences in poser expressivity. Secondly, overall differences in the expressivity of older and younger adult faces or difference in experience interacting with older and younger adults should have produced slower emotion categorisation times for old than young faces regardless of expression.

A further possibility was that age related changes in the physical structure of the face may have influenced the interaction of age and emotional expression. The presence of folds, wrinkles, and reduced muscle tone in the face may reduce the signal quality of the facial expression (Hess, Adams, Simard, Stevenson, & Kleck, 2012). Similar to the influence of reduced expressivity, this should only have resulted in slower categorisation times for expressions presented on older adult faces, and not in the interaction of age and emotion that was observed unless the reduction in signal quality only occurred for some expressions.

Age related skin and muscle tone changes may also lead faces to more closely resemble particular emotions, for example, wrinkles and downturned mouth corners that occur with old age may have made faces appear sadder (Malatesta & Izard, 1984) or as reported by Sacco and Hugenberg (2009), smaller eyes and narrower faces associated with facial maturity may have made faces more easily recognisable as angry. The pattern of responses in the emotion categorisation task did not support this account. If categorisation times were influenced by age related changes in the face, we would have seen faster categorisation of anger and sadness expressed by older adults, but this did not occur in either of the experiments.

Finally, stereotypes and attitudes towards younger and older adults have been proposed as a mechanism underlying the influence of age cues on emotion perception (Ebner & Johnson, 2009). As mentioned previously, expressing anger has been reported to be counter-stereotypic for older adults whereas expressing sadness is stereotypically associated with old age (Montepare & Dobish, 2014). Given that no sadness advantage was observed for older faces in Experiment 2 and no anger

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advantage was observed for young adults in Experiment 1, it is unlikely that the activation of age related emotion stereotypes influenced emotion perception in the current tasks.

The most parsimonious explanation of the pattern of results observed across experiments is the evaluative congruence account (Craig et al., 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006). It is likely that young adult faces were implicitly evaluated as pleasant relative to the older adult faces (e.g., Craig et al., 2014; Nosek et al., 2005) and the congruence between positive evaluations of young adults and happy expressions facilitated categorisation of emotion on young happy faces relative to young angry/sad or old happy faces. These findings are consistent with previous studies looking at the influence of race and sex cues on emotion recognition (e.g., Craig et al., 2017; Hugenberg, 2005; Hugenberg & Sczesny, 2006). This is not to say that the other proposed mechanisms do not play a role in the perception of faces, but within the constraints of speeded categorisation tasks used in the current investigation, implicit evaluations of age cues influencing emotion categorisation seems most likely to account for the results observed.

Other Implications

Although, we were mainly interested in whether emotional expressions influence age categorisation and vice versa, it was interesting to find that older adult faces were categorised by age faster than young faces. This is consistent with the finding that young adults are faster to categorise children's faces than young adult faces by their age (Johnston et al., 1997). It also resembles the other race categorisation advantage reported in the race perception literature (Levin, 1996, 2000; Valentine & Endo, 1992; Zhao & Bentin, 2008). It has been suggested that these other-race and other-age categorisation advantages reflect differences in the way that ingroup and outgroup faces are processed. When other age and other race faces are encountered, they are processed in less detail with attention to category specifying information whereas own age and own race faces are processed in more detail with attention to individuating information explaining the slight slowing in categorisation times (see Levin 1996, 2000; Hugenberg, Young, Bernstein, & Sacco, 2010).

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Consistent with recent findings in our lab (Craig & Lipp, 2017), it is also interesting to note that the sequence in which the emotion and age categorisation tasks were completed influenced how cues of age moderated emotion categorisation in Experiment 1. An interaction of age and emotional expression was observed for participants who completed the emotion categorisation task first, but not for those who completed the age categorisation task first. This finding suggests that engaging in age categorisation may eliminate the moderating influence of this social category cue on subsequent emotion perception under some circumstances. However, this task sequence effect was not observed in Experiment 2 or in the experiment described in the footnote. Failure to consistently observe this sequence effect may indicate that it is a spurious result. It is also possible that the task sequence effect is small and that we did not sampling enough participants to have a good chance of reliably finding the effect. Alternatively, there may be boundary conditions for the task sequence effect. For example, these effects may only be observed when a sufficiently large stimulus set is used as an influence of task sequence was observed in experiments with larger stimulus sets like in the current investigation and also by Craig and Lipp (2017), but not for the small stimulus set in the experiment described in the footnote. It is also possible that the task sequence effect occurs for some emotional expressions but not others as it was observed when participants categorised happiness vs. anger in the current study (Experiment 1) and in the study by Craig and Lipp (2017), but not when participants categorised happiness vs. sadness in Experiment 2. Further research is required to determine the replicability of this finding and to identify the circumstances under which social categorisation may alter the influence of age on subsequent emotion perception.

Finally, it was interesting to find that the number of stimuli used in the age and emotion categorisation tasks did not influence the nature of the interaction between facial age cues and emotional expression (see Experiment 1 and footnote). An asymmetrical interaction was observed using a small number of stimuli as well as a larger number of stimuli in each task. This is in contrast with the findings of Lipp, Karnadewi and colleagues (2015), who found that sex and emotion cues interacted symmetrically when a larger number of stimuli were used, but not when as smaller

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number of stimuli were used. We may only speculate as to why this is the case. One possibility is that the way sex and age cues interact with emotion is different. This is in line with the finding that the Age × Emotion interaction observed in the Garner paradigm was not altered by inverting the faces, but the Sex × Emotion interaction was (Karnadewi & Lipp, 2011). Beyond this, there were a number of methodological differences between the current investigation and the investigation by Lipp, Karnadewi, and colleagues (2015). For example, in the current study the same individuals were encountered expressing happiness and anger/sadness whereas different individuals were used to represent happiness and anger in the previous study. This may have changed the difficulty of the task and altered the nature of the interaction. In the current study, only one participant from 61 was not included in analysis of the age task due to high error rates. In the previous investigation (Lipp, Karnadewi, et al., 2015), as many as 30% of participants were excluded from analysis in one task using a small stimulus set as they categorised a female as a male or vice versa 100% of the time. If participants found even one face ambiguous but did manage to correctly categorise it most of the time or they implicitly processed a female as a male or vice versa during the emotion categorisation task, this could potentially influence the response times for all the trial in one condition and alter the typical interaction pattern observed. This highlights the benefit of using larger stimulus sets to investigate the interaction of multiple facial cues. With the use of a larger stimulus set, the influence of a few ambiguous or atypical stimuli on the overall pattern of response times would be reduced. A more systematic investigation will be required to pinpoint the exact source of the differing influences of small vs. larger stimulus set sizes on the interaction of multiple facial cues.

Future Directions

Further research will be required to determine whether the asymmetrical interaction between facial age cues and emotional expressions found here generalises across different types of tasks that tap different psychological processes as well as to faces expressing different emotions such as fear, or disgust (although see Craig et al., 2017, for a demonstration that the evaluative congruence account explains the influence of race and sex cues on emotion categorisation for a range of

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relatively negatively valenced emotions). It will also be necessary to investigate how facial age and emotion cues interact in samples of other ages. In the current investigation all participants were young adults (under 31). It would be interesting to see how the effects observed may differ for older adult participants who have accumulated life experience processing faces of a range of different age groups and to see whether an ingroup positivity bias is observed or whether the societal association of young adults as positive influences the speed of emotion recognition even in older adult samples. Further research is also needed to determine whether these results hold for female faces or for faces from other racial groups. Recent research has demonstrated that the influence of social category cues like race and sex on emotion perception can depend on a range of factors including the other faces presented within the task. For example, we observed a happy categorisation advantage for White male faces when these faces were categorised along with male other race faces, but not when these same faces were categorised along with female faces (Lipp, Craig, & Dat, 2015). It is possible that the influence of age cues on emotion perception is similarly sensitive to context. As such, further research looking at when and how particular facial cues interact is necessary.

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Figures and Tables

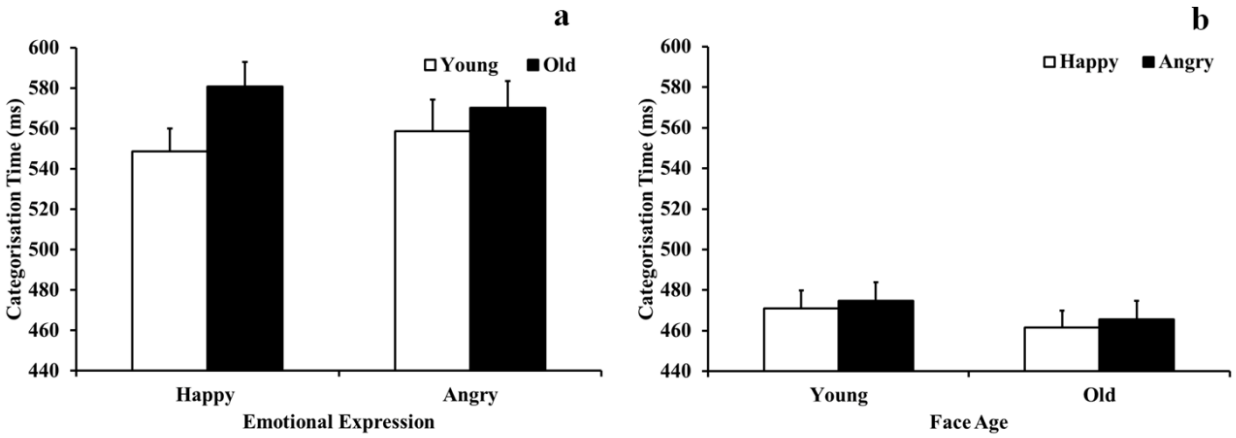

Figure 1. Figure 1 presents categorisation times as a function of the age and emotional expression of the face for the emotion categorisation task (a) and the age categorisation tasks (b) in Experiment 1. In the emotion task, categorisation speed was moderated by the age of the faces. Participants were faster to categorise happiness, but not anger, on young than on old faces. In the age categorisation task, participants were faster to categorise old than young faces, but this effect was not moderated by the emotional expression present on the face. Error bars represent one SEM.

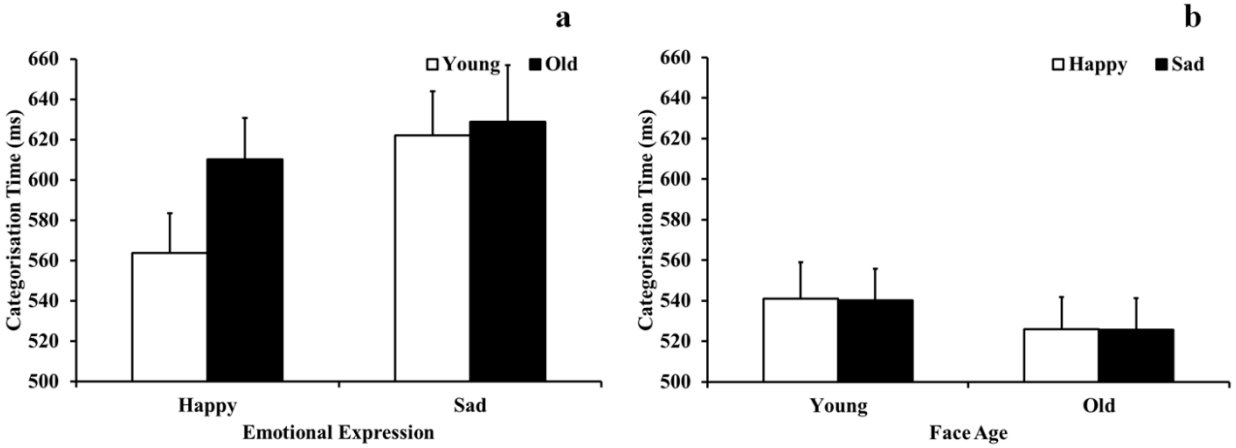

Figure 2. Figure 2 presents categorisation times as a function of the age and emotional expression of the face for the emotion categorisation task (a) and the age categorisation task (b) in Experiment 3. In the emotion task, categorisation speed was moderated by the age of the faces. Participants were faster to categorise happiness, but not sadness, on young than on old faces. In the age categorisation task, participants were marginally faster to categorise old than young faces, and this effect was not moderated by the emotional expression present on the face. Error bars represent one SEM.

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Table 1
Mean error percentages and standard deviations as a function of the age and the emotional expression present on the face for the age and emotion categorisation tasks in Experiments 1 and 2.

	Young Adult Face		Older Adult Face	
Condition	M	SD	M	SD
Experiment 1				
Emotion Categorisation Task				
Happy	3.61	5.15	4.98	4.75
Angry	2.93	3.17	4.49	4.82
Age Categorisation Task				
Happy	4.39	5.66	3.03	3.32
Angry	4.10	4.92	2.93	3.72
Experiment 2				
Emotion Categorisation Task				
Happy	2.79	3.93	4.69	5.28
Sad	3.24	4.29	3.13	2.82
Age Categorisation Task				
Happy	2.79	3.44	1.56	1.99
Sad	2.23	2.38	2.12	2.83

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