Effects of age on the identification of emotions in facial expressions: A meta-analysis

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Background. Emotion identification is a fundamental component of social cognition. Although it is well established that a general cognitive decline occurs with advancing age, the effects of age on emotion identification is still unclear. A meta-analysis by Ruffman and colleagues (2008) explored this issue, but much research has been published since then, reporting inconsistent findings.

Methods. To examine age differences in the identification of facial expressions of emotion, we conducted a meta-analysis of 24 empirical studies ($N = 1033$ older adults, $N = 1135$ younger adults) published after 2008. Additionally, a meta-regression analysis was conducted to identify potential moderators.

Results. Results show that older adults less accurately identify facial expressions of anger, sadness, fear, surprise, and happiness compared to younger adults, strengthening the results obtained by Ruffman et al. (2008). However, meta-regression analyses indicate that effect sizes are moderated by sample characteristics and stimulus features. Importantly, the estimated effect size for the identification of fear and disgust increased for larger differences in the number of years of formal education between the two groups.

Discussion: We discuss several factors that might explain the age-related differences in emotion identification and suggest how brain changes may account for the observed pattern. Furthermore, moderator effects are interpreted and discussed.

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24 **Abstract**

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31 conducted a meta-analysis of 24 empirical studies ($N = 1033$ older adults, $N = 1135$ younger

32 adults) published after 2008. Additionally, a meta-regression analysis was conducted to identify

33 potential moderators.

34 **Results.** Results show that older adults less accurately identify facial expressions of anger,

35 sadness, fear, surprise, and happiness compared to younger adults, strengthening the results

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37 are moderated by sample characteristics and stimulus features. Importantly, the estimated effect

38 size for the identification of fear and disgust increased for larger differences in the number of

39 years of formal education between the two groups.

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41 identification and suggest how brain changes may account for the observed pattern. Furthermore,

42 moderator effects are interpreted and discussed.

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Introduction

47

48   Emotion identification is defined as the "ability to visually analyze the configuration of

49 facial muscle orientations and movements in order to identify the emotion to which a particular

50 expression is most similar" (Wilhelm et al., 2014, p. 3) and is a central component of nonverbal

51 communication. The ability to accurately identify emotional expressions is essential for

52 successful interpersonal functioning throughout the life span (Carstensen, Gross, & Fung, 1997).

53 The interpretation of the emotions that others are experiencing is important to avoid conflict and

54 provide social support. Emotion identification ability is also fundamental to regulate behavior

55 such as selectively attending and approaching to positively stimuli to elicit positive feelings and

56 avoid negative ones (Gross, Richards, & John, 2006). Importantly, presenting facial emotional

57 stimuli is a valid and reliable approach in order to activate brain areas crucial for emotion

58 processing (Fusar-Poli et al., 2009) and emotion identification tasks have been used in studies

59 assessing emotional processing (Ebner & Johnson, 2009; Gonçalves et al., 2018; Grady,

60 Keightley, Hongwanishkul, Lee, & Hasher, 2007; Mienaltowski, Corballis, Blanchard-Fields,

61 Parks, & Hilimire, 2011; Williams et al., 2006).

62   A substantial body of research proposes an age-related "positivity effect" (Mather &

63 Carstensen, 2005), defined as a tendency for older adults to attend to, and better memorize

64 positive information relative to neutral and negative stimuli. According to the Socio-emotional

65 Selectivity Theory (Carstensen, Isaacowitz, & Charles, 1999), significant developmental changes

66 occur in older adults' regulation and processing of affect. In this sense, the theory attributes the

67 "positivity effect" to a motivational shift toward emotional regulation goals (i.e., achieving

68 positive affect) as older adults begin to view their lifetime as limited (Carstensen et al., 1999).

69 An alternative theoretical account of the age-related positivity effect, the dynamic integration

70   theory, posits that greater cognitive demands required to process negative information lead older

71   adults to automatically and preferentially process positive information (Labouvie-Vief, 2003).

72   A vast set of the literature shows emotion identification deficits in older adults (e.g.

73   Isaacowitz et al., 2007; Sullivan and Ruffman, 2004). Furthermore, Ruffman and colleagues

74   (2008) performed a meta-analysis to examine age differences in emotion identification across

75   four modalities – faces, voices, bodies/contexts, and matching of faces to voices. Specifically in

76   faces modality, Ruffman and colleagues (2008) found an age-related decline across all emotions,

77   except for disgust. However, the mean effect sizes in the faces modality range from 0.07 to 0.34

78   across all emotions, reflecting inconsistencies among findings in the studies included. Following

79   studies (García-Rodríguez et al., 2009; Orgeta, 2010; Suzuki & Akiyama, 2013) also reported

80   inconsistent findings, showing an age-related decline only in the identification of anger and fear

81   (García-Rodriguez et al., 2009) and anger and sadness (Orgeta, 2010), that raise again questions

82   about the effects of age on emotion identification.

83   Human aging is accompanied by the decline of various cognitive abilities (for a review,

84   see Salthouse, 2009). For example, sustained attention and working memory decrease with age

85   (Gazzaley et al., 2007; Park et al., 1996). Importantly, these cognitive abilities seem to be

86   relevant to the performance in emotion identification tasks (Lambrecht, Kreifelts, & Wildgruber,

87   2012). Furthermore, aging has been linked to a gradual reduction in visual acuity (Caban et al.,

88   2005; Humes et al., 2009). Despite the well-known age-related decline in certain cognitive and

89   sensory functions and its possible influence on emotion identification, the effects of age on

90   emotion identification abilities remain unclear.

91   Analyzing studies published after 2008, the present meta-analysis aims to clarify whether

92   age-related difficulties in identifying facial emotional expressions exist, quantify the magnitude

93   of age effects observed and identify potential moderators.

94   There are several factors known to influence the identification of facial expressions.

95   Specifically, studies focusing on emotional facial expressions support the idea of a female

96   advantage in emotion identification (Hall & Matsumoto, 2004; Montagne et al., 2005; Williams

97   et al., 2009). Furthermore, participants with no college education (M_{age}= 35.5, SD = 13.1, range

98   = 19-69 years) were more likely to select the correct label for anger and sadness, than were those

99   with a college degree (M_{age} = 33.9, SD = 11.0, range = 19-64 years). For fear and disgust, the

100   opposite pattern was reported (Trauffer et al., 2013). Besides participants characteristics,

101   stimulus features need to be considered when analyzing different studies of emotion perception.

102   For instance, color has been reported to improve the perception of general emotional clues

103   (Silver & Bilker, 2015). Additionally, dynamic stimuli can be more accurately recognized than

104   the static ones as shown by behavioral studies (Ambadar, Schooler & Cohn, 2005). Considering

105   that most real-word emotion recognition involves motion of the perceiver and the target rather

106   than looking at pictures, using dynamic stimuli in research makes sense (Isaacowitz & Stanley,

107   2011). Another element that may contribute to the differential interpretation of static and

108   dynamic facial expressions is motivation, particularly in older adults, since a static photo may

109   create a perception of an overly artificial task, as well as very different from daily life, so that

110   older adults may not engage sufficiently to perform well (Isaacowitz & Stanley, 2011). Given

111   these evidences, the variables sex, level of education of participants, and stimulus features

112   (virtual vs natural, color vs black and white, static vs dynamic) were tested as moderators of any

113   age effects observed. We expected to find larger effects for larger differences in the mean years

114   of education between the groups to be compared, as well as for higher percentage of female

115   participants and dynamic colored pictures of faces. With the present study, we will clarify how

116   emotion identification of facial expressions changes along aging and identify potential

117   moderators.

118

119   **Materials & Methods**

120   **Literature search**

121   A computer-based search of the PubMed, Web of Knowledge, and EBSCOhost

122   (including the Academic Search Complete, PsycARTICLES, Psychology and Behavioral

123   Sciences databases) was conducted in October 2017 by two researchers (ARG, CF). The search

124   expression was "(aging OR ageing OR "older adults" OR elderly) AND ("emotion recognition*"

125   OR "emotional processing" OR "emotion identification")". The search was limited to titles and

126   abstracts, published in English in the last nine years. In PubMed the filter "Humans" was also

127   used. A total of 1580 non-duplicated articles were found. Additionally, the references of the

128   included articles were searched manually to identify other relevant studies ($n = 20$).

129   **Selection criteria**

130   Studies assessing emotion identification in healthy younger ($20 \leq$ mean age ≤ 35) and older

131   adults (mean age ≥ 55 years old) were included (criterion 1). Also, only studies that allowed

132   effect size data (i.e., sample sizes, means, and standard deviations) to be directly recorded,

133   calculated, or measured (i.e., from a graph) were included. Authors were contacted if effect sizes

134   could not be obtained from the published data. Ten studies that did not present descriptive

135   statistics and the information requested was not provided, were excluded (criterion 2). Studies

136 that did not guarantee the neurological and psychological health of the participants, or had

137 missing details about the participants' inclusion criteria, were excluded ($n = 13$; criterion 3).

138   After screening for relevant studies ($n = 1600$), considering the title and abstract, two

139 researchers (ARG, CF) read the full-text of the studies that were retained ($n = 85$) and,

140 independently, decided their eligibility for further analysis. Disagreements were resolved by

141 consensus. The inter-rater agreement Cohen's kappa was used to compare agreement between

142 the researchers, revealing an almost perfect agreement ($k = .95$).

143   Detailed information on the study selection process is described in the PRISMA Flow

144 Diagram (Figure 1).

145 **Recorded variables and data collection**

146   The data of each paper were added to an extraction sheet, developed for this meta-

147 analysis and refined when necessary.

148   When present, the following variables were extracted from each paper: (a) characteristics

149 of the sample (sample groups, sample size, number of female participants, age, years of

150 education); (b) emotion identification tasks and conditions; (c) descriptive statistics of

151 participants' performance; (d) significant statistical differences between younger and older

152 adults' performance.

153 **Statistical analysis**

154   The Standard Mean Difference (*SMD*), based on Hedges' adjusted *g* formulation, was

155 used to assess the association between the two variables of interest, i.e. how much age-groups'

156 performance differ on the emotion identification task. The *SMD* was pooled across studies to

157 derive an estimate of the mean (i.e., effect size based on Hedges' *g*), with each effect weighted

158 for precision to correct for sampling error. To do so, a random-effects model was adopted.

159   Heterogeneity across the studies was tested using the I^2 and Q statistics. Methodological

160   and sample characteristics of the studies included in the meta-analysis are detailed in Table 1.

161   Publication bias was assessed by visual inspection of the funnel plot. Egger's tests were used to

162   estimate the severity of publication bias, with $p < .05$ considered statistically significant.

163   For each emotional expression, the unrestricted maximum likelihood random-effects

164   meta-regression of the effect size was performed with sex (% female), differences in the level of

165   education between older and younger adults, and stimulus features (virtual vs natural, color vs

166   black and white, static vs dynamic) as moderators to determine whether these covariates

167   influenced the effect size.

168   Statistical analyses were performed using Cochrane Collaboration Review Manager 5.3

169   (The Nordic Cochrane Centre, The Cochrane Collaboration, 2014) and SPSS version 22.0 (IBM

170   Corp, 2013) software.

171

172   **Results**

173   The negative overall effect size for *age-group* across all emotions ($M = -1.80$) showed

174   that facial expressions were less accurately identified by older adults (Table 2). For each effect

175   size, a negative value indicates that older adults have performed worse than younger adults,

176   whereas a positive value indicates the reverse. When analyzing data by emotion, the combined

177   effect sizes showed that facial expressions of anger, sadness, fear, surprise, and happiness were

178   less accurately identified by older adults (Table 2). Regarding the identification of facial

179   expressions of disgust, no significant differences were found between older and younger adults

180   (Table 2).

181   Significant heterogeneity was found for all emotions, indicating that the effects

182   contributing to each of the estimates differ substantively. Effect sizes for individual studies are

183   depicted in Table 3.

184   Egger's regression tests showed no significant funnel plot asymmetry across emotional

185   expressions, indicating the inexistence of publication bias.

186   The meta-regression analyses showed a significant association between participants'

187   performance by *age-group* and both *sex* and *level of education* as moderators on fear and disgust

188   identification (Table 4). Specifically, differences in *level of education* are associated with effect

189   sizes on the identification of fear and disgust expressions, with larger effects observed for larger

190   differences in education. Regarding the moderator *sex*, larger effects are observed for higher

191   percentages of female participants on the identification of fear and the opposite pattern (i.e.,

192   larger effects are observed for smaller percentages of female participants) is observed on the

193   identification of disgust expression. A significant association was also found between *stimulus*

194   *features* (virtual vs natural, color vs black and white, static vs dynamic) as moderator and

195   performance by *age-group* on disgust identification. Concerning fear identification the

196   association was marginally significant (Table 4). Whereas larger effects are observed for

197   grayscale pictures of faces on the identification of disgust, larger effects are observed for virtual

198   faces on the identification of fear.

199

200   **Discussion**

201   The present study aimed to identify potential age-related differences in identifying

202   emotions in facial expressions and quantify the magnitude of the observed age effects. Using a

203   meta-analytic approach with a random-effect model, our results showed that older adults

204 identified facial expressions of anger, sadness, fear, surprise, and happiness less accurately than

205 younger adults. In contrast, identification of disgust appears to be preserved with age, as older

206 and younger adults' performance was similar in this case. The present results support those

207 reported in a prior meta-analysis by Ruffman et al. (2008).

208   Taken together, our results are consistent with a general emotion identification decline

209 associated with aging. Thus, this meta-analysis does not support a positivity bias in the

210 identification of facial expressions of emotion, as impairments in this ability seem to extend to

211 positive facial expressions, nor previous findings suggesting that aging is associated with a

212 reduction in the negativity effect, rather than a positivity effect (Comblain et al., 2005; Denburg

213 et al., 2003; Knight, Maines, & Robinson, 2002; Mather et al., 2004). Age-related positivity

214 effects were found primarily in attention to, and recall and recognition memory for emotional

215 images which could have implications for emotion identification (Isaacowitz & Stanley, 2011).

216 Therefore, several studies aimed to investigate whether age differences in emotion identification

217 performance could also reflect positivity effects (e.g. Williams et al., 2006). Importantly, many

218 tasks assessing identification accuracy for positive emotions are constrained by ceiling effects

219 (due to the relative low difficulty of the task); however, in the present data, the typical ceiling

220 effects in younger adults' happiness recognition (e.g. Williams et al., 2006) seem to be absent.

221   Furthermore, our meta-regression results showed a significant association between

222 sample characteristics, namely the proportion of female participants and the level of education,

223 and participants' performance by age-group on the identification of fear and disgust. Stimulus

224 features were also found to be significantly associated with participant's performance by age-

225 group on disgust identification. Concerning fear identification, the association was marginally

226 significant. Regarding the level of education, the effect size increases for larger differences in the

227   mean years of education between the two groups. This result is consistent with the pattern

228   reported by Trauffer and colleagues (2013) in which participants with college education were

229   more likely to select the correct label for fear and disgust, than were those with no college

230   degree. According to the authors (Trauffer et al., 2013), the number of correct and incorrect

231   responses is partially influenced by the tendency to use certain labels. For instance, sadness and

232   ager have a broader meaning for preschoolers than for university undergraduates which matches

233   with the more frequent use of these words by participants with no college education, compared to

234   the ones with a college education (Trauffer et al., 2013). With respect to the moderator sex, the

235   pattern of effects observed suggests that female participants had better performance than male

236   participants when identifying fear expression and worst performance when identifying disgust.

237   For the identification of fear, the result is consistent with the idea of a female advantage in

238   overall emotion identification supported by studies focusing on emotional facial expressions

239   (Hall & Matsumoto, 2004; Montagne et al., 2005; Williams et al., 2009). For the identification of

240   disgust, the result may be explained by the higher value of within-group heterogeneity found in

241   the analysis of disgust expression ($I^2_{disgust}$ = .880 vs. I^2_{fear} = .053). Contrary to what was expected,

242   the meta-regression results of stimulus features suggest that disgust was better identified on

243   grayscale pictures and fear was better identified on virtual faces. However, it should be noted

244   that the report of color to improve the perception of emotional clues (Silver & Bilker, 2015)

245   refers to general emotional clues and not to one specific emotion. The better identification of fear

246   on virtual faces may be explained by less variability in expressive features, compared to natural

247   faces, which means by containing less noise (Dyck et al., 2008). Nevertheless, a note of caution

248   should be added here. Results of regression-based methods may not be robust in the current

249   meta-analysis, as such methods are more accurate with a larger number of studies.

250   Studies that explored the neural basis of emotion processing, either in younger or older

251   adults, present evidence that brain changes might be responsible for alterations in emotion

252   identification performance (Brassen, Gamer, & Büchel et al., 2011; Delgado et al., 2008; Ge et

253   al., 2014; Murty et al., 2009; Urry et al., 2009). In particular, the prefrontal cortex and amygdala

254   were found to be key players in the neural mechanisms underlying emotional regulation

255   (Delgado et al., 2008; Murty et al., 2009). Mather and colleagues (2004) reported reduced

256   amygdala activation for pictures of negative valence during their encoding in older adults. The

257   authors suggested that the on-line reductions in response to negative pictures should cause

258   disproportionately reduced subsequent memory for these negative stimuli. This pattern of

259   amygdala activation was also found by Keightley and colleagues (2007). Our results regarding

260   the identification of negative expressions, except for the identification of disgust, are consistent

261   with the abovementioned evidence. Besides a general reduction of the amygdala response,

262   according to Ruffman et al. (2008), the increased difficulty of older adults to recognize facial

263   expressions of anger may be related to a functional decline in the orbitofrontal cortex, sadness to

264   a decline in the cingulate cortex and amygdala, and fear to a decline in the amygdala.

265   Nevertheless, the identification of neural circuits rather than specific brain regions might be more

266   successful when trying to explain the differences found between younger and older adults'

267   performance (Almeida et al., 2016; Barrett & Wager, 2006; Clark-Polner, Johnson, & Barrett,

268   2016), including the identification of positive expressions.

269   Impairments in cognitive and sensory functions might also explain the changes in

270   emotion identification across the lifespan. Aging is often accompanied by a decline in cognitive

271   abilities (for review, see Salthouse, 2009), as well as by losses in visual and auditory acuity

272   (Caban et al., 2005; Humes et al., 2009), which could hinder higher-level processes such as

273   language and perception (Sullivan & Ruffman, 2004). However, these sensory features have

274   been reported to be poor predictors of the decline in visual or auditory emotional identification

275   that occurs with aging (e.g., Lima et al., 2014; Ryan, Murray, & Ruffman, 2010). We could not

276   examine these putative moderators due to a lack of consistent selection of cognitive ability

277   measures and its reporting across studies. Future studies incorporating common measures of

278   cognitive ability would allow addressing this issue.

279   As a final note, we highlight the ambiguity of emotion identification and emotion

280   recognition concepts in the literature. Some studies used both terms interchangeably (e.g.,

281   Circelli, Clark, & Cronin-Golomb, 2013; Silver & Bilker, 2015), while others distinguished the

282   terms and used specific tasks to assess emotion identification and emotion recognition separately

283   (Benito et al., 2013; Mathersul et al., 2009; Wilhelm et al., 2014). It is essential to use these

284   concepts uniformly in future studies. In this meta-analysis, we applied the term emotion

285   identification as the "ability to visually analyze the configuration of facial muscle orientations

286   and movements in order to identify the emotion to which a particular expression is most similar"

287   (Wilhelm et al., 2014). We assume that the term emotion recognition emphasizes a focus on

288   memory for facial expressions of emotion, i.e. the "ability to correctly encode, store, and retrieve

289   information regarding emotional expressions from memory systems" (Wilhelm et al., 2014). The

290   ambiguity in the use of these terms may lead to misunderstandings during the phase of literature

291   search and in the interpretation of the published results. In this sense, future studies should pay

292   more attention to this issue.

293

294   **Conclusions**

295   In sum, the present meta-analysis shows evidence of less accuracy of older adults in

296 emotion identification, not supporting a positivity bias nor a reduction in the negativity effect.

297 Meta-regression analyses suggest that effect sizes are moderated by sample characteristics such

298 as sex, level of education, as well as stimulus features. Several factors might explain the age-

299 related differences in emotion identification, but future studies are needed to explore whether and

300 to what extent they are involved.

301

302

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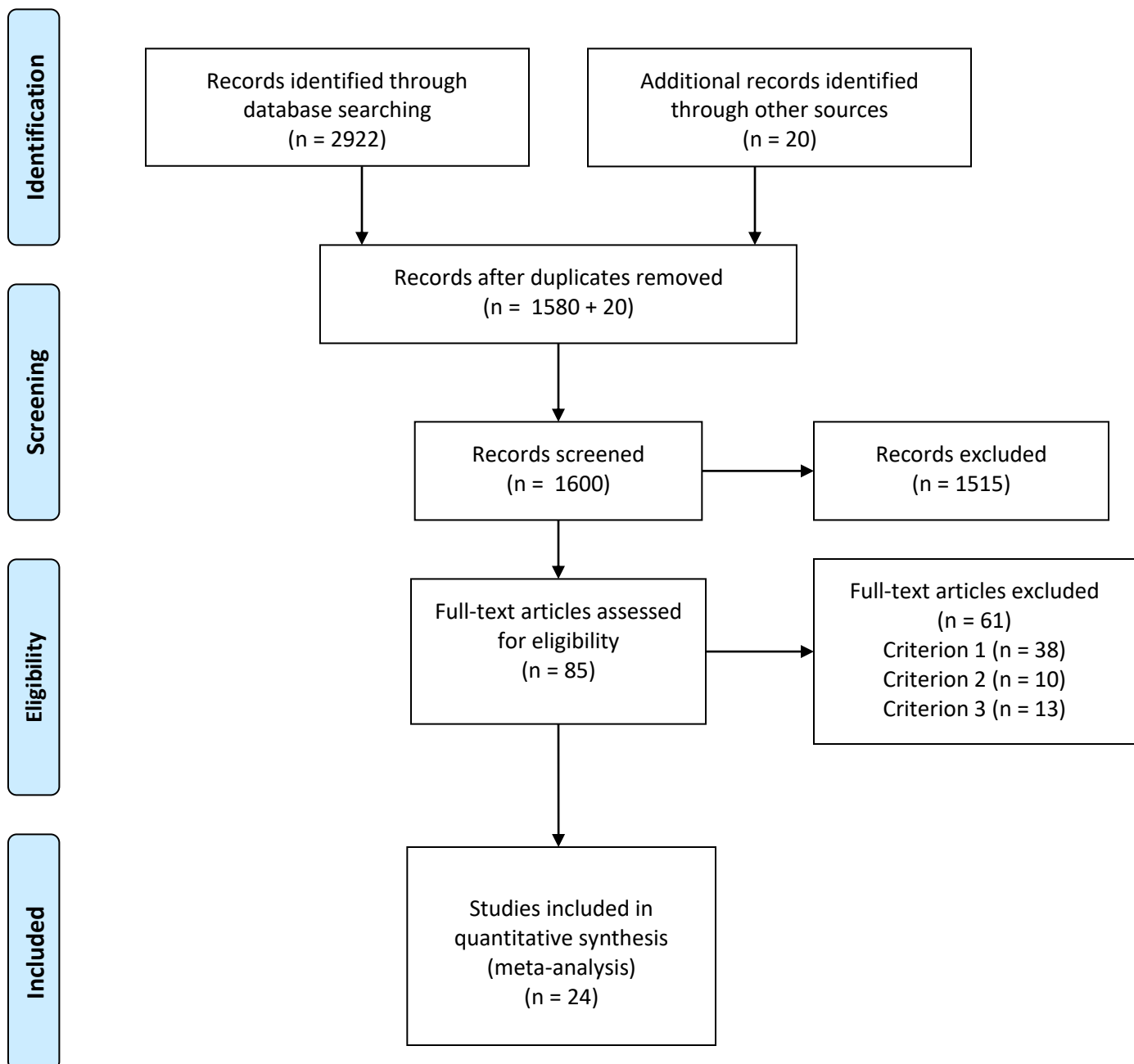
PRISMA flow diagram.

Methodological and Sample Characteristics of Studies Included in the Meta-Analysis

	Study	Condition	Paradigm	Stimuli	Sample size Older (F)	Younger (F)	Mean age Older	Younger	Mean years of education Older	Younger
1										
2	Baena et al., 2010	Human faces	EIT	VHF	39	39	69.9	23.7		
3	Campbell et al., 2015	Directed gaze/YF	EIT	FACC	32 (15)	32 (15)	71.0	20.4		
4	Carvalho et al., 2014		EIT	FACC	17 (12)	12 (6)	73.6	34.5	7.43	8.34
5	Chaby et al., 2015		EIT	FACC	31 (17)	31 (16)	67.2	25.8	13.6	14.2
6	Circelli et al., 2013/ Study 1		EIT	GFAC	16 (9)	16 (11)	68.9	19.2	16.4	13.9
7	Ebner et al., 2010	YF	EIT	FACC	51 (24)	52 (27)	73.6	26.0		
8	Ebner et al., 2012	YF	EIT	FACC	30 (17)	30 (16)	68.2	25.1	14.5	14.8
9	García-Rodríguez, Fusari et al., 2009		EIT	FACC	16 (8)	16 (8)	73.2	28.0	8.00	15.7
10										
11	Halberstadt et al., 2011	Faces	EIT	GFAC	61 (36)	60 (34)	70.5	20.5		
12	Hunter et al., 2010/ Study 1		EIT	VHF	25 (10)	25 (16)	67.0	22.6	15.4	15.1
13	Krendl et al., 2010/Study 1		DANVA2	FACC	42 (29)	36 (21)	75.8	19.8		
14	Krendl et al., 2014		DANVA2M	FACC	30 (21)	32 (26)	70.7	23.1	16.7	16.2
15	Lambrecht et al., 2012	Visual stimulus	EIT	VFAC	17 (8)	16 (8)				
16	Murphy and Isaacowitz, 2010		DANVA2	FACC	23 (15)	41 (22)	72.0	19.3		
17	Ngo and Isaacowitz, 2015/ Study 1	Neutral context	EIT	FACC	30 (19)	31 (19)				
18										
19	Noh and Isaacowitz, 2013	Neutral context	EIT	GFAC	47 (39)	37 (23)			18.1	15.7
20	Orgeta, 2010		EIT	GFAC	40 (27)	40 (27)	69.7	22.4	14.0	14.5
21	Sarabia-Cobo et al., 2015	EIP	EIT	VHF	37 (21)	50 (26)	72.3	28.5	8.30	16.9
22	Silver and Bilker, 2015	Visual stimulus	EIT	FACC	39 (0)	37 (0)	72.8	33.5	15.8	11.0
23	Sullivan et al., 2015		EIT	FACC	58 (30)	60 (30)	70	20		
24	Suzuki and Akiyama, 2013		EIT	GFAC	36 (18)	36 (18)	69.4	21.4	14.2	14.4
25	Svärd et al., 2012		URT	GFAC	20 (10)	19 (10)	73.7	26.4	14.2	14.4
26	Williams et al., 2009		EEI	FACC	276 (140)	176 (111)				
27	Ziaei et al., 2017	Direct gaze	EIT	GFAC	20 (10)	20 (10)	69.8	20.6	15.3	14.3

28 *Note.* Condition: YF = young faces; EIP = emotional intensity pronounced. Paradigm: EIT = emotion identification
29 task; DANVA2 = DANVA2 adults face task; DANVA2 M = DANVA2 modified task; URT = unmasked
30 recognition task; EEI = explicit emotion identification. Stimuli: VHF = virtual human faces; FACC = colour photos
31 of human faces; GFAC = grey scale photos of human faces; VFAC = video sequences of human faces. Sample size:
32 F = number of females

Age effects for recognition of different emotions

	M	K	N	I^2
Anger	-0.61***	21	1785	.76***
Sadness	-0.43***	18	1661	.64***
Fear	-0.62***	18	1606	.53**
Disgust	-0.04	16	1480	.88***
Surprise	-0.45***	9	621	.90***
Happiness	-0.19*	22	1832	.70***
Overall	-1.80***	24	1978	.98***

3 *Note*. M = mean effect size. K = number of independent studies contributing towards each respective mean effect
4 size. A negative effect size denotes that older adults are worse than younger adults; a positive effect size indicates
5 the reverse. N = number of participants. I^2 quantifies within-group heterogeneity. Significances are marked by * $p <$
6 .05, ** $p < .01$, and *** $p < .001$.

Effect Size Data for Individual Studies Included in the Meta-Analysis

Study	Sample size	Weight (%)	Effect size [95% CI]
Anger			
Campbell et al., 2015	64	4.9	-0.74 [-1.25, -0.23]
Carvalho et al., 2014	29	3.3	-1.32 [-2.14, -0.49]
Chaby et al., 2015	62	4.8	-0.87 [-1.40, -0.35]
Circelli et al., 2013	32	3.9	0.30 [-0.40, 1.00]
Ebner et al., 2010	103	5.4	-0.87 [-1.27, -0.47]
Ebner et al., 2012	60	4.9	0.15 [-0.36, 0.65]
García-Rodríguez, Fusari et al., 2009	32	2.6	-2.84 [-3.86, -1.83]
Halberstadt et al., 2011	121	5.7	-0.51 [-0.88, -0.15]
Hunter et al., 2010/ Study 1	50	4.4	-1.00 [-1.59, -0.41]
Krendl et al., 2010/Study 1	78	5.2	-0.63 [-1.09, -0.17]
Krendl et al., 2014	62	4.8	-0.93 [-1.45, -0.40]
Lambrecht et al., 2012	33	3.6	-1.31 [-2.07, -0.55]
Murphy and Isaacowitz, 2010	64	4.7	-0.98 [-1.52, -0.44]
Ngo and Isaacowitz, 2015/ Study 1	61	4.8	-0.80 [-1.32, -0.27]
Noh and Isaacowitz, 2015	84	5.3	-0.41 [-0.85, 0.02]
Orgeta, 2010	80	5.3	0.00 [-0.44, 0.44]
Sarabia-Cobo et al., 2015	87	5.3	-0.51 [-0.95, -0.08]
Sullivan et al., 2015	118	5.7	-0.28 [-0.64, 0.08]
Suzuki and Akiyama, 2013	72	5.0	-0.72 [-1.20, -0.24]
Williams et al., 2009	452	6.4	-0.64 [-0.83, -0.44]
Ziaei et al., 2017	40	4.1	1.06 [0.39, 1.73]
Sadness			
Baena et al., 2010	78	5.9	-0.09 [-0.53, 0.36]
Campbell et al., 2015	64	5.4	-0.36 [-0.85, 0.14]
Carvalho et al., 2014	29	3.5	0.21 [-0.53, 0.95]
Chaby et al., 2015	62	5.1	-1.02 [-1.55, -0.49]
Circelli et al., 2013	32	3.8	-0.34 [-1.04, 0.36]
Ebner et al., 2010	103	6.5	-0.37 [-0.76, 0.02]
García-Rodríguez, Fusari et al., 2009	32	3.7	0.65 [-0.06, 1.37]
Halberstadt et al., 2011	121	6.8	-0.29 [-0.65, 0.07]
Hunter et al., 2010/ Study 1	50	4.6	-0.91 [-1.50, -0.33]
Krendl et al., 2010/Study 1	78	5.8	-0.48 [-0.93, -0.03]
Krendl et al., 2014	62	5.3	-0.57 [-1.08, -0.06]
Murphy and Isaacowitz, 2010	64	5.2	-0.61 [-1.14, -0.09]
Orgeta, 2010	80	5.5	-1.38 [-1.87, -0.89]
Sarabia-Cobo et al., 201	87	6.0	-0.47 [-0.90, -0.04]
Silver and Bilker, 2015	76	5.8	-0.56 [-1.02, -0.10]
Sullivan et al., 2015	118	6.8	-0.28 [-0.64, 0.08]
Suzuki and Akiyama, 2013	72	5.7	-0.54 [-1.01, -0.07]
Williams et al., 2009	452	8.6	-0.13 [-0.32, 0.06]
Fear			
Campbell et al., 2015	64	5.5	-0.46 [-0.96, 0.04]
Carvalho et al., 2014	29	3.3	-0.22 [-0.96, 0.52]
Chaby et al., 2015	62	5.4	-0.36 [-0.86, 0.15]
Circelli et al., 2013/ Study 1	32	3.6	-0.52 [-1.23, 0.18]
Ebner et al., 2010	103	6.9	-0.50 [-0.89, -0.11]
García-Rodríguez, Fusari et al., 2009	32	2.7	-1.93 [-2.79, -1.07]
Halberstadt et al., 2011	121	7.4	-0.07 [-0.43, 0.28]

Study	Sample size	Weight (%)	Effect size [95% CI]
Hunter et al., 2010/ Study 1	50	4.7	-0.61 [-1.18, -0.04]
Krendl et al., 2010/Study 1	78	6.0	-0.60 [-1.06, -0.14]
Krendl et al., 2014	62	5.5	-0.10 [-0.59, 0.40]
Murphy and Isaacowitz, 2010	64	4.8	-1.23 [-1.79, -0.68]
Ngo and Isaacowitz, 2015/ Study 1	61	5.2	-0.75 [-1.27, -0.23]
Orgeta, 2010	80	6.1	-0.52 [-0.97, 0.08]
Sarabia-Cobo et al., 2015	87	6.0	-1.04 [-1.50, -0.59]
Sullivan et al., 2015	118	7.2	-0.65 [-1.02, -0.28]
Suzuki and Akiyama, 2013	72	5.6	-0.98 [-1.48, -0.49]
Svärd et al., 2012	39	4.0	-0.66 [-1.31, -0.02]
Williams et al., 2009	452	10.0	-0.64 [-0.83, -0.44]
Disgust			
Campbell et al., 2015	64	6.4	-0.39 [-0.88, 0.11]
Carvalho et al., 2014	29	6.0	-0.57 [-1.33, 0.18]
Chaby et al., 2015	62	5.5	0.92 [0.39, 1.44]
Circelli et al., 2013/ Study 1	32	6.1	0.31 [-0.39, 1.01]
Ebner et al., 2010	103	6.5	-0.56 [-0.95, -0.16]
García-Rodríguez, Fusari et al., 2009	32	5.9	-0.38 [-1.08, 0.32]
Halberstadt et al., 2011	121	6.5	0.72 [0.36, 1.09]
Hunter et al., 2010/ Study 1	50	6.3	-0.11 [-0.67, 0.44]
Lambrecht et al., 2012	33	6.0	-1.53 [-2.31, -0.74]
Ngo and Isaacowitz, 2015/ Study 1	61	6.1	-0.49 [-1.00, 0.02]
Noh and Isaacowitz, 2015	84	6.3	0.31 [-0.12, 0.75]
Orgeta, 2010	80	6.3	0.37 [-0.08, 0.81]
Sarabia-Cobo et al., 2015	87	6.4	-1.21 [-1.67, -0.74]
Sullivan et al., 2015	118	6.5	0.30 [-0.06, 0.66]
Suzuki and Akiyama, 2013	72	6.4	0.58 [0.11, 1.05]
Williams et al., 2009	452	6.6	0.62 [0.43, 0.81]
Surprise			
Carvalho et al., 2014	29	4.8	-0.62 [-1.38, 0.14]
Circelli et al., 2013	32	5.7	-0.02 [-0.72, 0.67]
García-Rodríguez, Fusari et al., 2009	32	3.5	2.08 [1.20, 2.96]
Halberstadt et al., 2011	121	21.6	0.00 [-0.36, 0.36]
Hunter et al., 2010/ Study 1	50	8.4	-0.67 [-1.24, -0.10]
Orgeta, 2010	80	15.0	-0.32 [-0.75, 0.11]
Sarabia-Cobo et al., 2015	87	9.2	-2.06 [-2.61, -1.51]
Sullivan et al., 2015	118	20.7	-0.39 [-0.76, -0.03]
Suzuki and Akiyama, 2013	72	11.2	-1.07 [-1.57, -0.58]
Happiness			
Baena et al., 2010	78	5.0	0.05 [-0.39, 0.49]
Campbell et al., 2015	64	4.7	0.00 [-0.49, 0.49]
Carvalho et al., 2014	29	3.3	0.17 [-0.57, 0.91]
Chaby et al., 2015	62	4.6	-0.14 [-0.64, 0.36]
Circelli et al., 2013	32	3.5	0.04 [-0.66, 0.73]
Ebner et al., 2010	103	5.3	-0.29 [-0.68, 0.10]
Ebner et al., 2012	60	4.5	0.37 [-0.14, 0.88]
García-Rodríguez, Fusari et al., 2009	32	3.5	-0.39 [-1.09, 0.31]
Halberstadt et al., 2011	121	5.5	-0.03 [-0.39, 0.33]
Hunter et al., 2010/ Study 1	50	4.2	-0.42 [-0.98, 0.14]
Krendl et al., 2010/Study 1	78	4.9	-0.47 [-0.93, -0.02]

Study	Sample size	Weight (%)	Effect size [95% CI]
Krendl et al., 2014	62	4.6	-0.40 [-0.91, 0.10
Lambrecht et al., 2012	33	2.8	-1.95 [-2.79, -1.10]
Murphy and Isaacowitz, 2010	64	4.5	0.07 [-0.44, 0.58]
Orgeta, 2010	80	5.0	0.16 [-0.28, 0.60]
Sarabia-Cobo et al., 2015	87	5.1	-0.44 [-0.87, -0.01]
Silver and Bilker, 2015	76	4.9	-0.24 [-0.69, 0.21]
Sullivan et al., 2015	118	5.5	-0.38 [-0.75, -0.02]
Suzuki and Akiyama, 2013	72	4.6	1.07 [0.58, 1.57]
Svärd et al., 2012	39	3.8	-0.61 [-1.26, 0.03]
Williams et al., 2009	452	6.5	-0.03 [-0.22, 0.15]
Ziaei et al., 2017	40	3.6	-1.21 [-1.89, -0.53]

Effect of moderators on the age-related differences in emotion recognition

	Q	df	*p*	Moderator	Z	*p*	β
Anger							
Model	1.28	3	.734				
Sadness							
Model	3.09	3	.377				
Fear	34.0	3	.000				
Model							
				Sex (%F)	2.06	.039	.35
				Mean Years of Educat. Dif.	4.12	.000	.78
				Stimulus	-1.86	.062	-.32
Disgust							
Model	22.4	3	.000				
				Sex (%F)	-2.28	.023	-.52
				Mean Years of Educat. Dif.	2.86	.004	.66
				Stimulus	2.40	.016	.55
Surprise							
Model	1.25	3	.742				
Happiness							
Model	0.54	3	.910				

Note. Moderator: %F = percentage of female.