Seniors' ability to decode differently aged facial emotional expressions

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Abstract— The present investigation aims at assessing elders' ability to decode facial emotional expressions conveyed by differently aged people in order to confirm (or disconfirm) the appropriateness of the "own age bias" theory, as well as investigate effects of different ages and different emotional categories. The study, involves 44 healthy elders (23 females), aged 65+ (mean age=75.09; SD=±7.9) which were requested to label 76 pictures depicting elders, middle-aged and young women and men displaying the six facial emotional expressions of disgust, anger, fear, sadness, happiness and neutrality. Results show a complex pattern of influences that calls for more deep investigations on the features to be accounted by providing socially and emotionally believable interfaces of effective and efficient algorithms to detect and decode their users' emotional facial expressions.

I. Introduction

Emotions play a central role in humans' social functioning (Keltner & Kring, 1998) and the ability to appropriately perceive and express them made successful human interaction and constitute one of the factors of the emotional competence (Cicogna & Occhionero, 2007). People not able to correctly encode and decode emotions may suffer of behavioral and clinical disorders. Despite to general beliefs, emotions are difficult to decode, without contextual information. In ad-dition, human ability to read and express them is strongly affected by several factors, among those individual traits, gender, personality, culture, social experiences and aging. These factors refer to the person who is experiencing or decoding an emotion. They are not the only ones capable of affecting human emotion recognition. This investigation intends to show that when people, in particular seniors, are required to decode facial emotional expressions, their performances are also affected by both the age and gender of the face expressing the emotion. The implications of these findings are important for the implementation of emotionally credible human machine interfaces aimed at assisting and supporting vulnerable people. In fact, in these cases, these interfaces must not only recognize and interpret the moods and requests of their users, but to be socially and emotion-ally believable they must be able to interact by expressing emotions credible and interpretable by their users.

II. Related Work

A. Age effect on emotion recognition

The effect of age on emotion decoding has been investigated by several studies which focused on how this ability evolve during the growth process and with aging. The results of these studies seem to converge on reporting that equally aged children are better in recognizing some emotions rather than others such as happiness and anger compared to sad-ness and fear (Esposito et al. 2018; Chronaki et al., 2015; Lawrance et al., 2015; Rodger et al., 2015). However, how the learning and growing processes affect children's ability to recognize emotions over time is still matter of investigation. Some studies showed an improvement in the recognition accuracy of sadness associated with the growth, while the ability to recognize happiness tends to remain stable (Chron-aki et al., 2015; Rodger et al., 2015); however other studies (Lawrance et al., 2015) highlighted that children's ability to recognize happiness increase with age, while the ability to recognize sadness would remain stable over time. As regards adults, it seems that aging is associated with a decreased ability in recognizing specific emotional expressions. Stud-ies involving people belonging to differently aged groups showed less accuracy in the recognition of emotions such as fear, anger and sadness by middle-aged and elderly people (Sullivan and Ruffman, 2004; Isaacowitz et al., 2007; Orgeta
& Phillips, 2007; Calder et al., 2013) compared to younger participants. Studies comparing young and older people's ability to recognize facial emotional expressions, showed better performances of younger participants compared to elderly, especially concerning recognition of emotions such as anger and sadness (Phillips et al., 2002; Richter et al., 2010). Similar results are reported for vocal expressions of these emotions (Ryan et al., 2009). Young peoples' higher accuracy than aged adults in recognizing emotional vocal expressions was also highlighted by Esposito et al. (2019) in a recognition task of non-native vocal emotional expressions. A generalized emotion recognition impairment associated with aging was highlighted in a study by Demenescu and colleagues (2014), involving participants belonging to dif-ferently age groups, such as young (aged between 18-35), middle-aged (between 36-55 years) and elders (aged between 56-75 years). This study required participants to decode vocal and facial emotional expressions of different emotions among which anger, fear, sadness, disgust, happiness and neutrality. Results confirmed seniors less accuracy and increased re-action time than youngers in the emotion recognition task, independently from the stimulus type.

One possible explanation of impairments showed by el-

derly in the recognition of specific emotional expressions refers to the natural deterioration of those brain areas responsible of emotions' processing, as the frontal and medial temporal areas (Petit-Taboue et al., 1997; Blair et al., 1999; Uono et al., 2017). This hypothesis is supported by lesions studies which demonstrated that patients with lesions in these areas show impairments in the recognition of facial expressions and emotions (Anderson & Phelps, 2000; Monte et al., 2012; Terasawa et al., 2015; Wolf et al., 2016). This hypothesis is debated by some authors attributing elderly's difficulties in emotion decoding mainly to the type of task administered. In fact, differences between young and older participants seem to disappear when the emotion recognition task becomes "multimodal", namely when emotions are not expressed through a single modality, such as only through faces or voices (Wieck et al., 2017). In addition, elders' accuracy in the recognition of emotional facial expressions seems to improve with dynamic compared to static stimuli (Grainger et al., 2015).

It is important to note that when the ability of elders to recognize emotional facial expressions has been investigated, the effect of age of the faces expressing such emotions has been largely neglected. As previously mentioned, the age of the face conveying the emotion can affect the recognition process. According to a social re-orientation theory towards peers, known as the "Own Age Bias (OAB) Theory", people tend to better recognize facial emotional expressions seen on faces of the same age (Rhodes & Anastasi, 2012). This theory suggests that human ability to decode emotions is affected by an "age-related prejudice" (Scherf et al., 2012; Proietti et al.,2014). Several studies showed that this is true for adults (Anastasi & Rodhes, 2006; Hills & Lewis, 2011), who tend to recognize facial expressions of peers more quickly and accurately than those expressed by younger or older people. Nevertheless results for children and ado-lescents are conflicting. In fact, while some studies have shown the existence of the OAB in children, who tend to better recognize facial expressions of their peers (Rodhes & Anastasi, 2005), others showed that children can recognize emotional expressions equally well, regardless of whether these are expressed by peers or adults (Esposito et al., 2018). Studies comparing elders and young adults' ability to recognize facial expressions, and the effect of the OAB on this process, reached discordant results. Denkinger & Kinn (2018) found that younger participants showed a clear OAB, as they recognized more accurately faces of their peers than older ones. Other researches (Firestone et al., 2007; Campbell et al., 2015; Schaich et al., 2016), highlighted a tendency to better recognize peers' facial expressions only by elderly, while younger participants' performances seem to not be affected by the OAB. He and colleagues (2011), found that both young and elder participants tend to spend more time looking at their own-age faces compared to differently aged age faces.

B. Gender effect on emotion recognition

Among factors capable of influencing the human ability to decode emotions stand the gender of both the decoder (i.e. the person interpreting the emotional expression) and the face portraying the emotion. From the decoder point of view, it seems that men and women differ in their ability to decode emotional expressions. Several studies have shown that women are more accurate (Grecori et al., 2014; Hall & Matsumoto, 2014) and faster (Saylik et al., 2018) than men in this process, in particular for fear, sadness and happiness (Bonebright et al., 1996). Women's higher accuracy seems to occur also as regards the identification of emotional vocal stimuli (Lausen & Schacht, 2018). In a study by Hoffmann and colleagues (2010) emerged that women's higher ability to process emotions depends on the emotional intensity of the stimulus, since women are more accurate than man on decoding subtle emotional expressions, while male and female differences disappear when the intensity of the emotional expression increases.

Researches also highlighted that the gender of the face (or voice) portraying an emotion affects participants' ability to decode such emotion. A study by Harris and colleagues (2016) showed that people tend to perceive male faces as more negative, in particular expressing more anger, than female ones. In another study (Calvo & Lundqvist, 2008) emerged a tendency to perceive male disgusted faces as angry and female angry faces as disgusted. As for voices, Bonebright and colleagues (1996) showed that the gender of stimuli affects participants' emotion recognition. Their re-sults highlighted that participants better recognized angry and neutral male voices more accurately than happy male voices, while happy female voices are more accurately decoded than female voices expressing fear, sadness and neutrality. Lausen
& Schacth (2018) found that emotional words and pseudo-words were better identified when spoken by male than by female actors, whereas emotional sentences and affect bursts were better recognized when conveyed by female compared to male actors. Another study by Grecoric and colleagues (2014) highlighted that facial expressions of sadness, surprise and neutrality are better recognized if conveyed by female faces.

In order to shed more light on these issues, the present paper carried out an investigation aiming to:

- assessing elders' ability to recognize facial emotional expressions of differently aged people;
- testing the appropriateness of the "own age bias" theory, verifying whether and how the age of the actors portraying a facial emotional expression affect elders' decoding ability;
- assessing the gender's effects in decoding emotional expressions considering both the gender of participants and that of the face portraying the emotion.

III. Material and Methods

The proposed experiment involved seniors aged over 65+ in an emotion recognition task aimed at investigating their

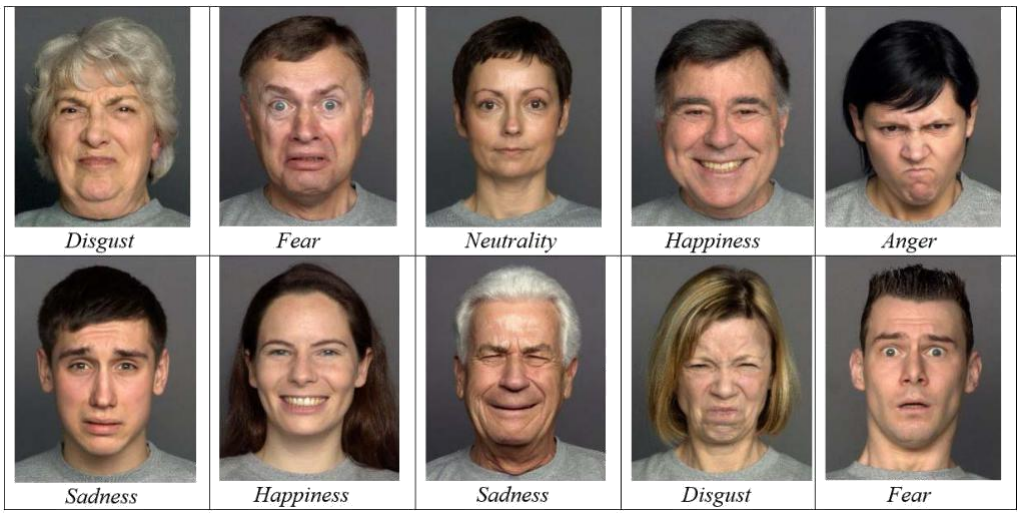

Fig. 1. A sample of stimuli exploited for the current investigation.

accuracy in the recognition of emotional facial expressions conveyed by elders, middle-aged and young females and males.

A. Participants

The sample consisted of 44 healthy subjects (23 females) aged 65+ (mean age=75.09; SD=±7.9). They were recruited in Campania, a region in the south of Italy and voluntarily joined the study signing an informed consent formulated according to the Italian and European laws about privacy and data protection. The research was authorized by the ethical committee at the Universita` degli Studi della Campania Luigi Vanvitelli with the protocol number 25/2017.

B. Stimuli

A total of 76 faces of elders, middle-aged and young women and men displaying the six facial expressions of disgust, anger, fear, sadness, happiness, and neutrality have been selected for the experiment. The pictures were selected from the FACES database (Ebner et al., 2010). Four of such faces were used within the trial session, while the remaining 72 in the experimental session. Fig. 1 illustrates, as an example, some of the differently aged faces involved in the emotion recognition task.

C. Tools and Procedures

In order to collect data about elders' ability to recognize facial expressions, an emotion recognition task was devel-oped using the software SuperLab 4.0. First, participants read and signed an informed consent, then they were asked to sit in front of a laptop, on which the experiment has been implemented, and carefully read the instructions. The task consisted of a trial session, composed by 4 randomized stim-uli aimed at allowing participants to familiarize with the pro-cedure, and an experimental session consisting in the viewing of 72 randomized stimuli. After the presentation of each stimulus participants had to decode the emotion displayed pressing the corresponding laptop key: d=disgust, a=anger, f=fear, s=sadness, h=happiness, n=neutral. Instructions were presented only once before to run the experiment, therefore, a small legend describing the laptop keys corresponding to the emotional labels was placed next to the laptop monitor to act as reminder.

IV. Results

This section reports the results of the proposed experiment. Repeated measures ANOVA were carried out for each emotional category (disgust, anger, fear, sadness, happiness and neutrality) considering participants' gender as a between factor variable and age of stimuli and gender of the stimuli as within factor variables. The significance level was set at $\alpha < .05$ and differences among means were assessed through Bonferroni's post hoc tests. Then, recognition scores were added up to obtain a single total score for each emotion, in order to explore which emotion was more accurately decoded by the involved seniors, independently from the age and gender of the proposed stimuli. Repeated measures ANOVA were carried out considering participants' gender as between factor and emotion (disgust, anger, fear, sadness, happiness and neutrality) as within factors. The significance level was set at $\alpha < .05$ and differences among means were assessed through Bonferroni's post hoc tests.

A. Seniors' recognition of elders, middle-aged and young (females and males) emotional faces

This section reports the results concerning elders' ability to recognize emotional facial expressions conveyed by old, middle-aged and young female and male faces separately for each emotional category under examination (disgust, anger, fear, sadness, happiness and neutrality). The goal is to understand whether and how the age and gender of the actors influence the accuracy of the emotional recognition of the elderly. A summary of these results is illustrated in Figure 2.

1) Disgust: No participants' gender effect was found ($F(1,42)=.078$, $p=.781$) while significant differences were observed ($F(2,84)=32.321$, $p<<.01$) concerning elders' ability to recognize differently aged faces expressing disgust.

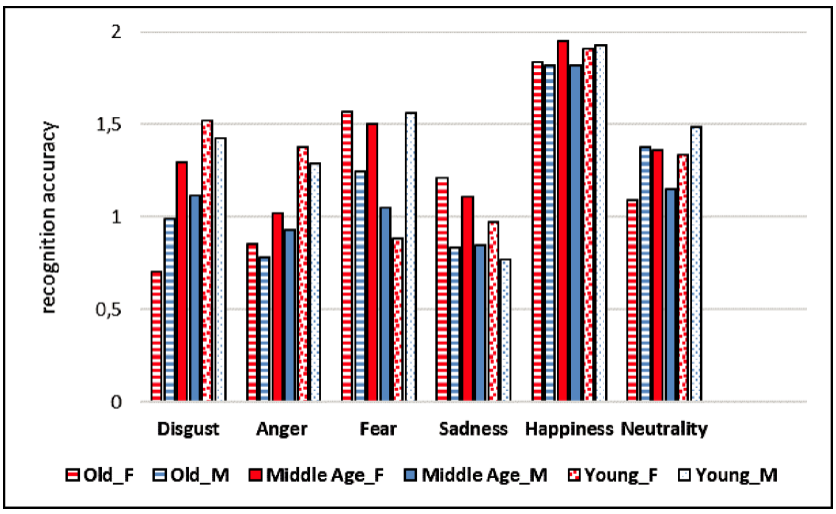

Fig. 2. Elders' recognition accuracy of emotional facial expressions conveyed by old, middle-aged and young women and men faces.

Bonferroni post hoc tests revealed that seniors' ability to decode emotional disgusted faces was strongly affected by faces' ages. Old aged faces (mean=.846) are significantly less accurately decoded than middle (mean=1.206, p<<.01) and young (mean=1.474, p<<.01) faces, and middle-aged faces are significantly less accurately decoded than young (p=.002) aged faces.

No effects were observed for the gender of stimuli (F(1, 42)=.003, p=.959). Nevertheless, a weak interac-tion between age and gender of stimuli (F (2,84)=3.147, p=.037) was found. Bonferroni post hoc tests revealed that elders are significantly less accurate in decoding old (mean=.703) rather than middle (mean=1.297, p<<.01) and young (mean=1.521, p<<.01) aged female disgusted faces, while performing similarly for middle and young (p=.56) female disgusted faces. Elders are also significantly more accurate in decoding young (mean=1.428) rather than middle (mean=1.115, p=.023) and old (mean=.989, p=.003) aged male disgusted faces, while performing similarly for middle and old (p=1.00) male disgusted faces.

In addition, no interaction was observed between partici-pants' gender and age of stimuli (F (2,84)=2.537, p=.085). However, comparisons showed that male participants were significantly less accurate on old (mean=.952) rather than young (mean=1.405, p<<.01) aged emotional faces, and per-formed equally well on old and middle (mean=1.238, p=.08) aged faces. Female participants were significantly less accu-rate on old (mean=.739) rather than middle (mean=1.174, p=.002) and young (mean=1.543, p<<01) emotional aged faces and less accurate on middle rather than young (p=.002) aged faces.

No interaction was found (F(1, 42)=1.297, p=.261) be-tween participants' gender and gender of stimuli.

2) Anger: A slightly significant difference (F(1,42)=4.724, p=.035) was found between male and female participants concerning anger recognition. This difference emerged because female (mean=1.203) were significantly more accurate than male participants (mean=.881) in decoding anger.

Significant differences were observed (F(2,84)=19.683, p<<.01) concerning elders' ability to decode differently aged faces expressing anger. Bonferroni post hoc tests re-vealed that seniors' ability to decode angry expressions is strongly affected by faces' ages. Young angry faces (mean=1.334) are significantly more accurately decoded than old (mean=.817, p<<.01) and middle aged (mean=.974; p<<.01) angry faces.

No effects were observed for the gender of stimuli (F(1, 42)=1.331, p=.255), and no interaction was found between age and gender of stimuli (F(2,84)=.005, p=.995). Neverthe-less, Bonferroni post hoc tests revealed that elders are signif-icantly less accurate in decoding old (mean =.853, p=.001) and middle aged (mean=1.020, p=.021) female angry faces rather than young ones (mean=1.378). Elders are also sig-nificantly more accurate in decoding young (mean=1.291) rather than middle (mean=.929, p=.033) and old (mean=.782, p<<.01) aged male angry faces, while performing similarly for middle and old (p=.912) male angry faces.

No interaction was observed between participants' gender and age of stimuli (F (2,84) =2.870, p=.062). However, male participants were significantly less accurate on old (mean=.548) rather than middle (mean=.905, p=.030) and young (mean=1.190, p¡¡.01) emotional faces, and performed equally well on middle and young (p=.085) aged emotional faces. Female participants were significantly less accurate on old (mean=1.087, p=.001) and middle (mean=1.043, p=.002) rather than young (mean=1.478) aged angry faces, while performing similarly on old and middle (p=1.000) aged angry faces.

No interaction was found (F(1, 42)=.003, p=.958) between participants' gender and gender of stimuli.

3) Fear: No significant effects of participants' gen-der (F(1,42)=.056, p=.815), age of stimuli (F(2,84)=1.920, p=.153), and gender of stimuli (F(1, 42)=.364, p=.549) were observed.

A significant interaction was found between age and gender of stimuli (F(2,84)=20.592, p<<.01). Bonferroni

post hoc tests revealed that seniors were less accurate to decode old (mean=1.245) and middle aged (mean=1.050) male faces rather than old (mean=1.568, p=.011) and middle aged (mean=1.505, p<<.01) female faces expressing fear, while female young faces (mean=.885) were less accurately decoded than male (mean=1.560, p<<.01) young faces expressing fear. In addition, Bonferroni post hoc tests revealed that elders were significantly more accurate in decoding old (mean=1.568, p=<<.01) and middle aged (mean=1.505, p<<.01) female faces expressing fear rather than young ones (mean=.885). Elders are also significantly more accurate in decoding young (mean=1.560) rather than middle aged (mean=1.050, p=.001) male fearful faces, while performing similarly for middle and old (mean=1.245, p=.597) male fearful faces.

No interaction was observed between participants' gender and age of stimuli (F(2, 84)=2.475, p=.090) and participants' gender and gender of stimuli (F(1, 42)=2.616, p=.113).

4) Sadness: Concerning sadness, no significant effects of participants' gender (F(1,42)=.077, p=.782), age of stimuli (F(2,84)=1.242, p=.294) or any significant interaction were observed. A significant effect of the gender of stimuli was observed (F(1, 42)=14.444, p<<.01). Bonferroni post hoc tests revealed that elders were significantly more accurate in recognizing sad female (mean=1.096) rather than sad male faces (mean=.818).This was significantly true both for male participants (female sadness mean=1.048, male sadness mean=.825, p=.042) and female participants (female sadness mean=1.145, male sadness mean=.812, p=.002).

No interaction was found between age and gender of stimuli (F(2,84)=.411, p=.664), participants' gender and age of stimuli (F(2, 84)=.272, p=.762) and participants' gender and gender of stimuli (F(1, 42)=.578, p=.451).

5) Happiness: No significant effects of participants' gender, (F(1,42)=.507, p=.480), gender of stimuli (F(1, 42)=1.952, p=.170) or any significant interaction were observed.

Slightly significant differences were observed concern-ing elders' ability to decode differently aged faces (F(2,84)=3.133, p=.049) expressing happyness. However, when Bonferroni post hoc tests were performed these differences disappeared due to multiple Bonferroni's adjustments.

No interaction was found between age and gender of stimuli (F(2,84)=1.770, p=.177), participants' gender and age of stimuli (F(2, 84)=1.275, p=.285), and participants' gender and gender of stimuli (F(1, 42)=.167, p=.685).

6) Neutrality: No significant effects of participants' gender (F(1,42)=1.894, p=.176) and gender of stimuli (F(1, 42)=1.019, p=.319) were observed.

Slightly significant differences were observed concern-ing elders' ability to decode differently aged neutral faces (F(2,84)=3.683, p=.029). However, when Bonferroni post hoc tests were performed these differences disappeared due to multiple Bonferroni's adjustments.

A significant interaction was found between age of stimuli and gender of stimuli (F(2,84)=3.965, p=.023). Bonferroni post hoc tests revealed that elders are significantly more accurate in decoding neutral young male (mean=1.487, p=.039) rather than neutral middle-aged male (mean=1.154) faces.

No interaction was observed between participants' gender and age of stimuli (F(2,84)=.727, p=.486). However, Bonferroni post hoc tests showed that female participants were significantly more accurate on young (mean=1.587) rather than middle aged (mean=1.348, p=.045) emotional faces.

No interaction was found between participants' gender and gender of stimuli (F(1, 42)=3.394, p=.073). How-ever, Bonferroni post hoc tests revealed that female par-ticipants were slightly more accurate in decoding neutral male (mean=1.536, p=.045) rather thatn neutral female faces (mean=1.319).

B. Elders' emotion recognition accuracy

This section discusses elders' ability to correctly decode the emotional categories under examination (i.e., disgust, anger, fear, sadness, happiness and neutrality), independently from the age and gender of the stimulus. In order to carry out these analyses, recognition scores obtained from all stimuli's types (old females and males, middle-age females and males, young females and males) were added up together for each emotion category. Repeated measures ANOVA were performed on these data, considering participants' gender as between and emotional categories as within variables.

The ANOVA analyses showed no participants' gender effect (F(1,42)=1.679, p=.202) but elders' recognition accuracy differed significantly (F(5,210)=23.435, p=.000) among emotional categories. Bonferroni post hoc tests revealed that elders were significantly more accurate in decoding happiness (mean=11.263) compared to disgust (mean=7.052, p<<.01), anger (mean=6.252, p<<.01), fear (mean=7.814, p<<.01), neutrality (mean=7.806, p<<.01) and sadness (mean=5.744, p<<.01) and to the significantly lower accuracy in the recognition of sadness compared to fear (p<<.01) and neutrality (p=.037). These results are illustrated in Fig. 3.

V. Discussion and Conclusion

The present investigation highlighted elders' impairment in recognizing facial expressions of anger and sadness, confirming previously reported results (Phillips et al., 2002; Sullivan and Ruffman, 2004; Isaacowitz et al., 2007; Orgeta & Phillips, 2007; Richter et al., 2010; Calder et al., 2013) that aging affect the ability to decode negative facial expressions.

The reported data are particularly interesting in showing a complex effect of contextual factors affecting seniors' ability to decode differently aged emotional faces.

As for disgust, seniors are significantly less accurate in decoding primarily old aged disgusted faces with respect to middle and young ones, and middle-aged faces with respect to young ones. Effects of the gender of stimuli were also observed, with female faces better decoded than male ones.

Anger was better decoded by seniors progressively in young, middle, and old faces, describing, as for disgust, a reverse pattern with respect to the own age bias theory. In

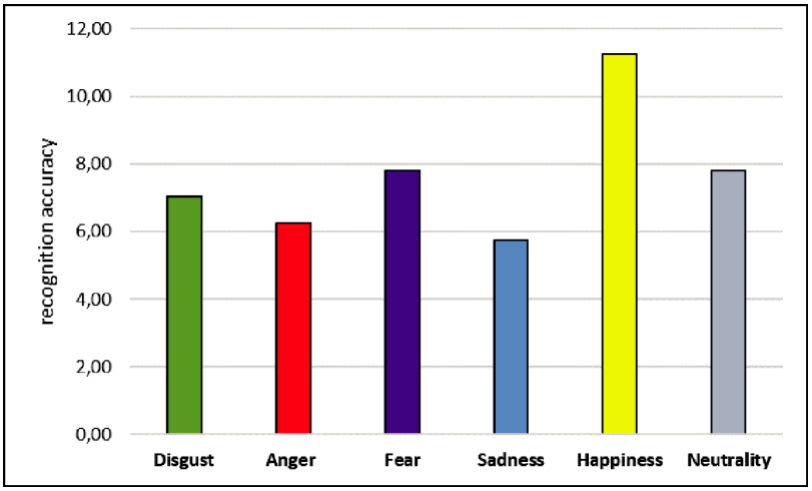

Fig. 3. Elders' facial expression decoding accuracy according to the investigated emotional categories.

addition, a participants' gender effect was observed with female more accurate than male in decoding facial expressions of anger.

The gender of stimuli appears to be the main factor affecting elders' recognition of emotional expressions of fear in favor either of female faces when fear is conveyed by old and middle-aged faces, or in favor of male faces when fear is conveyed by young faces.

The main factor influencing the ability of seniors to decode emotional expressions of sadness is the gender of the stimuli, in favor of female faces which were significantly better decoded than male ones.

Happiness was equally well decoded by seniors no matter the age of the faces.

Neutrality was better recognized when conveyed by young male faces. Female participants were more accurate in decod-ing young rather than middle aged faces particularly when the faces belong to young males.

To sum up, these results suggest that when elders recognize emotional facial expressions, both age and gender of the proposed stimuli affect their accuracy, which in turn also strongly depends on the emotional category accounted for. Figure 2 illustrates these results.

Concerning the effect of the age of stimuli our results do not support the Own Age Bias (OAB) theory. The elders involved in the present study showed impairments in decoding disgust and anger when conveyed by old faces and were more accurate in decoding facial expressions of their peers only for fear expressed by female faces. Participant's gender effects were observed only for anger, with women showing better performances than men, while the gender of stimuli affected only the recognition of sadness in favor of female faces.

Finally a very strong effects of the emotional categories, confirming as previously pointed out (Phillips et al., 2002; Sullivan and Ruffman, 2004; Isaacowitz et al., 2007; Orgeta & Phillips, 2007; Richter et al., 2010; Calder et al., 2013) elders' impairment in recognizing facial expressions of anger and sadness.

These experimental data suggest that body and context constrain individuals' social conduct as they render the world sensible and interpretable during everyday activities. In order to automatize this complexity it is necessary to manage multiple theoretical investments ranging from mathematical models of interaction and dynamics of signal exchanges (in terms of shared meanings, emotional states, cultural differences, and context effects), new mathematical models for representing data, learning, and decision making, as well as, new individual/group behaviour analysis models of social interaction in cross-cultural contexts. This will produce context-aware avatars replacing human in high risk tasks, companion agents for elderly and impaired people, socially believable robots interacting with humans in extreme, stress-ful time-critical conditions, computational intelligence, and automatic healthcare and education services. Such applica-tions will enhance quality of life in society and will change the individuals' social conduct, in typical as well as impaired circumstances.

The present results can be biased by the exploited stimuli (the FACE database) and therefore need further investigations.

The FACES database contains pictures depicting actors displaying emotions in a non-naturalistic environment. Since it is our opinion that the context in which an emotion is conveyed has a deep impact on people's ability to interpret and decode it, in a future study more genuine emotional facial expressions should be selected. In addition, surprised facial expressions must be considered, since the FACES database do not contain expression of this emotion. The authors (Ebner et al.,2010) decided to not include it, since according to them facial expressions of fear and surprise are often blended and may be confused with each other. Finally, in everyday life humans are called to decode dynamic multimodal emotional expressions.

ACKNOWLEDGMENTS

The research leading to these results has received fund-ing from the European Union Horizon 2020 research and

innovation programme under grant agreement N. 769872 (EMPATHIC) and N. 823907 (MENHIR). Partial supports were received from the Italian project SIROBOTICS, MIUR, PNR 2015-2020, DD 1735 July 13 2017; the Italian project ANDROIDS, Universita` della Campania Luigi Vanvitelli programme V:ALERE 2019, funded with D.R. 906 del 4/10/2019, prot. n. 157264, Oct 17, 2019, the Spanish project TIN2016-74946-P (MINECO/FEDER, UE) and CERCA Programme / Generalitat de Catalunya. This work is partially supported by ICREA under the ICREA Academia programme.

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