Categorical Perception of emotional faces is not affected by aging

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Abstract

Effects of normal aging on categorical perception (CP) of facial emotional expressions were investigated. One-hundred healthy participants (20 to 70 years old; five age groups) had to identify morphed expressions ranging from neutrality to happiness, sadness and fear. We analysed percentages and latencies of correct recognition for non-morphed emotional expressions, percentages and latencies of emotional recognition for morphed-faces, locus of the boundaries along the different continua and the number of intrusions. The results showed that unmorphed happy and fearful faces were better processed than unmorphed sad and neutral faces. For morphed faces, CP was confirmed, as latencies increased as a function of the distance between the displayed morph and the original unmorphed photograph. The locus of categorical boundaries was not affected by age. Aging did not alter the accuracy of recognition for original pictures, no more than the emotional recognition of morphed faces or the rate of intrusions. However, latencies of responses increased with age, for both unmorphed and morphed pictures. In conclusion, CP of facial expressions appears to be spared in aging.

Keywords: Affective neurosciences; Categorical perception; Aging; Emotions; Faces

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1. Introduction

Categorical perception (CP) is a well-documented phenomenon in the field of human perception (Harnad, 1987). Categorization consists of allocating different stimuli to discrete categories on the basis of common properties. Through categorization, linear physical changes present non-linear perceptual effects. For instance, the colour spectrum results from a continuous variation of light frequencies, but individuals perceive chunks of colours rather than a gradual continuum of colour change. Furthermore, authors have argued that discriminating two stimuli that are perceived as stemming from two different categories is easier than distinguishing between two stimuli classified as belonging to the same category *even if the physical distance is held constant between each pair of stimuli* (Harnad, 1987). This phenomenon of enhanced "between-category" differences compared to reduced "within-category" differences is called *the categorical perception effect*.

CP is not restricted to unidimensional stimuli such as colours; studies have shown that multidimensional stimuli, such as faces, are categorically perceived in terms of emotional expression (Calder et al., 1996; Campanella et al., 2002a; Campanella et al., 2002b; Etcoff & Magee, 1992; Young et al., 1997), even in 7 months-old infants (Kotsoni et al., 2001). CP of emotional expressions is typically studied by using a morphing procedure, i.e. artificial continua of interpolated (morphed) facial expressions deriving from two separate prototypical emotional expressions from the same individual (Bruyer et al., 2007). Two tasks are classically used to explore CP: identification and/or discrimination tasks. During the emotional identification task, morphed faces belonging to a continuum going from an emotional expression to another one are randomly presented one by one, and subjects have to attribute an emotional label to the facial display. A graphic representation of the subjects' responses reveals two different regions on the continuum: at first, the first emotion is clearly identified. Then, after a zone of vagueness, the second emotion is recognized. The intersection between these two curves of responses allows defining a categorical boundary representing the point of the continuum where we "move" from one emotion to the other, in spite of linear modulation of sensorial information (Calder et al., 1996; Etcoff & Magee, 1992).

In discrimination task, morphed stimuli are presented following an ABX design: stimuli A, B and X are presented sequentially and subjects had to decide whether X was the same as A or B. An other version consists to present morphed faces two by two, subjects having to decide whether they displayed similar emotional expression or not. For instance, Campanella et al. (2002a) asked participants to discriminate between three types of face-pairs, including two images of the same face displaying the same expression

(identical pair), two faces displaying two different emotions (between pairs) and two faces displaying the same emotion but with two different intensities (within pairs). Between- and within-pairs were separated by a constant physical distance (30%). Results showed that within pairs were harder to discriminate than between pairs, even though the physical distance within each pair was kept constant. These findings suggest that performance in perceiving emotion through facial expression is more influenced by the category membership than by objective physical distance (Campanella et al., 2002a; Campanella et al., 2002b). Tanaka and colleagues (1998) suggest different prototypical representations for different emotional facial expressions, the former being stored in long-term memory. Different prototypes are activated when individuals see faces portraying different emotional expressions. Thus, morphed faces of between-categorical pairs activate two different representations and facilitate discrimination, whereas within-categorical pairs rely on the same representation and are consequently harder to differentiate.

On the other hand, data showed an effect of normal aging on the recognition of emotional expressions (Chaby & Narme, 2009). A recent meta-analysis (Ruffman et al., 2008) stated that older adults have increased difficulties in recognising at least some of the basic emotions (anger, sadness, fear, disgust, surprise and happiness). While processing of positive emotions remains relatively unimpaired (Garcia-Rodriguez et al., 2008), some negative emotions elicit particular difficulties without impact of race nor verbal decision mechanisms (MacPherson et al., 2006). It is the case of anger and sadness (Phillips et al., 2002; Sullivan & Ruffman, 2004; Suzuki et al., 2007), as well as of fear (Calder et al., 2003). Grady and coworkers (2007) suggest that young adults have enhanced memory for negative faces and that this enhancement is not observed in older adults. By comparing angry to neutral face, neuroanatomical investigations have shown differential brain activations between younger versus older individuals (Fischer et al., 2005; Gunning-Dixon et al., 2003). Notably, aging seems to impact on specific nodes in the neural network involved in processing negative emotional face information (Fischer et al., 2005; Iidaka et al., 2002).

Overall, the literature provides support for an age-related impairment in the recognition of some emotions, particularly negative ones, independently of changes in perceptual abilities or face processing abilities (Phillips et al., 2002; Sullivan & Ruffman, 2004). However, if some results showed an independence between performance on social task and on cognitive tasks (Keightley et al., 2006), the decline of working memories observed in aging has been involved in the impairment of elderly's performance in some emotional processing tasks (Garcia-Rodriguez et al., 2008). Yet, tasks requiring implicit memory are not impaired in aging (Garcia-Rodriguez et al., 2008), and emotional information could be remembered as efficiently in older than in younger adults (D'argembeau & Van der Linden, 2004). Concerning the level of occurrence of these modifications, Hahn and colleagues (2006) used a visual search paradigm and suggested automatic attentional shift towards emotions are preserved by aging, which only influenced the controlled attentional process. By using the emotional version of the dot-probe task, Mather and Carstensen (2003) showed that older adults remember better positive than negative faces, and respond faster to the dot replacing a neutral than a negative face. These results outline the question of disengagement abilities and suggest that elderly people might demonstrate later avoidance of threatening faces.

Elderly people seem also impaired when recognizing morphed faces expressing anger and sadness, but not fear or happiness (Phillips et al., 2002; Sullivan & Ruffman, 2004). Other emotions have also been implicated by Montagne and coworkers (2007), who reported that older adults performed worse than young adults on anger, sadness, fear, and happiness recognition, but not on disgust and surprise. Since elderly people displayed affected recognition of pure and morphed facial expressions, it would have been possible that CP of emotion could be affected by age, but a study demonstrated that emotional categorical boundaries are not modified by age for happiness, sadness and disgust, even if aging was correlated with a higher rate of intrusions and longer latencies of response (Kiffel et al., 2005). The emotional representations stored in mind are stable enough so that the shift through one to another category is not affected by aging. Emotional CP seems therefore to be preserved by aging. To our knowledge, this study is the first to explore age influence on the perception of emotional stimuli varying along a physical continuum. However, the stimuli used in Kiffel's et al. study varied from an emotion to another one. That design did not provide information on the degree of intensity required to identify an emotional state or on the modulation of these intensity effects by aging.

In that framework, the main aim of the present study was to explore the recognition of emotional expressions on faces varying from neutrality to an emotional state – happiness, sadness and fear. More specifically, we aimed to compare the categorical aspect of face perception in a sample of subjects aged between 20 and 70 years-old, by answering to the question to know whether an emotional state appearing on a face is differently detected depending on the participants' age. In other words, do elderly detect faster or slower the appearance of an emotional expression on a neutral face? To address that question, the behavioural effects of aging on emotional recognition were investigated through CP of emotional faces. Neuroimaging and neuropsychological studies have demonstrated modulation of emotional processing in

elderly, in terms of the cognitive strategies used and, subsequently, in terms of brain activity. For instance, if elderly experience difficulties to recognize sadness, happiness and fear, as suggested by Montagne et al. (2007), the locus of categorical boundary should be delayed for continuum going from neutrality to these emotional facial expressions. To explore the potential development of alternative cognitive strategies, emotional recognition accuracy will be compared with speed of responses, under the hypothesis of an age decrement in the ability to recognize sad faces coupled with modifications of categorical boundaries.

2. Materials and methods

2.1. Participants

One hundred participants (age range: 20-69 years) were enrolled and divided into five age groups of twenty subjects according to their age (age groups: 20-29, 30-39, 40-49, 50-59 and 60-69 years). Subjects were administered the Spielberger State and Trait Anxiety Inventory (STAIS and STAIT; Spielberger et al., 1983), and the 13-items Beck Inventory Scale (BDI) (Beck & Beamesdefer, 1974), in order to control self-reported psychological attributes. Statistical analysis showed that age groups were not significantly different with respect to BDI Scores ($F(4,95) = .473$, ns) nor STAIS ($F(4,95) = 2.159$, ns) or STAIT scores ($F(4,95) = .542$, ns).

Subjects had normal or corrected vision, and they were screened to rule out intellectual function impairments, psychiatric illness and neurological disease. Mean age, age range, male/female ratio and psychological tests scores are reported into Table 1.

Table 1. Participant characteristics

Age Range	20-29	30-39	40-49	50-59	60-69
Mean Age	24.45 (1.8)	34.45 (2.6)	45.8 (2.9)	54.45 (3.3)	64.1 (2.8)
Ratio Male/Female	9/11	9/11	7/13	7/13	9/11
Beck	4.3 (3.3)	3.8 (4.1)	4.1 (2.7)	4.5 (3.5)	5.2 (3.4)
STAIS	54.8 (10.7)	46.6 (8.1)	49.5 (10.0)	46.9 (12.4)	48.4 (9.0)
STAIT	49.5 (8.2)	45.4 (7.3)	47.6 (8.5)	46.9 (11.0)	46.8 (10.0)

2.2. *Material and procedure*

Emotional continuum task
In this facial emotion identification task, subjects were shown a series of 62 digitalised facial images of two actors, a man and a woman, taken from the highly standardized set of pictures of Ekman and Friesen (1976), and each portraying neutral, happy, fearful and sad expressions.

Using the computer software Morph 2.5, the prototype photographs were morphed to create linear continuum of images between the two extremes representing the same actor (from 100% neutrality to one of the three emotions). (Details of the morphing technique could be found in Campanella et al., 2000; Etcoff & Magee, 1992; Young et al., 1997). Stimuli were prepared by blending two faces in the following proportions: 0:100 (i.e. 0% A Happy and 100% A Neutral), 10:90, 20:80, 30:70, 40:60, 50:50, 60:40, 70:30, 80:20, 90:10 and 100: 0 (see Figure 1). Sixty-two stimuli constituted the experimental material (54 images obtained by morphing technique -9 images inside each of the three continuums for each actor, and 8 basic images).

Figure 1. Illustration of the stimuli used for the continua going from neutrality to fear: original photographs (0:100 and 100:0) and four example of morphed faces (20:80, 40:60, 60:40, 80:20)

Procedure
Stimuli were presented on a 17inch computer screen, and stimulus presentation and data acquisition were controlled by Superlab 1.6 ßeta for Macintosh®. The 62 stimuli composing the experiment were presented four times, divided into eight blocks of 31 images. Within block, stimuli, sizing 6 cm horizontally and 8 cm vertically and subtending a visual angle of 6 x 8°, were shown one by one in the centre of a black background, in a random order. Each trial begins with the presentation of a fixation cross during 500ms, followed by the faces until the subject response and for a maximum of 3000ms.

Individuals were tested individually in a quiet room, and the experimental procedure used a "forced choice paradigm". Before the experiment proper, the experimenter instructed the participants to identify the emotional expression of faces by pressing one of four keys on an Azerty keyboard (corresponding to the letter Q, F, J and M and counterbalanced between participants) and labelled J- for happiness, P- for fear, T for sadness and N for neutrality (referring to the French labels of these emotions), without receiving any feed-back. Practice trials during which participants could ask for additional information, were discounted before starting the experimental session to familiarize participants with the procedure. The entire experiment took about 40 minutes, and the experimenter stay in the room during the whole session.

3. Data analysis

Five dependant variables were analyzed: the percentage of correct recognition of non morphed emotional faces, the percentage of emotional responses for morphed faces, the locus of the boundaries along the different continua, the latency of responses, and the number of intrusions. For each continuum, the proportion of correct responses was expected to reach 100% for the basic emotions and to diminish near the middle of the continuum, close to the categorical boundary.

Statistical analyses were computed using spss 14.0. Mixed ANOVA designs were conducted on dependant variables, with Greenhouse-Geiser epsilon correction being used to compensate for violation of sphericity when appropriate. The sources of significant interactions were systematically examined through simple effects; Bonferroni post-hoc tests were used when appropriate. The alpha level of significance was set at 0.05 throughout. More details will be provided in the results section.

4. Results

4.1. *Emotional recognition of unmorphed faces*

Correct responses
For each basic emotional face, the percentage of correct recognition was analysed. A mixed design 4 x 5 ANOVA was computed with Emotion (Neu-

trality, Sadness, Happiness, Fear) as within factor and age-group as between factor. We observed a significant main effect of Emotion ($F(3,285) = 26,101$, $p < .001$), meaning diminished recognition for sadness (89%) and neutrality (85%) as compared to fear (97.5%) and happiness (98%) (Bonferroni post-hoc comparisons S-F, S-H, N-F and N-H : $p < .001$; F-H and S-N : ns) (see Figure 2).

Age did not significantly affect emotional recognition ($F(4,95) = .700$, ns) and we did not observe significant interaction effect.

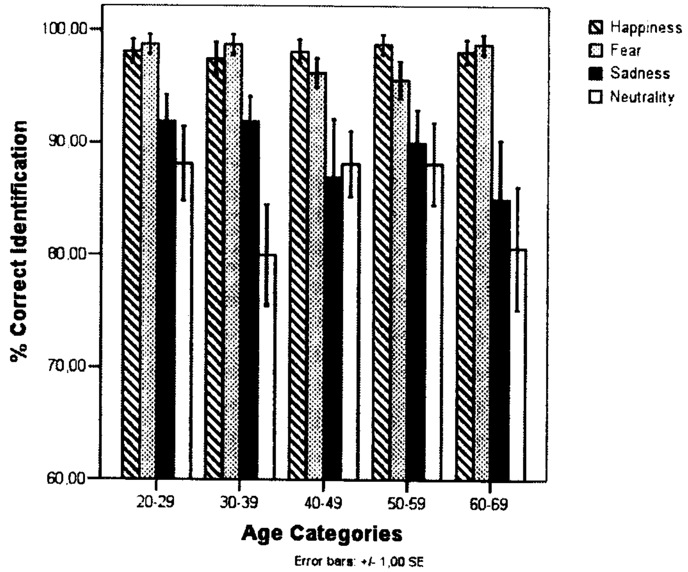

Figure 2. Percentage of correct identification for the unmorphed faces

Response latencies

We conducted the same analysis on response latencies of correct responses. A significant main effect of Age Groups ($F(4,95) = 7.312$, $p < .001$) indicated slower reaction time in 60-69 people as compared to youngest ones ($p < .001$), 30-39 ($p = .01$), 40-49 ($p = .02$) and 50-59 groups ($p = .003$), and faster reaction time in youngest subjects compared to 30-39 ($p = .008$), 40-49 ($p = .028$) and 50-59 ($p = .023$). Beside of these effects of extreme, intermediate groups did not differ from each other (see Figure 3).

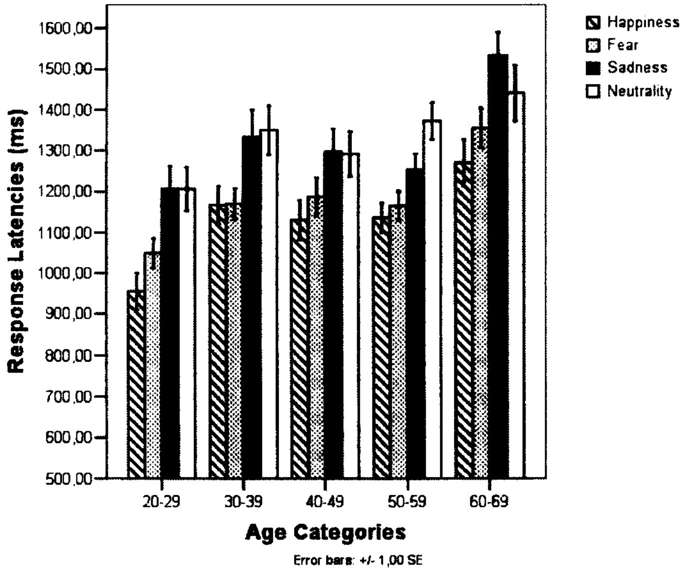

Figure 3. Response Latencies for the unmorphed faces

Emotion significantly affected response latencies ($F(3,285) = 37.679$, $p < .001$) (see figure 4) with slower responses for sadness and neutrality (without difference between them, $p = .766$) as compared to happiness and fear (Bonferroni post-hoc tests : all p-values $< .001$). On the other hand, happiness tended to be faster detected than fear ($p = .007$). There was no interaction effect between Age Group and Emotion.

In consequence to these analyses on response latencies and correct recognition of non-morphed faces, we did not observe speed-accuracy tradeoffs since analyses of correct responses demonstrated a better recognition of happiness and fear as compared to sadness and neutrality, whereas these two last emotions gave rise to longer response latencies.

4.2. Category boundaries

For each continuum, we computed the percentage of responses referring to extremities of the continuum, e.g. neutrality and the involved emotion (fear, happiness or sadness). So, we obtained two curves of responses for each continuum, the first one reporting the "neutral" responses and the second one referring to the 'emotional' responses, and we identified the intersection between the two curves as the categorical boundary, the point where the subjects responded half A and half B for the continuum AB (see Figures 4 and 5).

We computed a 3 x 5 ANOVA on these boundaries, with Emotion (located at the extremity of the continuum: Happiness, Fear, Sadness) as within factor, and Age Categories (5 levels) as between factor. Results showed a significant main effect of Emotion ($F(2,130) = 37.094, p < .001$), meaning the categorical boundary appears for an higher emotional saturation for sadness than happiness or fear (Bonferroni post-hoc tests: both $p < .001$), and for a lower emotional saturation for happiness as compared to fear ($p < .001$) (see Figure 5). Age did not modulate boundaries position ($F(4,68) = 1.963$, ns) and there was no interactional effect.

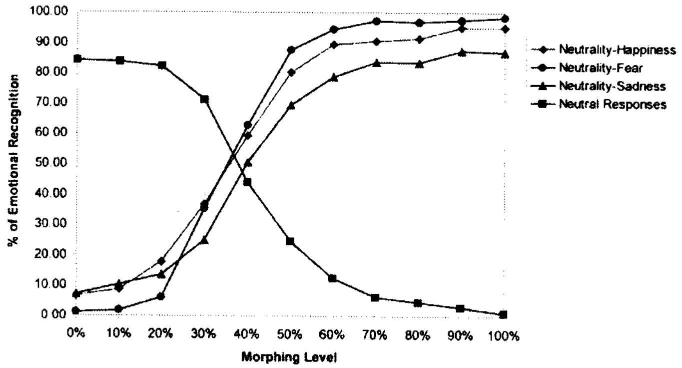

Figure 4. Emotional Responses and Categorical Boundaries

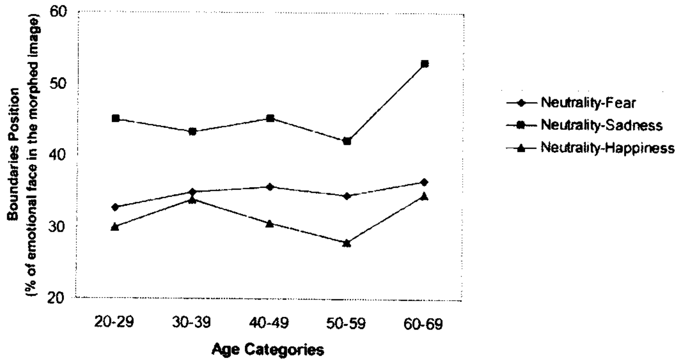

Figure 5. Boundary Positions for the Different Continua as a function of Age Group

4.3. Emotion responses

For each level of morphing (from 0% to 100% of emotional face), we computed the percentage of emotional responses (0% expected for 0% morph, 100% for 100% morph), and expected a progressive but not linear evolution of emotional response if CP applies. We computed a 3 x 11 x 5 ANOVA on percentage of emotional responses, with Emotion (located at the extremity of the continuum: Happiness, Fear, Sadness) and morphing Levels (11 levels, from 0 to 100%) as within factors, and Age Groups (5 levels) as between factor (see Figure 6).

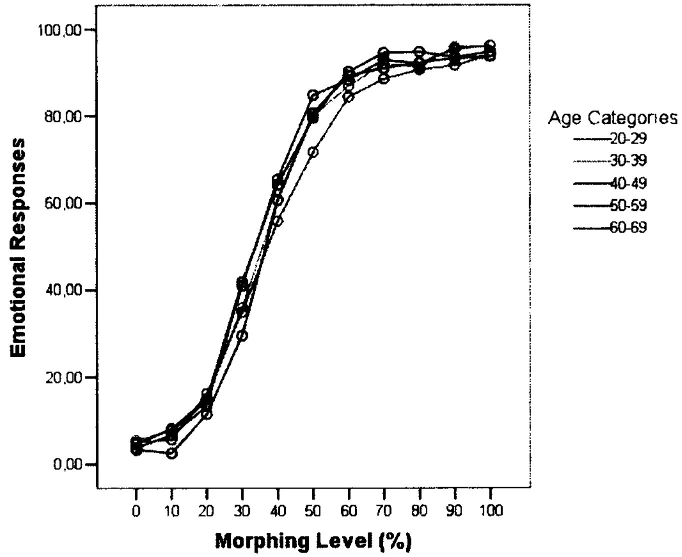

Figure 6. Representation of the sigmoidal shape of the curves for the different morphing levels as a function of Age Group

A significant main effect of emotion was evidenced ($F(2,190) = 21.495$, $p < .001$), with a higher percentage of emotional attribution to continuum implying happiness as compared to sadness and fear (both $p < .001$), not differing from each other. The significant main effect of Morphing Level ($F(10,950) = 2011,005$, $p < .001$) indicated a progressive increase of emotional response with percentage of emotional face in the morph. Analyses of polynomial contrasts demonstrated that linear component explained 81.3% of the variability. The remaining 18.7% were mainly explained by the quadratic (33.16%) and the cubic (26.7%) components. Thus, the sigmoidal shape of the curves (see figure 6) is obvious, a typical signature of CP.

Emotion significantly interacted with morphing level ($F(20,1900) = 30,227$, $p < .001$) and the level of morphing required to recognize an emotional expression varied as a function of the emotion used. Main effect of Age Groups did not reach the significance ($F(4,95) = 1.509$, ns), and we did not evidence interactions with the other factors.

4.4. Latencies

We conducted the same analysis on the latencies reported to morphed faces, with the hypothesis of a lengthening near the categorical boundaries.

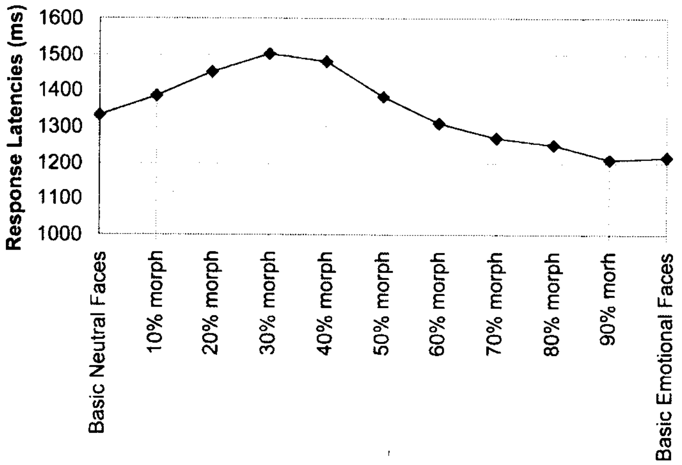

Figure 7. Response latencies for the different levels of morphing

We observed a significant main effect of Level ($F(10,950) = 79.269$, $p < .001$), with significant longer latencies located around the categorical boundaries, and shorter for the emotional faces than for the neutral ones (see Figure 7). Together, linear, quadratic and cubic components explained 81% of variability (linear component: 20.4%; quadratic: 26.7% and cubic: 33.9%).

Emotion significantly influenced the latencies ($F(2,190) = 18.164$, $p < .001$): fear gave rise to shorter reaction time as compared to happiness and sadness (both $p < .001$) whereas sadness lengthened reaction time (Bonferroni

post-hoc comparisons: S-H : $p = .016$; S-F : $p < .001$). Emotion interacted with Levels ($F(20,1900) = 20.382$, $p < .001$), meaning that different levels of morphing evoked different latencies according to the emotion.

A significant main effect of age was observable ($F(4,95) = 7.679$, $p < .001$). 60-69 participants were significantly slower than other groups (Bonferroni post-hoc comparisons: /20-29 : $p < .001$; /30-39 : $p = .009$; /40-49 : $p = .001$; /50-59 : $p = .014$). At the opposite, youngest individuals responded quicker thorough the task (/30-39 : $p = .006$; /40-49 : $p = .041$; /50-59 : $p = .004$). People aged between 30 and 59 years-old did not differ from each other. Age did not significantly interact with the other factors.

4.5. Intrusions

As the participants had to choose among four responses (Neutral, Happy, Fearful, Sad), intrusions were possible (for instance, when the subject select Happy for a morph belonging to the Neutral-Fear continuum). We conducted a 3 x 5 ANOVA on percentage of intrusions on continua with Emotion (located at the extremity of the continua: Happiness, Fear, Sadness) as within factors, and Age Groups (5 levels) as between factor (see Figure 8).

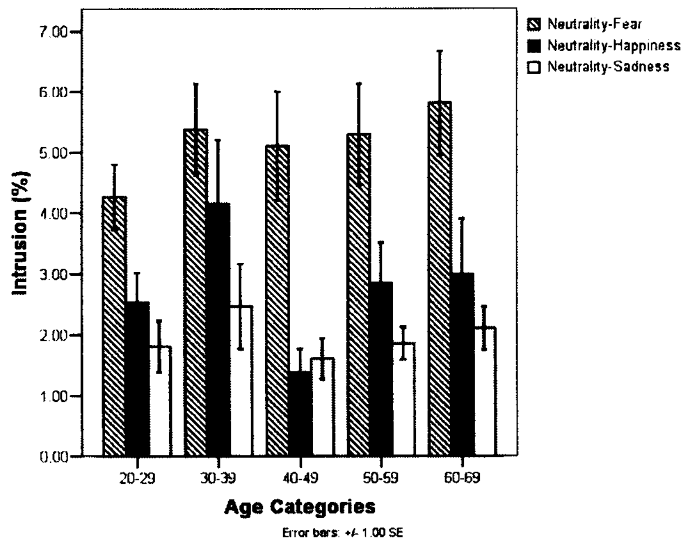

Figure 8. Percentage of intrusions for the different continua

Emotions significantly influenced Intrusions ($F(2,190) = 57.369$, $p < .001$). Post-hoc tests revealed significantly more intrusions in Neutral-Fear continuum (5.17) than in Neutral-Happiness (2.74, $p < .001$) or Neutral-Sadness (1.97, $p < .001$), this last giving rise to the weakest rate of false identification (NS – NH : $p = .009$). Age Groups did not reach significance ($F(4,95) = .977$, ns) and did not interact with Emotion.

4.6. Correlations

In order to explore the influence of psychological variables, anxiety and depression, on emotional perception, Pearson's correlations were computed between Beck, STAIS and STAIT scores. Firstly, depression, trait and state anxiety were highly correlated (STAIS – STAIT : $r = .627$; STAIS – Beck: $r = .575$; STAIT – Beck: $r = .655$, all p-values < .001), meaning that high scores on a scale were associated with high scores on the other ones. Level of trait-anxiety was negatively correlated with the position of boundary on neutrality-sadness continuum ($r = -.217$, $p = .042$): the higher was the score of trait anxiety, the earlier appeared the boundary. On the opposite, state anxiety was correlated with the level of correct recognition of non-morphed Fear faces ($r = .198$, $p = .048$) while depression was negatively correlated with that measure on Happy faces ($r = -.201$, $p = .045$). However, response speed was not correlated with psychological variables.

Taken together, these results indicated that psychological variables affected the emotional recognition, in the sense of a modulation of emotional recognition abilities correlated with depression and anxiety, but without influence on processing speed.

5. Discussion

The aim of this study was to examine whether CP of emotional facial expressions was affected by aging, by presenting participants with an emotion identification task in which they had to categorize morphed faces varying along a continuum going from neutrality to an emotional expression (fear, sadness or happiness).

Common sense would suggest several hypotheses about age effect on emotional perception. First, elderly could benefit of higher experience (Ross & Mirowsky, 2008) to improve their perception of emotional states in others, and consequently they may detect faster the presence of an emotion on a face.

However, literature globally dismissed that hypothesis by showing alterations in the recognition of facial expressions, beginning from the age of 50 years and increasing after 70 (for a review, see Chaby & Narme, 2009). Second, the decline of visual abilities, added to an increase of self-concerns, could deteriorate that aptitude, and lead to a decrease of recognition of emotional faces. That second hypothesis received supports from different studies (Ruffman et al., 2008; Suzuki et al., 2007), which also demonstrated significant changes in neurophysiological (Wieser et al., 2006) and neuroanatomical (Fischer et al., 2005; Gunning-Dixon et al., 2003; Iidaka et al., 2002; Tessitore et al., 2005) correlates of emotional processing. Some studies even provided data confirming each of both alternative hypotheses, by showing a decline in the recognition of some emotions linked to a facilitation for others (Suzuki et al., 2007). Finally, elderly may seek to maximize pleasure through positive emotions and minimize displeasure and thus negative emotions (Ready et al., 2006). This could lead to the emergence of an affective bias (Mather & Carstensen, 2003), similar to those described in depressed states for instance (Hale, 1998).

Our results did not support any of these hypotheses, by demonstrating that labelling standard and morphed emotional faces is not affected by aging, and that elderly demonstrated similar accuracy in emotional recognition than younger individuals. Moreover, we do not confirm difficulties of elderly in labelling sadness or fear (Keightley et al., 2006; MacPherson et al., 2006). Similarly, CP, meaning the position of the boundary pointing the perceptual shift from emotion, was not affected by age. This observation is in line with those of Kiffel et al. (2005) who did not observe age influence on categorical shift for happiness, sadness and disgust. Our results not only support those of this study but extend the sparing of CP to fear perception, and strengthen the conclusions on a wider sample (100 participants), subdivided in stricter age groups. Moreover, Kiffel and collaborators used faces morphed between two emotional expressions (e.g. happiness-sadness) while we developed faces going from neutrality to an emotion. Consequently, the confirmation of a spared CP is all the more interesting as it was observed on different experimental designs, using different emotional expressions.

However, aging affected response latencies. Elderly were slower to identify emotional faces and to categorize morphed images, supporting previous reports (Keightley et al., 2006; Sullivan & Ruffman, 2004). This effect is certainly due to the general slowing associated with aging in literature (Birren & Fisher, 1995; Falkenstein et al., 2006; Kolev et al., 2006), and also specifically reported concerning emotional processing of angry and fearful faces (Tessitore et al., 2005). Moreover, our task, implying a forced-choice paradigm with four response-key, was particularly sensitive to motor retardation, and as suggested by Kolev and his collaborators (2006), this response slowing in aging is probably more attributable to task complexity than to differences in cognitive strategy. Alternatively, the hypothesis of Tessitore and colleagues (2005) is that elderly individuals engage a more distributed network during the perceptual processing of emotional faces, which might reflect strategic changes.

Our results also evidenced some emotional effects. Firstly, happiness and fear gave rise to better level of recognition and faster response latencies than sadness and neutrality. Kirita and Endo (1995) already demonstrated faster recognition of schematic happy faces as compared to sad faces and hypothesized a holistic mode of recognition of happiness in contrast to an analytic processing of sadness. On the other hand, a number of studies have pointed the advantage of fearful expressions in capturing visual attention (Pourtois & Vuilleumier, 2006). Fear expression is a socially threatening stimulus, and a particularly important signal to process as it often warns off the potential presence of a danger in the environment, and prepares the individual to confront it or to escape from it. The detection of fearful faces is consequently mediated by automatic detection mechanisms, which act before consciousness and elicit autonomic responses (Öhman, 1996; Pourtois et al., 2004).

Morphing did not seem to modify the particular features of happiness and fearful displays since morphed faces involving fear and happiness were categorized faster. Moreover, boundaries aroused earlier in continua implying fear and happiness, as if the physical characteristics of these expressions were more easily perceptible than those of sad faces.

In conclusion, our study demonstrated that categorical shift and emotional attribution are not affected by aging, even if a global slowing alters elderly's performance. However, some alternative explanations may be advanced to explain discrepancies between our results and other data demonstrating modulation of CP in aging (Montagne et al., 2007; Sullivan & Ruffman, 2004). Firstly, we used morphed images built between an emotional and a neutral face, whereas most of studies used continua between two different emotional faces (Kiffel et al., 2005; Maurage et al., 2008; Montagne et al., 2007; Rossignol et al., 2007; Vermeulen et al., 2008). Two main reasons justify our choice. Firstly, we wished to use continua varying in emotional intensity from a non-emotional state, and to keep face with non-ambiguous emotional state. Since the morphing of two emotional expressions give rise to chimerical emotional display, the neutrality established itself as a relevant choice. On the other hand, we wanted to examine how the particular physical properties of emotional faces would be considered and would take the step on the recognition of the neutrality. However, the use of neutrality may explain why the boundaries appeared so early in the continua, since physical

features of emotional faces seem to be more perceptible when they are superimposed on a neutral face with less salient traits, than when the particular features of two emotional faces are mixed. Nevertheless, it is worth noting that some authors consider neutrality as a true emotional expression (Shah & Lewis, 2003). It should also be noted that the neutral to emotional continua a more realistic and ecologically valid than the emotion to emotion ones.

Finally, the important role of psychological variables has been outlined, and it could be that mental state interferes with performance in elderly. For instance, Grady et al. (2007) have demonstrated that lower levels of extraversion and better emotional sensitivity predicted superior negative face memory in older adults, whereas recognition of faces was not influenced by mood or personality traits in young adults. Other arguments in favour of this hypothesis could be found on studies reporting widespread evidences of impaired emotional processing and attentional biases in emotional perception in subjects with anxious or depressive tendencies (Mialet, 2000; Rossignol et al., 2005). Since psychological variables did not differ between our groups, we did not include these values in our analyses, in order to simplify the presentation. However, psychological vulnerabilities could influence elderly people performance in emotional task, and must be taken into consideration in further studies.

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