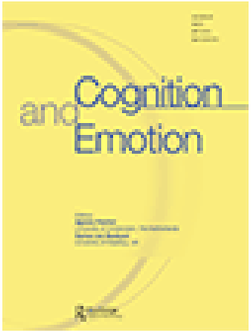

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Evaluative ratings and attention across the life span: emotional arousal and gender

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ABSTRACT

This study was designed to investigate the evolution of emotional processing over the whole adult life span as a function of stimulus arousal and participants' gender. To this end, self-reported affective evaluation and attentional capture prompted by pleasant and unpleasant pictures varying in arousal were measured in a large sample of participants ($n = 211$) balanced by gender and equally spread across seven decades from 20 to 90 years. Results showed age differences only for affective evaluation of pleasant stimuli, with opposite patterns depending on stimulus arousal. As age increased, low-arousing pleasant cues (e.g. images of babies) were experienced as more pleasant and arousing by both males and females, whereas high-arousing stimuli (e.g. erotic images) were experienced as less pleasant only by females. In contrast, emotional pictures (both pleasant and unpleasant) were effective at capturing attention in a similar way across participants, regardless of age and gender. Taken together, these findings suggest that specific emotional cues prompt different subjective responses across different age groups, while basic mechanisms involved in attentional engagement towards both pleasant and unpleasant stimuli are preserved in healthy ageing.

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Ageing; gender; evaluative ratings; natural scenes; emotion

A range of studies outline the fact that cognitive, affective and social aspects of human life have different trajectories across the life span (Baltes, Staudinger, & Lindenberger, 1999; Kensinger, 2009). Indeed, one relevant issue that has prompted intensive research in recent years concerns whether and to what extent ageing affects emotional processing (Ebner & Fischer, 2014; Isaacowitz & Blanchard-Fields, 2012; Scheibe & Carstensen, 2010).

Emotion has been widely investigated via the presentation of affective pictures that are effective cues in evoking a broad range of emotional reactions, and that involve both pleasant and unpleasant affects (Bradley, 2000; Ferrari et al., 2016; Lang, Greenwald, Bradley, & Hamm, 1993). Several studies have shown that valence and arousal are the most important dimensions of emotional reactivity, and that they control most of the variance of subjective reports (Bradley, Codispoti, Cuthbert, & Lang, 2001; Osgood, 1969; Russell & Barrett, 1999).

To date, many studies have focused on the subjective impact of emotional stimuli (i.e. affective evaluation) across age groups, but findings are not consistent across studies. Several studies failed to find any age effect (e.g. Mikels, Larkin, Reuter-Lorenz, & Cartensen, 2005; Neiss, Leigland, Carlson, & Janowsky, 2009; Ritchey, Bessette-Symons, Hayes, & Cabeza, 2011; Smith, Hillman, & Duley, 2005; Söderholm, Häyry, Laine, & Karrasch, 2013; Tsai, Levenson, & Carstensen, 2000; Wieser, Muhlberger, Kenntner-Mabiala, & Pauli, 2006; Wurm, Labouvie-Vief, Aycock, Rebucal, & Koch, 2004), while others found a general decline of the appetitive system activation with increasing age, as all (both high and low in arousal) pleasant stimuli were rated as less arousing and less pleasant in older compared to younger participants (Keil & Freund, 2009). On the contrary, other studies reported higher pleasantness ratings for low-arousing pleasant and/or neutral cues in older compared to younger adults (Backs, da Silva, & Han, 2005; Grühn & Scheibe,

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2008; Keil & Freund, 2009; Mather & Knight, 2005; Neiss et al., 2009; Streubel & Kunzmann, 2011). In terms of unpleasant emotions, several studies did not observe relevant age-related changes in reported feelings prompted by unpleasant stimuli (e.g. Dolcos, Katsumi, & Dixon, 2014; Keil & Freund, 2009; Mather & Knight, 2005; Wieser et al., 2006) but others found enhanced subjective reactivity to stimuli inducing negative emotions in older compared to younger adults (Beaudreau, MacKay, & Storandt, 2009; Fajula, Bonin-Guillaume, Jouve, & Blin, 2013; Grühn & Scheibe, 2008; Kunzmann & Grühn, 2005; Kunzmann & Richter, 2009; Streubel & Kunzmann, 2011), despite the lack of age differences in terms of autonomic reactivity (Gavazzeni, Wiens, & Fischer, 2008; Kunzmann & Grühn, 2005; Kunzmann & Richter, 2009).

One explanation for these inconsistencies may have to do with differences or weaknesses in the sampling criteria across studies. The large majority of cross-sectional studies in ageing and emotion consists of comparisons of samples of young and old adults (i.e. extreme-groups design), however, this type of experimental design can be problematic for several reasons. First, two groups that differ in age are also likely to differ in other respects, hence, it is always possible that the observed results are attributable to some variable other than age. If data are available from adults across the complete age range (i.e. *continuous*-groups design, Salthouse, 1999), then we are in a better position to separate the effects of other confounding variables that are unlikely to covary with age, or might partly covary within certain age ranges. Second, a continuous group design allows us to assess whether changes in emotional reactivity occur linearly during the ageing process, or whether they are more abrupt (nonlinear patterns), as they may coincide with significant biological, psychological or sociocultural changes. Third, in many previous studies, the "older group" comprised participants with a wide range of ages (60–80+), and the mean age varied across studies, making it difficult to evaluate the findings. Considering that people experience very different conditions (e.g. the degree of mental and physical decline) as they grow older (e.g. Baltes et al., 1999; Hof & Mobbs, 2009), a more accurate portrayal of significant life changes could be provided by subdividing the elderly population into separate decades, rather than grouping together all people over 60.

Some of the previous studies did not compare gender-balanced groups; indeed, differences between sexes have rarely been analysed (Gomez, von Gunten, & Danuser, 2013; Keil & Freund, 2009). One might hypothesise that gender may mediate differential responses to specific emotional cues across the life span and may thus contribute to the variety of findings across studies. Sex differences in emotional response are well documented in young adult populations (Bradley, Codispoti, Sabatinelli, & Lang, 2001; Murnen & Stockton, 1997), indicating that women are generally more defensively reactive, whereas men are specifically more aroused by erotic cues. Whether these affective preferences in men and women remain stable or change over the ageing process has yet to be clarified. Thus, in the present study, we used a picture-viewing paradigm to assess emotional reactivity in participants covering a large segment of the adult life span (age 20–80+), grouped into seven age decades in which males and females were equally represented.

It is well established that arousal is a critical factor in emotional reactivity at the level of both self-report affective evaluations, as well as physiological (cortical, subcortical and peripheral) changes (Bradley, Codispoti, Cuthbert et al., 2001; Codispoti, De Cesarei, & Ferrari, 2012; Codispoti, Ferrari, De Cesarei, & Cardinale, 2006; Lang & Bradley, 2010; Kensinger, 2008; Streubel & Kunzmann, 2011). Moreover, several recent findings suggest that ageing affects emotional reactivity differently as a function of the level of stimulus arousal (Backs et al., 2005; Streubel & Kunzmann, 2011). Therefore, we assessed ageing effects here by examining emotional reactivity to high- and low-arousing pictures within each valence category.

High-arousing emotional pictures are also known to engage attentional resources naturally and reflexively (Bradley, 2009; Ferrari, Codispoti, Cardinale, & Bradley, 2008; Lang, Bradley, & Cuthbert, 1997). A number of studies are consistent in showing greater attention allocation to pleasant and unpleasant pictures compared with neutral contents. For example, interference effects caused by task-unrelated emotional pictures have been observed during a variety of visual and acoustic tasks, suggesting that motivationally relevant (pleasant and unpleasant) stimuli draw more on attentional resources, leaving them less available for task processing (Bradley, Cuthbert, & Lang, 1999; Calvo & Nummenmaa, 2007; De Cesarei & Codispoti, 2008; Mitchell et al., 2008; Okon-Singer, Tzelgov, & Henik, 2007; Weinberg & Hajcak, 2011). In addition to self-reports of affective experience, in the present study we examined

attentional capture by the same emotional pictures in the same participants, to better clarify the relationship between the two components (self-report and attention) of affective processing over the entire adult life span. Assuming that self-reports and attention to emotional cues reflect different facets of emotional processing, with the former being more vulnerable to sociocultural factors as well as to subjective control, we might expect different age-related effects across these two measures of emotional processing.

Methods

Participants

A total of 211 adults (108 female) participated in this study. Participants were distributed among seven different age decades (from age 20 through 90), with a balanced number of males and females in each age group. Most of the young adults (20–29 years old) were undergraduate psychology students from the University of Bologna; middle-aged and older adults were recruited through voluntary organisations and social centres for elderly people. Prior to participating, all subjects were informed concerning the potentially disturbing content of some stimuli and signed a written informed consent in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and with the recommendations of the local ethical committee of the Department of Psychology of University of Bologna.

All participants had normal or corrected-to-normal visual acuity and were screened using a standardised health interview prior to inclusion in the study. All participants scored 27 or higher on the Mini-Mental State Examination (Folstein, Folstein, & McHugh, 1975), consistent with normal cognitive functioning. Education was lower with increasing age $F(6,197) = 35.8$, $p < .0001$, $\eta_p^2 = .5$, in line with the normative increase in formal education over the last century in Italy. This pattern was not modulated by participant's gender (age x gender, $F < 1$). Table 1 presents participants' demographic and affective well-being information in each group.

Materials and procedure

The study consisted of two sessions. During the first session, participants completed several questionnaires assessing demographic and affective well-being characteristics (Table 1). The second session (held about one week later) required participants to sit comfortably in front of a laptop and perform two tasks: The emotional interference task, followed, after a short break, by the affective rating task.

Affective well-being measures: The questionnaire packet included: (1) The Positive and Negative Affect Schedule (PANAS); (2) The Affect Intensity Measure (AIM); (3) The Emotion Regulation Questionnaire (ERQ): (4) The Beck Depression Inventory-II (BDI-II) and (5) The State-Trait Anxiety Inventory (STAI).

The PANAS is a 20-item self-report measure of positive affect (PA) and negative affect (NA) developed by Watson, Clark, and Tellegen (1988). PA reflects the extent to which a person feels enthusiastic, active and alert. NA reflects the extent to which a person feels NA states, such as being nervous and upset. Participants were asked to rate how they felt in general (general instruction; see Watson et al., 1988). The AIM (Larsen & Diener, 1987) is a 40-item questionnaire that measures trait levels of affective intensity. A sample item from the AIM is the following: "My emotions tend to be more intense than those of most people." The AIM has been shown to have good internal consistency, test–test reliability and good discriminant validity (Larsen & Diener, 1987). The ERQ (Gross & John, 2003) consists of 10 items covering two factors: Cognitive Reappraisal (six items) and Expressive Suppression (four items). The six-item reappraisal subscale assesses the frequency with which individuals regulate their emotions through the use of thought-change strategies. The four-item suppression subscale measures the extent to which individuals regulate their emotions through the use of suppression strategies. The ERQ has been shown to have excellent psychometric properties. The BDI-II (Beck, Steer, & Brown, 1996) consists of 21 items to assess the intensity of depression in clinical and normal patients. Each item has a list of four or more statements, arranged according to increasing severity, about a particular symptom of depression. The STAI (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) is a self-report assessment device that includes separate measures of state and trait anxiety. We report only the trait form, composed of 20 items. Trait anxiety denotes a general tendency to respond with anxiety to perceived threats in the environment.

Experimental stimuli: The stimuli were 72 coloured pictures (800×600 pixel resolution) selected from the International Affective Picture System (IAPS, Lang, Bradley, & Cuthbert, 2008), consisting of 24

Table 1. Demographic and affective well-being information in male and female participants across different age groups.

Age group	*N*	Age	Education (year)	MMSE	AIM	STAI	PA	NA	BDI	ERQs	ERQr
20–29	*F* = 20	25 (2.1)	12 (2.1)	30 (0.5)	166 (24)	43 (5.3)	31 (6.4)	24 (5.3)	8 (4.1)	11 (5.1)	30 (6.1)
	M = 20	25 (2.5)	11 (2.3)	30 (0.6)	143 (18)	40 (8.7)	28 (4.6)	23 (4.3)	7 (4.6)	12 (3.7)	27 (6.9)
30–39	*F* = 15	34 (2.8)	16 (3.5)	30 (0.2)	154 (25)	39 (8.3)	31 (4.8)	22 (4.9)	7 (5.6)	11 (5.0)	29 (7.7)
	M = 15	34 (2.8)	15 (4.1)	30 (0.1)	144 (20)	35 (5.9)	33 (4.4)	21 (4.4)	5 (4.1)	14 (4.1)	28 (7.0)
40–49	*F* = 15	44 (3.1)	14 (3.3)	30 (0.4)	154 (16)	38 (9.6)	30 (4.4)	22 (4.5)	6 (4.2)	13 (5.9)	30 (6.7)
	M = 15	45 (2.9)	13 (4.3)	30 (0.1)	139 (23)	38 (7.6)	32 (4.3)	22 (5.4)	7 (6.2)	14 (5.3)	30 (5.3)
50–59	*F* = 15	54 (2.7)	12 (2.7)	29 (0.5)	154 (15)	46 (7.4)	31 (4.1)	24 (6.2)	8 (5.6)	15 (4.4)	29 (5.5)
	M = 14	54 (2.8)	11 (3.4)	30 (0.3)	142 (23)	36 (7.4)	32 (3.4)	22 (5.2)	5 (3.5)	13 (3.2)	31 (6.9)
60–69	*F* = 14	65 (2.6)	8 (3.3)	30 (0.8)	157 (15)	38 (9.4)	32 (4.4)	25 (6.9)	10 (6.7)	15 (6.5)	32 (8.4)
	M = 12	67 (2.2)	8 (3.3)	29 (0.8)	145 (24)	39 (9.2)	31 (5.6)	24 (5.6)	8 (5.1)	18 (4.8)	34 (5.4)
70–79	*F* = 13	73 (2.8)	6 (1.5)	30 (1.0)	149 (23)	45 (6.3)	32 (5.3)	27 (4.6)	17 (9.2)	19 (7.4)	35 (6.6)
	M = 14	74 (2.5)	7 (3.4)	28 (1.8)	153 (25)	38 (6.1)	30 (4.1)	24 (6.2)	11 (6.4)	16 (6.4)	29 (9.7)
> 80	*F* = 17	83 (2.9)	6 (2.1)	28 (1.5)	153 (21)	39 (9.1)	32 (4.6)	25 (4.7)	10 (5.6)	19 (7.6)	35 (4.7)
	M = 13	84 (2.7)	7 (2.9)	28 (1.7)	155 (21)	40 (7.7)	31 (4.4)	24 (4.9)	11 (7.6)	19 (5.9)	34 (6.4)

Note. MMSE, Mini-Mental State examination (Folstein et al., 1975); AIM, Affective Intensity Measure (Larsen & Diener, 1987); STAI: State-Trait Anxiety Inventory (Spielberger et al., 1983; Italian version: Pedrabissi & Santinello, 1989); Positive (PA) and Negative (NA) affect scale (PANAS, Watson et al., 1988); BDI, Beck Depression Inventory-II (Beck, Steer, & Brown, 1996); ERQ suppression scale and ERQ reappraisal scale of the Emotion Regulation Questionnaire (Gross & John, 2003). All values represent raw mean (± SEM) scores.

pleasant, 24 unpleasant and 24 neutral pictures. Based on normative ratings acquired from college students (Lang et al., 2008), both pleasant and unpleasant pictures were selected in such a way that half were typically rated as high-arousing – pictures of erotic couples and pictures of injured bodies and the other half as low-arousing stimuli – pictures of babies/families and pictures of accidents, contamination, illness and loss. Neutral pictures depicted non-arousing scenes, such as people and objects. Therefore, picture stimuli were arranged as a function of standardised pleasantness (*p*) and arousal (*a*) ratings (Lang et al., 2008) in five picture content categories: high-arousing pleasant ($p = 6.5$; $a = 6.4$) and unpleasant pictures ($p = 1.9$; $a = 6.3$), low-arousing pleasant ($p = 6.6$; $a = 4.5$) and unpleasant pictures ($p = 2.8$; $a = 5.1$), and neutral pictures ($p = 5.3$; $a = 3.4$).

In the *emotional interference task* (Mitchell et al., 2008; Weinberg & Hajcak, 2011), participants were instructed to respond with their left and right index fingers in a simple discrimination task (circle/square stimuli, 3° x 3°of visual angle, white filled on a black background). The display showing the target stimulus (circle/square) was always preceded by the presentation of an IAPS picture (either emotional or neutral), which was irrelevant for the task. The components of each trial were presented serially. First a fixation cross was shown (1 s), then an IAPS picture (2 s), which was immediately followed (no blank in between) by the onset of the target (2 s). Subjects were required to respond as fast and accurately as possible as to whether they saw a square or circle by pressing one of two digits on the keyboard ("x" or "m"). For half of the participants, the probe-digit mapping was reversed. Participant response was allowed during the target presentation, as well as during the inter-trial interval (for a total of 6 s). Two presentation orders were constructed that varied, across participants, the order of picture presentation, as well as the association of a specific picture with the target (square or circle). In this task, there was a total of 72 trials, corresponding to the 72 pictures originally selected for the study, so that each picture exemplar was presented only once throughout the task.

In the *affective rating*, the same 72 pictures used in the interference task were then presented again and subjects viewed each picture for as long as they liked, terminating exposure with a key press. After termination, the subjects were required to rate first the pleasantness (i.e. valence) and then the intensity (i.e. arousal) of the experienced emotional state on a 9-point scale using the Self-Assessment Manikin (SAM; Lang, 1980). A computer version of the SAM scales was displayed and remained on the screen until participants provided their ratings using the 1–9 keys on the laptop keyboard.

For all participants, the interference task always went first, so that the amount of attentional capture was not affected by picture repetition (Ferrari, Bradley, Codispoti, & Lang, 2015). Stimulus presentation and response recording were controlled by E-Prime (Version 1.2) experimental software. Both tasks were presented on a PC laptop, situated approximately 0.5 m from the participant. For both tasks, instructions were given both orally by the

experimenter and visually on the laptop screen, and before beginning the actual task, participants performed several practice trials to ensure compliance with task instructions. Each task consisted of a total of 72 trials. Each session took about 1 hour.

In accordance with the guidelines of the journal, we reported how we determined our sample size, all data exclusions, all manipulations and all measures in the study.

Data analysis

A multivariate repeated measure ANOVA, with factors age Group (7: Age 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, Over 80) x Gender (2) x picture Content (5: Pleasant High-Arousing, Pleasant Low-Arousing; Neutral, Unpleasant High-Arousing, Unpleasant Low-Arousing) was conducted on pleasantness and arousal ratings as well as on reaction times (RTs) in the emotional interference task.[1] All post-hoc tests were corrected for multiple comparisons with the Bonferroni procedure. The partial eta squared statistic (η_p^2), indicating the proportion of the variance explained by one experimental factor and the total variance, was calculated and is reported.

Analysis of RTs was performed only for accurate response trials. In addition, RTs that were shorter or longer than the mean (within each subject and condition) ± 3 times the standard deviation of the mean were not included in the analysis.

A statistical power analysis was performed for sample size estimation (G*Power 3; Faul, Erdfelder, Lang, & Buchner, 2007). Assuming a medium effect size (Cohen's $f = 0.25$; Cohen, 1988) at 95% power, the current sample ($n = 211$) was considered reasonable to detect a statistically significant interaction between our factors (age group, gender and picture content) as well as the mean comparisons of interest.

Results

Affective space

Figure 1 presents each of the 72 pictures used in this study (solid symbols) in the two dimensional space formed by plotting each picture by its mean pleasantness (i.e. valence) and arousal rating separately for women (upper panel) and men (lower panel) in each age group.

Pleasantness rating: A significant age Group x Gender x picture Content interaction, $F(24, 677) = 2.3$, $p < .0001$, $\eta_p^2 = .1$, indicated that changes in pleasantness rating of specific picture contents were different for men and women across age groups. This thee-way interaction was primarily due to high-arousing pleasant pictures, mostly depicting erotic contents (see Figure 1, lower-left panel): whereas men rated high-arousing pleasant pictures as highly pleasant, compared to neutral contents, $F(1,96) = 392$, $p < .0001$, $\eta_p^2 = .78$, and this pattern remained stable across the whole life span (main effect of age group for high-arousing pictures in men, $F < 1$), women rated this picture content as less pleasant with advancing age, $F(6,101) = 8.5$, $p < .0001$, $\eta_p^2 = .33$; linear trend $p < .0001$. More specifically, women in young and middle-aged adulthood (age group 1–4; age < 60) rated high-arousing pleasant pictures as more pleasant then neutral pictures ($Fs > 9$, $\eta_p^2 > 4$) with no difference across groups; the pattern was then reversed in older women (age > 60), who rated this picture content as less pleasant than younger women ($ps < .05$), and even significantly less pleasant than neutral pictures (age group 60–69, $F(1,13) = 9.8$; $p < .01$, $\eta_p^2 = .4$; 70–79, $F(1,12) = 7.7$; $p < .05$, $\eta_p^2 = .5$; over 80, $F(1,16) = 37$; $p < .0001$, $\eta_p^2 = .7$).

On the other hand, both low-arousing pleasant and neutral pictures were rated as more pleasant with increasing age (main effect of group, $Fs(6,204) > 12.4$, $ps < .0001$, $\eta_p^2 > .3$; linear trend $ps < .0001$), with a slight but significant steeper increase for low-arousing pleasant, compared to neutral, pictures (linear trend, $F(6,197) = 2.8$, $p < .05$, $\eta_p^2 > .8$). This increase in pleasantness for low-arousing pleasant and neutral pictures with increasing age was similar in men, $Fs(6,101) > 5.7$, $ps < .0001$, $\eta_p^2 > .25$, linear trend, $ps > .0001$, and women, $Fs(6,96) > 4.5$, $ps < .0001$, $\eta_p^2 > .22$; linear trend, $ps > .0001$. Therefore, whereas young and middle-aged men generally rated low-arousing pleasant pictures as less pleasant than high-arousing pleasant pictures (group 20–29; 30–39; 40–49 $Fs > 52$, 20, 9, respectively), in older men (>50 years old), pleasant low-and high-arousing pictures did not differ in pleasantness ratings.

It is worth noting that pleasantness ratings of unpleasant pictures, either high or low in arousal, did not change across the life span ($Fs < 1$). High-arousing unpleasant pictures were rated as more unpleasant than low-arousing pictures in all age groups ($Fs > 314$), and compared to men, women rated both low- and high-arousing unpleasant pictures as generally more unpleasant, $Fs(1,197) > 21$, $ps < .0001$, $\eta_p^2 > .1$.

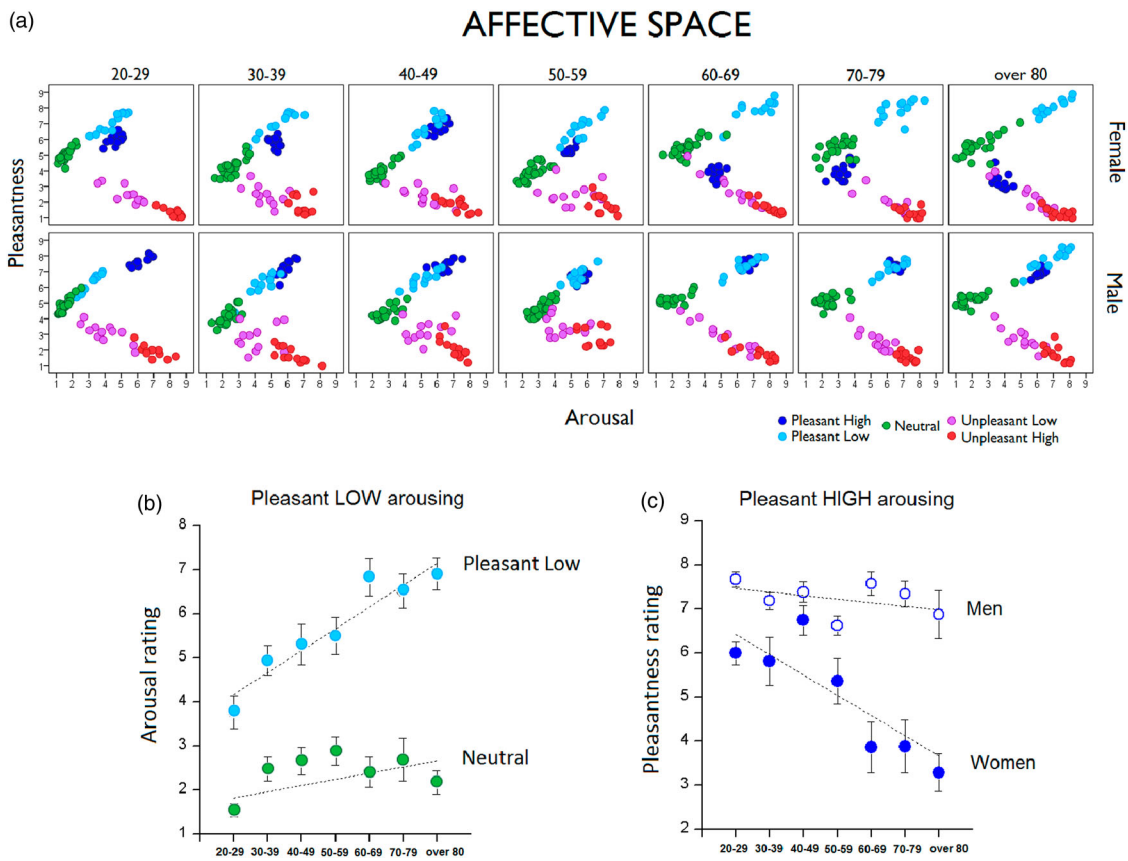

Figure 1. (a) Each of the 72 pictures presented in this experiment is plotted in the affective space formed by its mean pleasure and arousal rating scale, averaged across participants separately for the seven age decades and for women (upper row) and men (lower row). Colours represent picture content (blue: pleasant high-arousing; light blue: pleasant low-arousing; green: neutral; purple: unpleasant low-arousing; red: unpleasant high-arousing). (b) Each circle represents the mean value (± SEM) of *arousal* ratings for neutral (green symbols) and low-arousing pleasant (light blue symbols) pictures in each age group. (c) Each circle represents the mean value (± SEM) of *pleasantness* ratings for high-arousing pleasant pictures in each age group, separately for women (solid symbols) and men (open symbols).

Arousal rating: A significant interaction of picture Content x age Group, $F(24,678) = 6.9$, $p < .0001$, $\eta_p^2 = .17$, indicated that an age effect for arousal ratings was evident only for low-arousing pleasant pictures, main effect of Group, $F(6,197) = 18$, $p < .0001$, $\eta_p^2 = .35$, which were rated as increasingly more arousing with advancing age (linear trend, $p < .0001$). More specifically (see Figure 1, lower-right panel), young adults (20–29) rated these pictures as less arousing than did older people starting from 40 years of age (all comparisons, $ps < .005$). Also, arousal ratings of middle-aged adults (40–49; 50–59 years) were significantly lower compared to older people (from 60 to over 80 years; $ps < .05$). No further differences were found between older age groups (60–69 vs. 70–79 vs. 80–89, $Fs < 1$). Moreover, this linear increase in arousal ratings for low-arousing pleasant pictures was similar in men, $F(6,96) = 11$, $p < .0001$, $\eta_p^2 = .41$ linear trend, $p < .0001$, and women, $F(6,101) = 7$, $p < .0001$, $\eta_p^2 = .29$ linear trend, $p < .0001$.

As expected, men and women differed in arousal ratings in all picture contents except for neutral images, gender x content $F(4,194) = 19$, $p < .0001$, $\eta_p^2 = .28$. Compared to men, women rated unpleasant pictures, both high and low in arousal, as more arousing, $Fs(1,197) > 11$, $ps < .005$, $\eta_p^2 > .1$; conversely, men rated high-arousing pleasant pictures as more arousing, $F(1,197) = 26$, $p < .0001$, $\eta_p^2 = .16$, and low-arousing pleasant pictures as less arousing $F(1,197) = 8$, $p < .01$, $\eta_p^2 = .05$, than women. These gender effects were consistent across age group.

Emotional interference task

Reaction times to the visual target (either the square or the circle) were significantly modulated by picture

content, $F(4,792) = 25$, $p < .0001$, $\eta_p^2 = .11$; quadratic trend, $F(1,198) = 68$, $p < .0001$; $\eta_p^2 = .26$, see Figure 2: high-arousing pictures, both pleasant and unpleasant, prompted longer RTs, compared to neutral, $Fs(1,197) > 51$, $ps < .0001$, $\eta_p^2 > .21$, and low-arousing pictures, pleasant low, $Fs > 38$, $ps < .0001$, $\eta_p^2 > .16$; unpleasant low, $Fs > 9$, $ps < .005$, $\eta_p^2 > .04$. High-arousing pleasant and unpleasant pictures did not differ from each another. RTs after viewing of low-arousing unpleasant pictures were also slower compared to neutral and low-arousing pleasant pictures, $F(1,197) = 28$, $p < .0001$, $\eta_p^2 = .13$; $F(1,197) = 16$, $p < .0001$, $\eta_p^2 = .08$, respectively, whereas low-arousing pleasant and neutral pictures prompted similar RTs.

More interestingly, despite a general RT slowdown with ageing, $F(6,197) = 20$, $p < .0001$, $\eta_p^2 = .38$, picture content similarly modulated RTs in all age groups, (age Group x picture Content, $F(24,678) = 1$, $p = .4$; quadratic trends in each age group, $Fs > 6$, $ps < .05$, $\eta_p^2 > .17$, Table 2). Aside from a small Gender effect, $F(1,197) = 6.5$, $p < .05$, $\eta_p^2 = .03$, due to slower RTs in women compared to men, no other significant effect involving Gender was found.

Discrimination accuracy was overall good (> 97%) across participants, and was not affected by picture content. Women were slightly less accurate than men, $F(1,6) = 6,13$, $p < .05$, $\eta_p^2 = .03$, means = 97, 98%, respectively, and the oldest participants (over 80 years old, mean= 95%) performed significantly worse than all the other age groups, $F(6,197) = 7.1$, $p < .0001$, $\eta_p^2 = .18$.

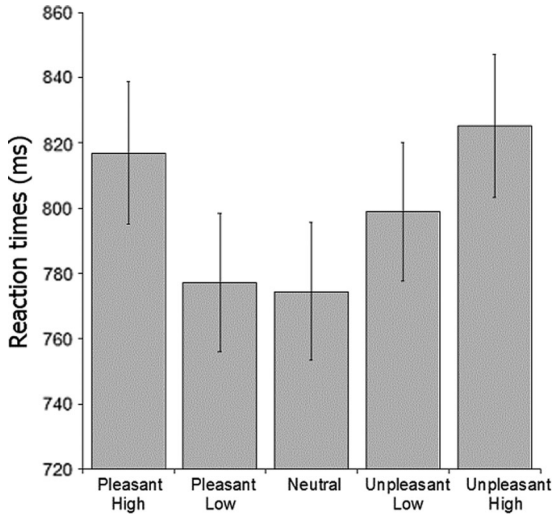

Figure 2. Overall mean RTs (± SEM) to a visual target discrimination (circle/square) after viewing of a pleasant, neutral or unpleasant picture. Pleasant and unpleasant pictures were further subdivided according to arousal intensity (high or low).

Individual differences and ageing

A multivariate ANOVA, with factors age Group (7: Age 20–29, 30–39, 40–49, 50–59, 60–69, 70–79, Over 80) x Gender was conducted on all questionnaire scores. All post-hoc tests were corrected for multiple comparisons with the Bonferroni procedure. Table 1 reports mean scores (±SEM) in each age group, separately for males and females.

Age effects were found for the BDI, $F(6,197) = 7.4$, $p < .0001$, $\eta_p^2 = .18$, as well as for the ERQ, both in the reappraisal, $F(6,197) = 3$, $p < .001$, $\eta_p^2 = .08$, and suppression scale, $F(6,197) = 7.7$, $p < .0001$, $\eta_p^2 = .19$. The highest BDI scores were observed in the age group 70–79, being significantly higher compared to the groups ranging from 20 to 60 years old, $Fs > .005$. The oldest group (>80) only differed from age decade 30–39, $F(1,56) = 10$, $p < .005$, $\eta_p^2 = .16$, and the group 60–69 was similar to all age groups. For the ERQ-reappraisal scale, post-hoc comparisons revealed that only the oldest group (>80) scored higher compared to the two youngest groups, $ps < .05$. Similar age effects were found for the ERQ-suppression scale, where the highest scores were found again in the age group > 80, that differed from the younger groups 20–59, $ps < .05$. The group 70–79 scored higher compared to the first two young decades (20–29, 30–39, $p < .0001$; $p < .05$, respectively) and the group 60–69 only differed from the very young group (20–29, $p < .01$).The three old groups did not significantly differ from each other.

An overall significant Gender effect was found for NA, AIM, STAI and BDI, with females showing higher scores compared to males, $F(1,197) = 4.7$, $p < .05$, $\eta_p^2 = .02$; $F(1,197) = 10$, $p < .005$, $\eta_p^2 = .05$; $F(1,197) = 8.4$, $p < .005$, $\eta_p^2 = .04$; $F(1,197) = 4.4$, $p < .05$, $\eta_p^2 = .02$, respectively. No significant age Group x Gender interaction was found in any of the questionnaires.

This pattern of results was confirmed by a multiple linear regression analysis, in which participant's age was treated as continuous variable. The BDI and both the ERQ subscales (suppression and reappraisal) showed significant regression coefficients, $Fs(2,209) > 9$, $p < .0001$, $R^2s > .08$, where age was the only significant predictor ($\beta s > .27$, $ps < .0001$). A significant regression equation was found, $Fs(2,209) > 4$, $p < .05$, $R^2s > .03$, for the STAI, NA and AIM, where only

Table 2. Raw means (± SEM) of RTs (ms) to the visual target (circle/square) for each age group and picture content.

	20–29	30–39	40–49	50–59	60–69	70–79	> 80
Pleasant high	638 (26)	718 (25)	643 (30)	689 (42)	812 (57)	1045 (66)	1143 (57)
Pleasant low	607 (25)	676 (35)	611 (26)	664 (34)	750 (51)	979 (63)	1112 (68)
Neutral	615 (24)	677 (42)	609 (24)	672 (34)	731 (46)	967 (65)	1109 (64)
Unpleasant low	639 (24)	705 (39)	637 (26)	690 (35)	772 (53)	1008 (64)	1123 (61)
Unpleasant high	670 (27)	747 (35)	684 (29)	697 (34)	803 (67)	1011 (66)	1142 (69)

gender was a significant predictor, $\beta s > -.19$, $ps < .01$, suggesting that females, compared to men, showed higher scores in all these questionnaires. PA scores did not show any significant relationship with age or gender.

Discussion

The present study provides clear evidence for age-related changes of subjective emotional experience to specific pleasant cues, whereas unpleasant cues seem to prompt emotional feelings that remain stable across the life span. Moreover, ageing affected emotional reactivity differently as a function of the arousal level of the stimuli. Low-arousing pleasant pictures, which mostly included pictures of families and babies, prompted reports of more pleasant and arousing affective experiences in elderly people, and this was found for all participants regardless of gender. An opposite pattern, that is, a decrease in pleasantness, was found, however, for high-arousing pleasant pictures, which seem to vary in affective meaning and prompt differential responding in women, but not in men, over the ageing process.

Several theories on emotional ageing (for a review see Scheibe & Carstensen, 2010) hold that the ageing process may prompt changes in emotional preferences and strategies, enhancing emotionally gratifying experiences and minimising negative ones. Consistent with these theories, in the present study, pleasant emotions prompted by low-arousing pleasant cues are reported to be more pleasant and more intense with increasing age. Interestingly, this age effect specific for pictures of babies and smiling families seems to develop linearly over age decades, starting from middle adulthood (> 40 years old) and becoming even more evident across old age; moreover, it applies equally to men and women, suggesting that it does not necessarily depend on motherhood or gender roles, but rather reflects a general drive toward these affective cues. One possible speculation could be that the increased affective engagement for these specific contents reflects the need to somehow deal with the limited future time perspective in older people, for example providing cues to retrieve autobiographical past memories related to relatively happy times, when they were younger and actively engaged in childrearing (Charles, Mather, & Carstensen, 2003). Whether this selective difference in emotional preferences reflects an explicit and conscious strategy, or rather, a more inherent biological need is hard to establish here, but either way it might reflect an adaptive behaviour for the benefit of momentary mood and presumably long-term well-being (Freund & Baltes, 2007; Scheibe & Carstensen, 2010).

A different age-related effect mediated by gender differences was found in the subjective ratings of high-arousing pleasant pictures, mostly depicting erotic couples. Sexual cues represent primary reinforcers that directly engage the appetitive system, and several studies have demonstrated that, within pleasant picture categories, sexual cues are the most effective in eliciting autonomic, cortical and subcortical changes (Bradley, Codispoti, Sabatinelli et al., 2001; Codispoti & De Cesarei, 2007; Sabatinelli, Bradley, Lang, Costa, & Versace, 2007; Schupp, Junghöfer, Weike, & Hamm, 2004). Consistent with this, the present study showed that young and middle-aged adults, both men and women, reported pleasant and intense subjective reactions after viewing pictures depicting sexual contents, and consistent with previous studies, ratings were less extreme in women (Bradley, Codispoti, Sabatinelli et al., 2001; Codispoti, Surcinelli, & Baldaro, 2008; Murnen & Stockton, 1997). With increased age, men continued to evaluate erotic scenes as highly pleasant and arousing; women, instead, rated this picture content as unpleasant as they grew older (60+). A decrease in pleasantness ratings with ageing was previously observed (Backs et al., 2005; Keil & Freund, 2009), with pleasant pictures prompting lower pleasantness in older, compared to younger, adults, but no sex modulatory effects emerged in these studies, probably because of the relative low number of males in the sample group or the specific picture contents used in the high-arousing condition. Thus, the present findings indicate that the age-related appetitive impairment for high-arousing contents depicting sexual cues more likely affects

the female population, rather than being a general effect of ageing.

We have to be cautious in interpreting these results, though, given the nature of the subjective ratings, which are clearly a type of measure of affective reactivity that can be highly vulnerable to sociocultural factors as well as to subjective control. In our study, thus, ratings of sexual contents could be biased by social desirability/appropriateness, in addition to (or instead of) subjective feelings about the stimulus. Due to possible cohort effects, the group of older women could be more sensitive, compared to older men or younger participants, to the social context of the experiment and feel uncomfortable watching pictures of erotica in such context, prompting therefore a negative judgment towards these specific picture content. Various sociocultural factors, such as culture and religion, have an influence on sexual attitudes and behaviour (Rupp & Wallen, 2008), and we cannot exclude that our sample of older female participants had a high sense of religiosity. Thus, rather than reflecting a real age-related decline in appetitive engagement towards erotic cues, these findings may reflect group differences in a more general social desiderability bias, triggered by erotic cues. Distinguishing between these alternatives relies on future research in which the relationship between age, gender and sociocultural factors in affective ratings will be carefully assessed.

The present design allowed us to track age differences along a continuum, showing that the age effect specific for low-arousing pleasant pictures appears gradually over age decades, already starting from middle (>40 years) adulthood, whereas the age effect for high-arousing pleasant pictures only occurs in late (> 60 years) adulthood; both effects, however, are more evident starting from the group of sixty, possibly reflecting the impact of relevant events of social life (e.g. retirement, becoming grandparents) that somehow mark the official transition into the period of old age. Although future studies may consider to increase the sample size ($n > 20$) per group to ensure a more adequate statistical power, the fact that these effects of ageing in emotional reactivity remain pretty much stable across the three groups of older people (60–69; 70–79; > 80 years) makes our findings rather convincing,[1] as it avoids confounding issues that may arise when comparing two extreme groups ("extreme-groups design", see introduction). When ageing effects in emotional reactivity are observed, a critical question is whether the age group differences in emotional processing simply reflect sociocultural or personality traits (e.g. PA and NA) that differ across groups. Data derived from the affective well-being questionnaires did not reveal any reliable difference between age groups, except for a slight increase of the BDI scores in the age decades ranging from 70 to 79 years, compared to younger participants. Consistent with recent findings that highlight the role of emotion regulation in successful ageing (Suri & Gross, 2012), increasing age was associated with both types of emotion regulation strategies (ERQ-suppression and -reappraisal). However, these age differences in the questionnaire scores do not seem to help in explaining group differences observed in evaluative ratings. Future studies with a larger sample size are needed to explore more closely the role of sociocultural (e.g. religiosity beliefs) factors as well as personality traits in age-related differences of emotional reactivity.

The perception of emotional cues is also associated with attentional engagement (i.e. natural selective attention, Bradley, 2009), here measured through an emotional interference paradigm. Overall, participants showed the typical RT slowdown to the target after viewing a high-arousing emotional (either pleasant or unpleasant) picture, compared to when the picture depicted a neutral content, consistent with previous findings with different variants of the paradigm (Bradley et al., 1999; De Cesarei & Codispoti, 2008; Ferrari et al., 2008; Ferrari, Mastria, & Bruno, 2014; Mitchell et al., 2008; Weinberg & Hajcak, 2011). Low-arousing unpleasant pictures were also effective in prompting a slight but significant RT slowdown relative to neutral and low-arousing pleasant pictures. It is more relevant to the current study to note that this RT affective modulation was similar across age groups: both high-arousing pleasant and unpleasant pictures were equally effective in capturing attention in younger as well as older people, suggesting that the basic mechanism involved in attentional engagement prompted by motivationally relevant cues, which is clearly driven by emotional arousal and not valence (Wangelin, Bradley, Kastner, & Lang, 2012) is preserved from ageing (Knight et al., 2007; Leclerc & Kensinger, 2008; Murphy & Isaacowitz, 2008; Steinmetz, Muscatell, & Kensinger, 2010).

Summary and conclusions

Evaluative ratings of pleasant emotions were clearly affected by the ageing process, showing, on one

hand, an enhanced affective engagement for low-arousing pleasant contents in older people, both men and women, and on the other hand, a polarity reversal of the ratings for high-arousing pleasant pictures (e.g. erotic cues) in older women only, who reported unpleasant affect during viewing of these stimuli that are typically associated with appetitive emotional experiences. Interestingly, subjective ratings of unpleasant stimuli, with either high- or low-arousal contents, did not show relevant changes across the lifespan.

Moreover, although specific affective cues were judged differently across age groups, the same stimuli were effective in capturing attention to the same extent in young and older people. The dissociation between subjective ratings and attentional capture in terms of ageing effects is consistent with the idea that emotional stimuli prompt different processes that have evolved in order to assist the selection of appropriate survival behaviours (Lang et al., 1997). According to this reasoning, it is not surprising that "natural selective attention" that is engaged by the presentation of motivationally significant (either pleasant or unpleasant) cues in the absence of overt tasks or specific instructions (Bradley, 2009; Ferrari et al., 2008) is preserved from ageing. Conversely, affective evaluation of specific cues seems to vary as a function of age and gender, possibly reflecting the interaction of several factors (biological, psychological, sociocultural and other factors) that inevitably occur during the ageing process. Using a multiple measurement approach may be considered for future studies; this would help to outline a more detailed picture of the specific effects of ageing on the complex dynamic of the emotional response.

Notes

1. In order to decrease chances of Type II error (false negative), we increased the sample size by collapsing more age decades, ending up with only two age groups – middle (30–59) and old (60–90), with an average of about 45 participants per cell. Participants in the very young age decade (20–29 years) were left out because of the even number of decades. The key findings were nearly the same as when we performed the statistical analysis with less observations per cell (see results by age decade).

   Only for the ratings of unpleasant pictures, a slight but significant effect emerged with the two-group vs. the seven-group analysis: all unpleasant pictures (both low and high arousing) were rated as more unpleasant and more arousing in the old group (60–90), compared to the middle-age group (30–59), $Fs(1,167) > 5$, $ps < .05$, $\eta^2_{ps} > .03$. Again, RTs in the emotional interference task did not show any significant age group x picture content interaction.

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