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Changes in the Perception and the Psychological Structure of Musical Emotions with Advancing Age

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Abstract

This study was designed to test whether there are age-related changes in emotional judgments and psychological structure for musical emotions. Twenty-five older and 25 younger listeners performed emotional judgments and free categorization tasks on happy, peaceful, sad and threatening musical excerpts. Compared to younger adults, older adults did not discriminate the arousal difference between peaceful and threatening excerpts and showed higher association between arousal and valence judgments. A multidimensional scaling analysis indicated that the emotional space showed by older listeners did not fit younger listeners' bi-dimensional valence-arousal structure. There was also a better categorization for happy excerpts among the older group. Altogether, these data are consistent with the view that advancing age may result in the reduction of emotional complexity and a distortion of the emotional processing in a positive direction.

There is increasing evidence that healthy aging is characterized by a decrease in the processing of negative versus positive information. Relative to younger adults, older adults have relatively high levels of positive affect and low negative affect (e.g., Cartensen, Pasupathi, Mayr, & Nesselroade, 2000; Mroczek & Kolarz, 1998), use more positive and fewer negative affect words (e.g., Pennebaker & Stone, 2003), attend less to negatively than to positively valenced stimuli (e.g., Mather & Carstensen, 2003), and are more effective at disengaging from negative material (Hahn, Carlson, Singer, & Gronlund, 2006). Older adults also show reduced memory for negative information (e.g., Charles, Mather, & Carstensen, 2003; Grühn, Scheibe, & Baltes, 2007), are prompter to disengage from unpleasant situations (Charles & Carstensen, 2008), and solve decision-making tasks by placing more emphasis on wins than on losses (Wood, Busemeyer, Koling, Cox, & Davis, 2005).

This does not mean that aging is characterized by diminished emotionality. Dissociation between subjective ratings and electrophysiological reactivity has been taken as evidence that even though older adults might sometimes show dampened autonomic reactivity (for empirical findings showing that age differences in the magnitude of the autonomic reactions strongly depend on the age-relevance of the emotion elicitors, see Kunzmann & Grühn, 2005; Kunzmann & Richter, 2009), their subjective experiences of emotions remain intact (e.g., Levenson, Carstensen, Friesen, & Ekman, 1991; Mather et al., 2004; Tsai, Levenson, & Carstensen, 2000; Wood & Kisley, 2006).

Most of these findings have been interpreted within the framework of the Socioemotional Selectivity Theory (SST, Carstensen, Isaacowitz, & Charles, 1999) which postulates that older adults show a motivational shift towards emotionally

meaningful goals because of a limited perspective of time. Older people would prioritize emotion regulation so that less emphasis would be placed on negative information than on positive ones (Cartensen & Mikels, 2005). This motivational shift has been called the *positivity effect* even though it does not allow distinguishing between whether strategies for emotion regulation in the elderly depend on an increase in responding to positive information or to a decrease in responding to negative information (Langeslag & van Strien, 2009).

Although older adults are able to make fine distinctions between positive and negative valence, the question of how aging may impact the perception of the two main emotional dimensions of valence and arousal has been only recently addressed. Grühn and Scheibe (2008), followed by Keil and Freund (2009) found that compared with younger adults, older adults showed a stronger linear association between judgments of valence and arousal for pictures taken from the International Affective Picture System (IAPS; Lang, Bradley, & Cuthbert, 1998a)[1], suggesting a possible dedifferentiation of emotional processing with advanced age. So far, the notion of emotional dedifferentiation based on a correlation between valence and arousal which becomes stronger as people age, has remained little understood. In cognitive research, dedifferentiation in old age has been found to be characterized by an increase in correlations between cognitive/sensory abilities (Baltes & Lindenberger, 1997) and has been thought to be a declining specialization (i.e., the ability to engage specific mechanisms for different activities) with age. According to the literature on emotion and aging, the emotional dedifferentiation hypothesis has been linked to a possible decline in emotional functioning with age (Grühn & Scheibe, 2008). Generally, the hypotheses of emotional dedifferentiation and positivity effect have been addressed as two distinct phenomena. However, the Dynamic Integration

Theory of Labouvie-Vief (DIT, 2003, 2008) may provide a theoretical framework in which the emotional dedifferentiation and the positivity effect could be viewed as two related mechanisms. Indeed, the DIT model postulates that, given the cognitive decline characterizing older adults, their attempt to maximize positive affects and to minimize negative affects may result in a reduction in complex emotional reasoning so that simplified representations of emotion would help to distort emotional processing in a positive direction. Here, the degradation of emotional complexity is viewed as a possible cognitive counterpart of the attempt to preserve well-being in advanced age. The DIT model also includes the level of activation as another factor of vulnerability such that emotion processing for older adults would be more difficult than for younger adults in highly activating (or arousing) situations (regardless of their valence).

To date, studies addressing the positivity bias or the emotional dedifferentiation phenomenon have primarily focused on visual or autobiographical material, leaving open the question of how advancing age may impact perception of emotions in music (Laukka, 2007; Laukka & Juslin, 2007).

Current Study

Previous works showed that older adults reported feeling positive emotions most often while listening to music (Laukka, 2007) and were less accurate than their younger counterparts in recognizing negative emotions (i.e., fear, sadness) among other emotion categories (Laukka & Juslin, 2007). The aim of the current study was to extend this previous data by examining the impact of age on emotional judgments as well as the psychological structure of musical emotions. To this end, we employed emotional judgments including various rating scales such as valence (unpleasant

versus pleasant), hedonic value (negative *versus* positive), arousal (relaxing *versus* stimulating) and liking (not at all *versus* very much), as well as a free categorization task. The distinction between the hedonic value and the valence judgments allowed us to check whether a musical excerpt judged as negative could, at the same time, be considered as pleasant (e.g., sad music). The free categorization task was used because of its relative simplicity and the ecological relevance of spontaneous categorization allowing listeners to create emotional categories based directly on the perceived stimulus cues (e.g., dynamic, pleasantness) without needing to verbalize. For instance, Bigand, Vieillard, Madurell, Marozeau, and Dacquet (2005) used a free categorization task and a multidimensional scaling analysis to show that the emotional groupings of musician and non musician listeners of musical excerpts fit the intended emotions and could be accounted for by an emotional solution with valence and arousal as the two primary dimensions.

In this research, we focused on a validated set of unfamiliar musical excerpts composed in the genre of film music so as to express happiness, peacefulness, sadness and threat (for a validation of this musical material, see Vieillard et al., 2008). These emotional stimuli controlled both for valence and arousal, should provide insights on whether older people are biased toward positive (or against negative) musical stimuli no matter the arousal level or in contrast, whether the older adult's emotional bias depends on arousal. Younger and older participants were first presented with an emotional rating task including four musical emotion categories and then were asked to perform a free categorization task with the same material. Our main interest was whether there would be age differences in emotional judgments and psychological structure for emotions in music. Regarding the hypothesis of a dedifferentiation of emotional processing in old age, it was expected

that, if compared to younger adults, older adults have a lesser potential for emotional complexity in the perception of valence and arousal, they would show an increased co-variation between judgments of valence and arousal for musical emotions. In this line, it was also expected that in the free categorization task, older listeners would have an emotional structure which would be based on more composite dimensions instead of valence and arousal dimensions. Regarding the hypothesis of a positivity bias, if older adults show a decrease in responding to negative stimuli —the other facet of the positivity bias— it was expected that, compared to younger adults, they would rate threatening music as less arousing. Moreover, as observed in previous works (e.g., Mather & Carstensen, 2003), it was expected that older adults would pay greater attention to stimuli they have judged as the more pleasant, then facilitating their categorization. As a result, the older adults' categorization would be more precise for positive musical emotions than for the other emotion categories.

Method

Participants

Fifty non-musician participants composed of 25 younger adults (18-30 years, M = 22; 64% females) and 25 older adults (64-81 years, M = 70 years; 72% females) participated in this study. The younger adults were recruited at the Psychology Department of the University of Franche-Comté. The older adults were recruited through senior social programs in Besançon. All participants were volunteers and reported correct or corrected-to-normal vision and normal hearing. No medical or psychiatric antecedent was reported. Younger adults reported slightly more years of education (i.e., two additional years of education) than older adults, with F (1, 48) = 5.01, $p < .05$, $\eta_p^2 = .09$. Listening to classical music was reported more often by

older adults (72%) than by younger adults (20%) with (F (1, 48) = 17.94, $p < .001$, $\eta_p^2 = .27$). As shown in Table 1, younger adults outperformed older adults in fluid intelligence (measured by Raven's progressive matrices, set I, Raven, Raven, & Court, 1998), F (1, 48) = 45.26, $p < .001$, $\eta_p^2 = .49$, and in working memory (measured by digit span from WAIS-III, Wechsler, 2000), F (1, 48) = 13.30, $p < .001$, $\eta_p^2 = .23$. The depression (BDI-II; Beck, Steer, & Brown, 1998) and state-trait anxiety (STAI-Y; Spielberger, 1993) measures were not significantly different between the age groups, indicating identical mean scores between younger (M = 6.36, SD = 5.31) and older (M = 6.36, SD = 5.40) adults, F (1, 48) = 0.00, $p = 1.00$, $\eta_p^2 = .00$. Measures indicated a minimum level of depression (BDI-II Score < 7) as well as low state-anxiety scores (Score < 31) and moderate trait-anxiety (Score < 42) whatever the age of the participants. The younger adults showed a better state of health (M = 4.76, max. 5; SD = .43) than the older adults (M = 4.36, max. 5; SD = .70), F (1, 48) = 5.882, $p < .05$, $\eta_p^2 = .11$). The Mini Mental State Examination (MMSE; Petit et al., 1998) scores for the older adults were 27 or higher.

(Table 1)

Material

Forty short musical excerpts taken from Vieillard et al. (2008)'s set of musical stimuli validated on young listeners' judgments, were selected based on their power to convey four distinct emotions (i.e., happiness, peacefulness, sadness and threat)[3]. Musical excerpts were controlled for their valence (unpleasant vs. pleasant) and arousal (low vs. high) such that the four emotion categories represented the four possible combinations of valence and arousal. Each emotion category included ten musical excerpts of a mean duration of 13 seconds (range: 8s-16s).

Procedure

The experiment was divided into two sessions separated by an interval of one week. During the first session, the participants completed a set of questionnaires and cognitive tests. The second session dealt with behavioral measurements. Participants were individually tested in a quiet room with the presence of the experimenter. Before participating in the study, they were informed about the unfolding of the experiment and signed a consent form.

During the first session, the participants were asked about their age, musical listening skill, education level, self-reported health, visual acuity, auditory acuity and medical history. Neuropsychological tests mentioned above were also carried out. The first session lasted about one hour.

The second session was divided into two testing phases, presented in the same order. Participants were asked to perform emotional ratings and then a free categorization task. Musical excerpts were presented using professional 240 Sennheisser headphones. The overall sonority of the excerpts was adjusted manually to ensure a constant noise level across the experiment. Stimuli presentation and response recordings were carried out using E-prime Software (Schneider, Eschman, & Zuccolotto, 2002), except for the free categorization task that used Powerpoint display to present auditory stimuli.

In the emotional judgment task, participants were instructed to listen to 40 musical excerpts that were presented binaurally in a random order. Participants began each trial by pressing one key on the keyboard. For each trial, they listened to the whole musical excerpt and then rated its valence (0 “unpleasant” to 9 “pleasant”), hedonic value (0 “negative” to 9 “positive”), and arousal (0 “relaxing” to 9

"stimulating") on 10-point scales. They also rated how much they liked each musical excerpt on a scale ranging from 0 "not at all" to 9 "very much". The order of the rating scales was counterbalanced. The emotional judgment phase allowed a previous exposure to the musical stimuli before the free categorization task. In the free categorization task, the participants were presented with a random visual pattern of 40 small loudspeaker icons displayed on a Powerpoint file. Each participant worked on a different Powerpoint file and listened to the excerpts by clicking on the icons. They were instructed to look for musical excerpts which convey a similar emotion and then to group them together by dragging and dropping them into the same location. Participants were allowed to listen to the excerpts as many times as they wished, and to regroup as many excerpts as they wished in distinct groupings. No time limit was imposed. Because not all of the older adults were equally at ease using a mouse and a computer, we used a testing method in which they were all assisted by the experimenter. The procedure was quite similar to the one for the younger adults except that the computer was handled by the experimenter following the instructions of the older adults. To minimize the direct influence of the experimenter's behavior on their responses, the experimenter sat next to the older adults but slightly behind them so as to be out of sight, and kept verbal interactions to a minimum. The second session lasted about one hour. At the end, the participants were fully debriefed.

Results

Emotional Judgments

Analysis of covariance (ANCOVA) was adopted to explore whether differences in emotional judgments exist between the younger and older adults having controlled/adjusted for differences in Educational Level, Fluid Intelligence

(i.e., Raven's progressive matrices set I performance) and Working Memory (i.e., WAIS-III Digit Span performance) as the covariates. For each emotional judgment (i.e., valence, hedonic value, arousal and liking), the mean score of rating of each participant was included as dependent measure, the Educational Level, Fluid Intelligence, and Working Memory as covariates, and Age Group as the independent variable. Preliminary analyses evaluating the homogeneity-of-slopes assumption indicated that the relationship between the covariates and the emotional judgments did not differ significantly as a function of Age Group with (Wilks's Lambda = .93, F (4, 31) = .61, p = .66, η_p^2 = .07 for Hedonic Value; Wilks's Lambda = .98, F (4, 31) = .16, p = .96, η_p^2 = .02 for Arousal; and Wilks's Lambda = .79, F (4, 31) = 2.10, p = .11, η_p^2 = .21 for Liking) except for the valence scale which showed non-homogeneity of variance (Wilks's Lambda = .70, F (4, 31) = 3.29, p = .02, η_p^2 = .30).

The Analysis of Covariance computed for Hedonic Value, Arousal and Liking judgments, respectively, showed that there was an almost significant effect of Age Group on the Arousal rating, Wilks's Lambda = .80, F (4, 42) = 2.55, p = .053, η_p^2 = .20. Results indicated a significant relationship between Age Group and the Arousal rating for peaceful music, F (4, 45) = 3.85, p = .009, η_p^2 = .25, with the Age Group factor accounting for 26 % of the variance of the dependent variable, holding constant the Educational Level, Fluid Intelligence, and Working Memory. As shown in Figure 1 and confirmed by planned comparisons between adjusted group means, the younger listeners judged peaceful excerpts as less stimulating (*Adjusted Mean* = 2.94, *SE* = 0.30) than the older adults did (*Adjusted Mean* = 4.25, *SE* = 0.30), F (1, 45) = 7.30, p = .01, η_p^2 = .14. Moreover, while the younger listeners judged threatening excerpts as more stimulating (*Adjusted Mean* = 5.02, *SE* = 0.37) than peaceful excerpts (*Adjusted Mean* = 2.94, *SE* = 0.30), F (1, 45) = 21.43, $p < .001$, η_p^2

= .95, no significant difference was observed between these two emotion categories (with *Adjusted Mean* = 4.56, *SE* = 0.37 for threat and *Adjusted Mean* = 4.25, *SE* = 0.30 for peacefulness) in the older adults, F (1, 45) = 0.46, p = .50. Although the planned comparison was not significant (p = .45), results indicated that in relation to younger listeners (*Adjusted Mean* = 5.02, *SE* = 0.37), older listeners tended to judge threatening music as less stimulating (*Adjusted Mean* = 4.56, *SE* = 0.37). No other significant effect of Age Group was observed for hedonic value or liking scale. Because the homogeneity of slopes requirement was not met for the valence scale, an alternative analysis to ANCOVA, the separate-slope model, was used and indicated no significant effect of Age Group, Wilks's Lambda = .96, F (4, 39) = .46, p = .77, η_p^2 = .04.

(Figure 1)

To test whether valence and arousal ratings fit the orthogonal structure of emotional responses (e.g., Lang et al., 1998), correlation analyses were carried out for each Age Group between the mean rating of arousal and valence for each musical excerpt. As illustrated Figures 2a and 2b, arousal and valence ratings were strongly correlated in the older listeners (r (40) = .74, p <. 05) but not in their younger counterparts (r (40) = .08) (Z = 3.74, p < .01).

(Figures 2a and 2b)

Free Categorization

Number of groupings. The mean number of groupings was equivalent between younger adults (M = 4.4 groupings, *SE* = 0.43) and older adults (M = 5 groupings, *SE* = 0.43), F (1, 48) < 1, η_p^2 = .02, suggesting that emotion categorization did not change with age.

Multidimensional scaling. We used an MDS analysis to examine which dimensions guide adult's categorization of musical emotions with increasing age. The groupings made by the participants for each set of musical stimuli were converted into a 40 x 40 co-occurrence matrix. Each cell of the matrix indicated the average number of times that two musical excerpts were grouped together. The mean of the co-occurrence matrix was subtracted from 1 to produce a dissimilarity matrix. Thus, in each cell, the smaller the value, the more similar the two musical stimuli were. Two grand mean dissimilarity matrices were obtained for the younger and older listeners respectively. These two matrices correlated positively, (r (780) = .74, p <. 001).

MDS analyses were applied to examine relations between the musical stimuli as a function of the Emotion Category for each Age Group. Matrices obtained for the younger and older adults were processed separately using the PROXSCAL MDS algorithm in SPSS software (Kinnear & Gray, 1999). This produced two two-dimensional solutions in a common geometrical space (using Torgerson's classic metric analysis). The badness-of-fit measures for the MDS solutions, represented by the normalized stress value, reached .02 and .06 for the younger and older adults respectively. This means that more than 93% (98% and 94% for the younger and older adults respectively) of the distances between the points located in the three geometrical solutions matched the rank order of the dissimilarities in their related proximity matrix. The percentages of variance explained by the MDS solutions were 97% and 94% for the younger and older adults respectively. Taken together, these indexes indicated that the two-dimensional Euclidean models gave a good fit to the dissimilarity values. Locations of the 40 musical stimuli in the two-dimensional space for each age group are shown in Figures 3a (MDS solution for younger

listeners) and 3b (MDS solution for older listeners). Among the younger adults, the musical excerpts were organized in four distinct groups that exactly fit the four intended emotion categories. However, among the older adults, the distribution of the musical stimuli was rather dispersed, except for the happy excerpts which delineated a clear category.

(Figures 3a and 3b)

Canonical correlation analysis was carried out among the age groups on the average coordinates obtained for each stimulus in the two-dimensional space to provide a quantitative comparison of the MDS solutions for the two age groups. The correlation value was high (.93) and statistically significant ($p < .001$) indicating that the MDS solution was not completely dissimilar among the age groups.

Additional correlational analyses were performed to test for associations between the mean coordinates of each musical excerpt along Dimensions 1 and 2 and their mean of valence, arousal, hedonic value and liking ratings. Table 2 shows that dimension 1 was highly and positively correlated with arousal ratings both among the younger (r (40) = .88, $p <$. 001) and the older (r (40) = .94, $p <$. 001) listeners. No other correlation was observed with dimension 1 among the younger adults. However, among the older adults, dimension 1 was also highly (.80 < r < .88) and significantly ($p <$.001) correlated with ratings of valence, hedonic value and liking, respectively. It was found among the younger listeners that the valence ratings were strongly associated with dimension 2 (r (40) = .83, $p <$. 001) and weakly associated with arousal (r < .08), observing the assumption of orthogonality in the MDS solution. In older listeners, dimension 2 was moderately and negatively correlated with valence (r (40) = -.43, $p <$. 05) and liking (r (40) = -.43, $p <$. 05) ratings, which were both strongly associated (r (40) = .99, $p <$. 001).

(Table 2)

Cluster analysis. An additional hierarchical cluster analysis was processed to explore the extent to which the hierarchical psychological structure of emotions in music may change with advancing age. This analysis allows a set of objects to be arranged in clusters (classes) to establish a set of object clusters (tree structure) such that the objects within a given cluster are more similar to each other than they are to those in other clusters. Two hierarchical tree structures were computed based on the dissimilarity matrices obtained for the younger and the older adults, respectively. We applied the average linkage method, using the Euclidian distance between all pairs of objects in any given cluster. The correlation between the dissimilarity matrices and their associated proximity matrices (distances between elements in the tree structure) showed that the tree structure represented 77 % and 98 % of variance, with $r(1600) = .88$, $p < .001$ and $r(1600) = .99$, $p < .001$ in the older and the younger participants respectively. There was a positive correlation between the proximity matrices of the older and the younger adults with $r(1600) = .77$, $p < .001$. For each age group, the differentiation between classes was achieved by setting a threshold dissimilarity value of 1.8 on the distance scale (ranging from 0 to 4) of the tree structures. This allowed us to identify different partitions within the tree structures as a function of the age. In each age group, the classes and subclasses were superimposed on the corresponding MDS solution illustrated in Figure 3. In younger adults, four main classes (solid lines) were found, distinguishing the four intended emotion categories. In older adults, there were two main classes discriminating happy excerpts from all other musical stimuli. This latter class included two subclasses distinguishing threatening from peaceful excerpts, with sad music distributed across these two subclasses.

Discussion

We investigated whether advanced age may influence emotional judgments and psychological structure for unfamiliar musical excerpts composed to express happiness, peacefulness, sadness and threat. To this end, younger and older listeners were asked to listen to these musical stimuli and rated them on valence, arousal, hedonic value and liking scales. After judging the musical excerpts, the listeners performed a free categorization task on the same musical pool.

Previous studies have shown that increasing age is synonymous with important changes in emotion processing such as emotional bias or valence-arousal dedifferentiation for visual material. The current findings extend these conceptual findings to musical emotions, younger and older listeners show differences in perceiving and categorizing emotions in music. In the emotional judgment task, in which each judgment was relative to other musical excerpts that were being judged on the same dimensions, it was found that compared to younger listeners, older adults did not discriminate peaceful and threatening musical excerpts on the arousal dimension, while these musical stimuli can be considered as conveying two opposite emotions in terms of arousal and valence. The fact that older listeners did not assess threatening excerpts as more arousing than peaceful music seems to be in line with Mather and colleagues' (2004) data which showed that older adults rated negative pictures as less arousing. This is also in line with behavioral findings showing that older adults may be more efficient than younger adults in inhibiting negative and arousing stimuli such as angry facial expressions in visual search tasks (Hahn et al., 2006). More generally, our results are consistent with findings suggesting that the age differences in the emotional judgment of negative stimuli might reflect a decrease in perceptual processing (St. Jacques et al., 2010) as well as a greater

investment in controlling emotional response (Lawton, Kleban, Rajagopal, & Dean 1992) characterized by less attention given to negative emotional stimuli (Carstensen & Mikels, 2005).

As predicted, older adults showed a strong linear relationship between judgments of valence and arousal while the younger listeners did not. This extends previous results (Grühn & Scheibe, 2008 ; Keil & Freund, 2009) to musical emotions, supporting the hypothesis of a dedifferentiation of emotional processing with advanced age. In contrast to previous studies showing that older adults rated low-arousing pictures as the most pleasant and high-arousing pictures as the most unpleasant (Grühn & Scheibe, 2008; Keil & Freund, 2009), our findings indicated that the older adults rated low-arousing musical excerpts as the most unpleasant (i.e., threatening excerpts) and high-arousing musical excerpts as the most pleasant (i.e., happy excerpts). This suggests that age differences in sensitivity to pleasant and unpleasant arousal may vary as a function of sensory modality. Furthermore, while older adults are able to finely discriminate valence in emotional experience in others and in themselves (Löckenhoff, Costa, & Lane, 2008), this subtle emotional discrimination is no longer effective in an affective judgment task for musical stimuli controlled for their valence and arousal.

The emotional dedifferentiation hypothesis was corroborated by current data from the free categorization task. While the younger listeners organized musical excerpts in four distinct groups that fit the intended emotion categories, the older listeners showed fuzzier emotion categories based on two composite dimensions that cannot be interpreted in terms of valence or arousal. These results replicate previous studies demonstrating the young listeners' ability to discriminate distinct emotions in musical excerpts selected to purposely convey these emotions (e.g., Bigand et al.,

2005). In the older listeners, the MDS solution showed a dispersed distribution for all musical emotions, with the exception of the happy excerpts which delineate a clear category. The current findings also indicated a similar number of groupings for the two age groups as well as a high correlation between the younger adults' and the older adults' MDS solution. Taken together, these data suggest that the older listeners succeed in distinguishing the different emotion categories in music, but they did not use arousal and valence as cues for emotion categorization. Although this data does not allow identification of the very nature of the emotional cues that determine the psychological structure of musical emotions in the older adults, it is consistent with the assumption that instead of using arousal and valence, the older adults focused on happy music, perhaps using this as a potential standard for comparison. The more precise grouping for happy music among older adults corroborates previous studies showing that advanced age may be synonymous with greater attention allocated to positive information (e.g., Mather & Carstensen, 2003). In fact, it is not to say that older adults do not discriminate emotion categories. Instead, their conscious perception and the organization (i.e., psychological structure) of musical emotions were not completely similar to those of the younger listeners because of a likely reduction in the emotion complexity and a preference for positivity. In future studies, it would be useful to examine verbalizations associated to the groupings for each age group to provide additional highlights.

It is well established that older adults experience high frequency hearing loss (ISO, 2000). Therefore, one may argue that the present results can be explained by the fact that differences in age are mediated by hearing loss. Given that happy excerpts are characterized to a large extent by high-frequency energy, emotional judgment and categorization of happy music would have been directly affected the

most. However, this was not the case. In addition, although the older listeners' emotional structure was based on more distinct emotion cues than that of younger adults, older adults were as able as their younger counterparts to finely distinguish emotion categories in music, indicating that potential hearing deficits did not influence distinction of musical emotion categories.

Conclusion

To our knowledge, this study is among the first to demonstrate that emotional judgment and psychological structure for musical emotions show differences with advancing age. These age differences are characterized by a) a diminished processing of arousal for threatening music that might refer to an attempt to minimize negative affects, b) a likely increased focus on happy music that might refer to an attempt to maximize positive affects, and c) an emotional dedifferentiation that might refer to a decrease in emotional differentiation and complexity. This is in line with the affect optimization processing, a strategy of regulation that aims to dampen negative while maximizing positive affect. According to Labouvie-Vief (2003, 2008), such strategy may result in a reduction in complex emotional reasoning so that emotion representations were simplified. Given that the optimization effect (i.e., minimizing negative affects and maximizing positive affects) was not observed with the low arousing musical stimuli (i.e., peacefulness and sadness), our findings do not fully support the idea that valence and increasing age are the only two variables that affect cognitive processes. This result underlines the critical role played by the level of activation (i.e., arousal) on how older adults process emotions conveyed by music. Furthermore, additional examinations of how aging may change the way emotions are regulated through music would be worthwhile. Recent studies using music as mood induction reported that older adults might be better at regulating their emotions

than their younger counterparts (Larcom & Isaacowitz, 2009). However, it still remains to be determined whether older listeners exert greater or lesser cognitive effort when regulating their emotions through music as opposed to other sources of affective information.

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Footnotes

[1]When testing young people, arousal and valence are generally perceived as two orthogonal dimensions of emotions (Lang, Bradley, & Cuthbert, 1998b; Russell, 1980).

[2] Given that the familiarity with classical music varied as function of Age Group, we controlled the potential influence of this factor by conducting additional separated analyses of variance on emotional judgments (i.e., valence, hedonic value, arousal and liking) , with Age Group and Classical Music Listening as a between-subjects factors and Emotion Category as a within-subjects factor. Neither significant main effects nor interactions were observed for emotional judgments excepted for Liking judgment. For this rating, a significant Age Group by Emotion Category by Classical Music Listening interaction has been observed, F (3, 138) = 3.59, p = .02, η_p^2 = .07, indicating that among classical music listeners, young adults gave higher liking judgments (M = 6.14, SE = 0.39) to musical stimuli than older adults (M = 5.01, SE = 0.21).

[3]The happy excerpts were written in a major mode at an average tempo of 137 Metronome Markings (MM range: 92 to196), with the melodic line lying in the medium high pitch range (the pedal was not used). The peaceful excerpts were composed in a major mode, had an intermediate tempo (mean: 74 MM, range: 54 to 100), and were played with pedal and arpeggio accompaniment. The sad excerpts were written in a minor mode at an average slow tempo of 46 MM (range: 40 to 60), with the pedal. The threatening excerpts were composed with minor chords on the third and sixth degree, hence implying the use of many out-of-key notes. Although most threatening excerpts were regular and consonant, a few had irregular rhythms and

were dissonant. Their tempo varied from 44 to 172 MM. Examples can be heard at www.brams.umontreal.ca/peretz.

Table 1

Demographic Characteristics, Cognitive Performances and Affective State of the Sample

Demographic Characteristics	**Younger Listeners**	**Older Listeners**
Ethnicity	100 % Caucasian	100 % Caucasian
Socioeconomic status	100 % Students	80 % white-collar
Marital status	100 % Singles	63 % Married, 23 % Divorced and 13 % Widowed
Cognitive Performances		
Raven's progressive matrices, set 1 (raw data, max. 12)	10.68	8.04
Digit span (WAIS III, max. 30)	17.24	14.12
Mini Mental State Examination (MMSE)	-	$\geq$ 27
Affective State		
Depression, BDI-II (max. 63)	6.36	6.36
Anxiety state, STAI-Y (max. 80)	30.24	29.68
Anxiety trait, STAI-Y (max. 80)	41.52	37.20

Table 2

Pearson Correlation Coefficients between Mean Coordinates of Dimensions 1 and 2 from MDS Solutions and Mean Ratings for Valence, Hedonic Value, Arousal and Liking Scales as a Function of Age Group

	Valence	**Hedonic Value**	**Arousal**	**Liking**	**Dimension 1**
Young Listeners					
Valence					
Hedonic Value	.80**				
Arousal	.08	.54**			
Liking	.95**	.68**	.06		
Dimension 1	-.34	.18	.88**	-.33	
Dimension 2	.83**	.95**	.36	.70**	.00
Older Listeners					
Valence					
Hedonic Value	.99**				
Arousal	.74**	.80**			
Liking	.99**	.99**	.76**		
Dimension 1	.81**	.87**	.94**	.83**	
Dimension 2	-.43*	-.39*	.09	-.43*	.00

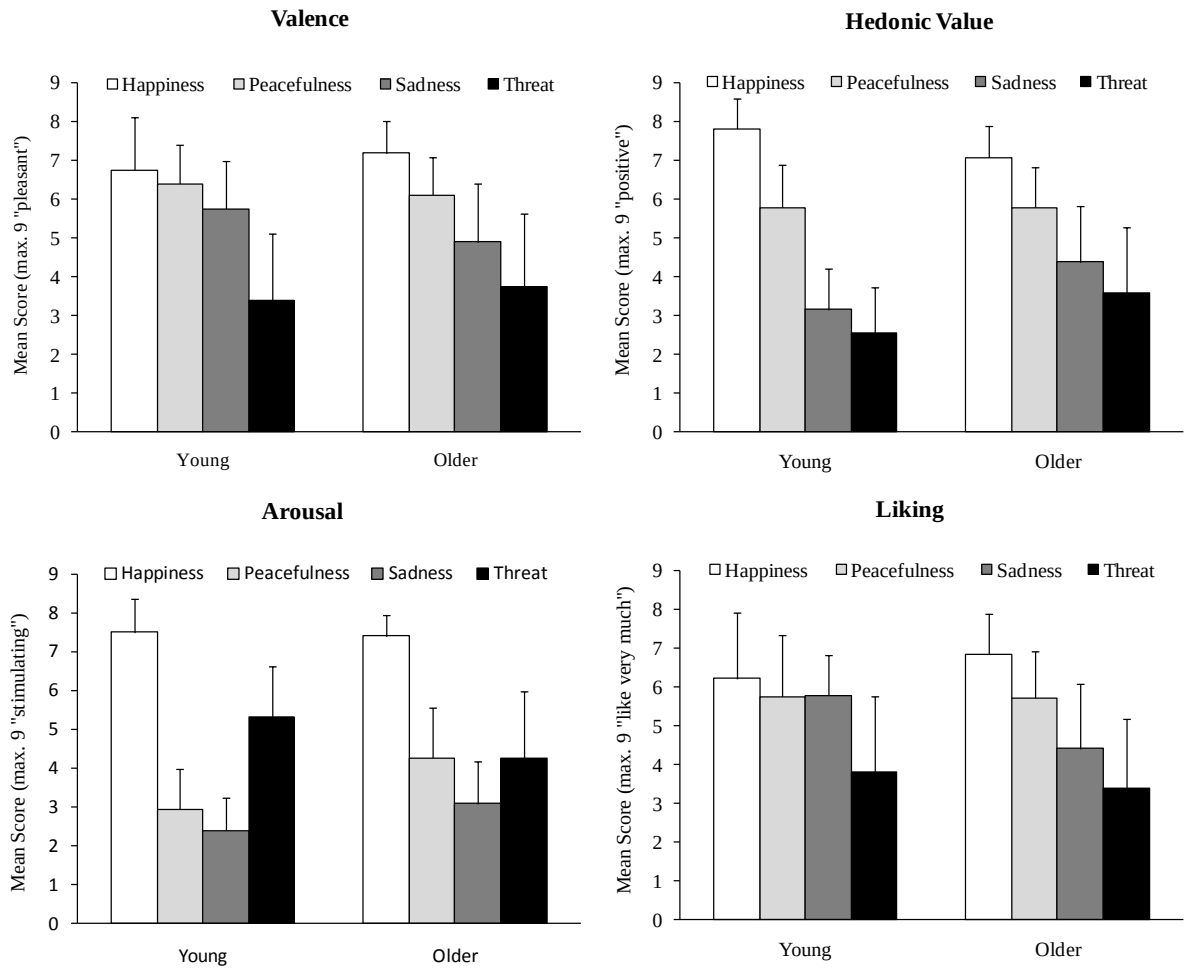
*Note. * significant at p < .05, ** significant at p < .001*

Figures

Figure 1: Mean and standard deviation for valence, hedonic value, arousal and liking ratings in young and older listeners.

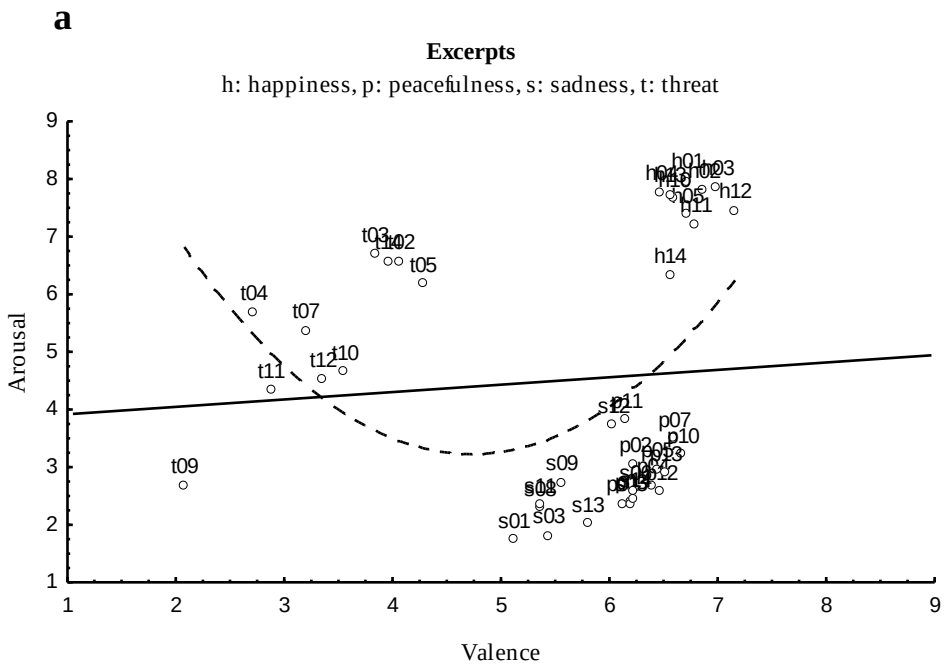
Figure 2: Scatterplots for valence and arousal ratings of the musical excerpts in young (a) and older (b) listeners. The linear and quadratic associations between valence and arousal ratings are represented by solid and dashed lines, respectively.

Figure 3: Two-dimensional MDS solution for happy (circle), peaceful (square), sad (lozenge), and threatening (triangle) musical excerpts in young (a) and older (b) listeners. The main outcomes of the cluster analyses are superimposed onto each MDS solution. Solid black lines represent the main classes, and dashed lines represent subordinate classes.


Valence
Hedonic Value
Arousal
Liking
Happiness
Peacefulness
Sadness
Threat
Mean Score (max. 9 "pleasant")
Mean Score (max. 9 "positive")
Mean Score (max. 9 "stimulating")
Mean Score (max. 9 "like very much")
Young
Older
0
1
2
3
4
5
6
7
8
9

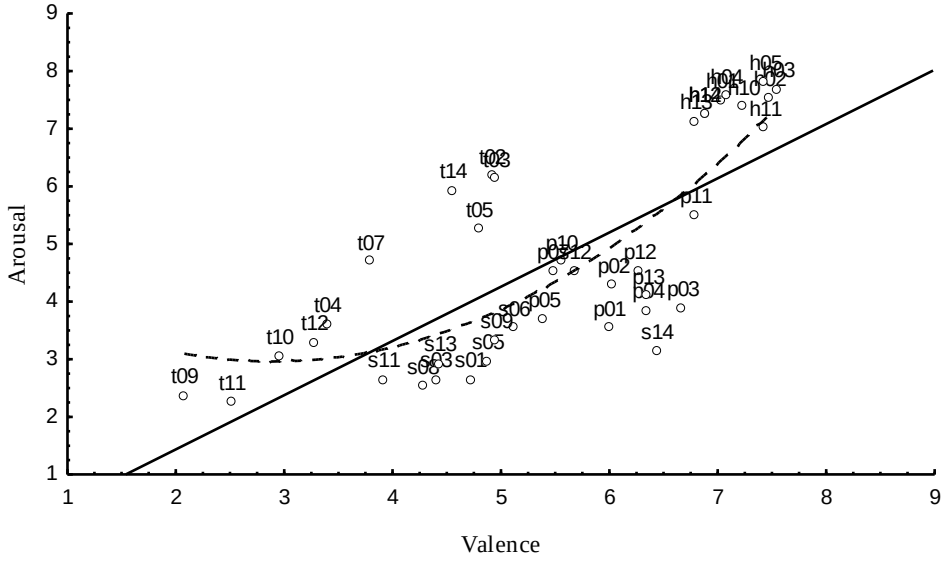
YOUNG LISTENERS

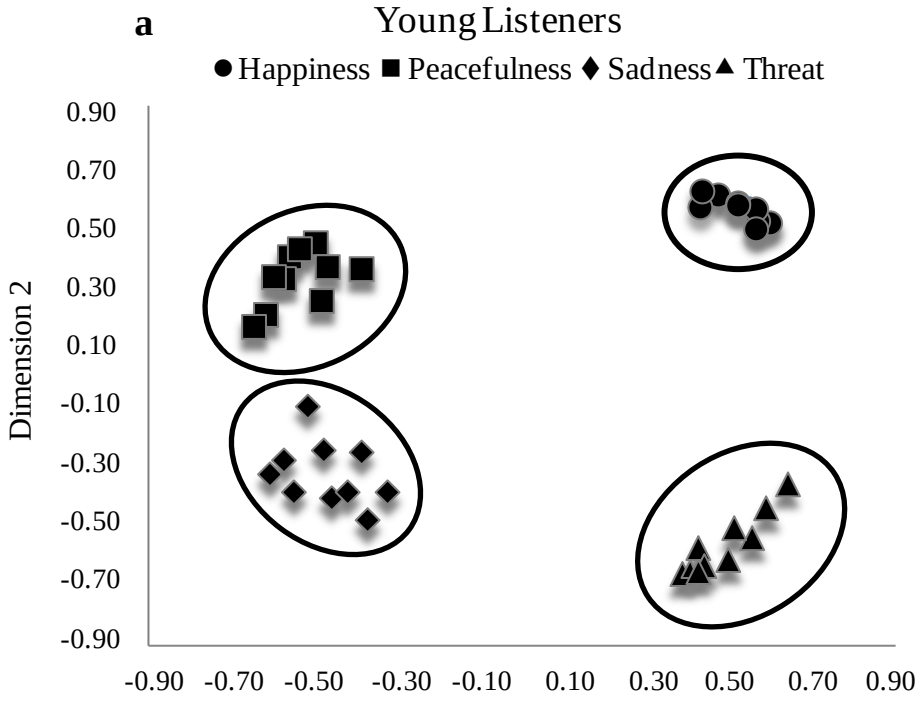
a

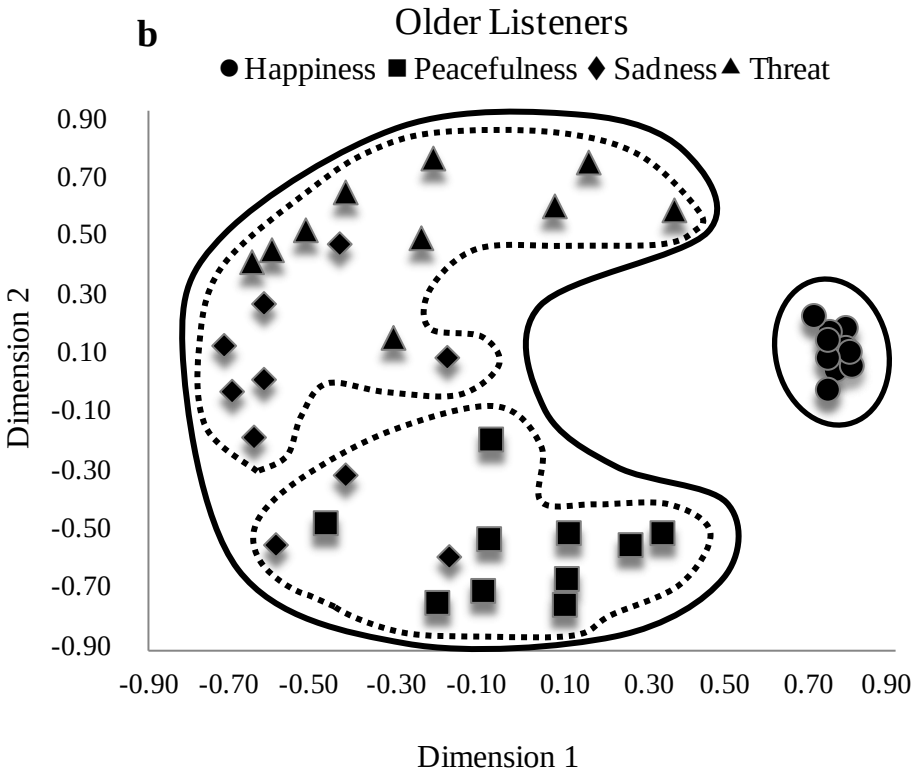


OLD LISTENERS

b




a
Young Listeners
Happiness Peacefulness Sadness Threat
0.90
0.70
0.50
0.30
0.10
-0.10
-0.30
-0.50
-0.70
-0.90
Dimension 2
-0.90 -0.70 -0.50 -0.30 -0.10 0.10 0.30 0.50 0.70 0.90
Dimension 1


b
Older Listeners
Happiness Peacefulness Sadness Threat
0.90
0.70
0.50
0.30
0.10
-0.10
-0.30
-0.50
-0.70
-0.90
Dimension 2
-0.90 -0.70 -0.50 -0.30 -0.10 0.10 0.30 0.50 0.70 0.90
Dimension 1