Age trends in musical preferences in adulthood 3: Perceived musical attributes as intrinsic determinants of preferences

Date: 10th April 2017

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Abstract

Increased age has been found to be associated with differences in musical preferences in adulthood. In past research, these differences were mostly attributed to changes in the social context. However, these influences were small and a large proportion of variance in age trends in musical preferences still remains to be explained. The aim of this paper is to investigate the hypothesis that age trends in musical preferences are related to differences in preferences for some intrinsic attributes of the music in line with the Music Preferences in Adulthood Model (Bonneville-Roussy et al., 2017). Adult participants (N= 481) were asked to rate their preferences for extracts of 51 audio-music recordings (music clips) and musical attributes related to dynamics, pitch, structure, tempo, and timbre. Audio-features of the 51 clips were extracted using Music Information Retrieval methods. Using self-report, we found that the musical preferences of adults were linked with distinct likings for musical attributes, with large effects. We also discovered that self-rated attributes associated with dynamics and timbre moderated the links between age and musical preferences. Using the extracted features, we found that musical preferences were linked with distinct patterns of musical features. Finally, we established that the patterns of preferences of emerging, young and middle aged adults were increasingly influenced by audio-features of timbre, dynamics and tonal clarity. These findings suggest that age trends in musical preferences could be partially explained by differences in the ways individuals process the intrinsic attributes of the music with age.

Keywords: Musical preferences, age differences, intrinsic musical attributes

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This paper explores the roles of the perceived intrinsic properties of music as determinants of musical preferences in adulthood. Specifically, using self-reports and Music Information Retrieval, we investigate the roles of subjective and objective musical attributes (further defined in the following section) in age trends in musical preferences in adulthood. This paper is the last of a series of three that aims to provide a developmental psychological framework for examining musical preferences in adulthood, namely the Music Preferences in Adulthood Model (MPAM). The first paper (Bonneville-Roussy, Stillwell, Kosinski, & Rust, 2017) presented the MPAM, that suggests that the musical preferences of adults are influenced by psychological factors that are extrinsic to the music (e.g. individual differences and social influences) and factors that are intrinsic to the music (the perceived acoustical properties of the music; Gabrielsson & Lindström, 2010). This first paper also validated the Music Genres-Clips Test (MG-CT), that provides a reliable and valid assessment tool to examine musical genres and clips in parallel. The second paper (Bonneville-Roussy & Rust, 2017) showed that musical preferences in adulthood are partly determined by social influences, and that adults are more disposed to social influences when rating their preferences for musical genre labels than for musical audio-recordings. In addition, dispositions towards conformity was shown to be the most important source of social influence that moderated age trends in musical preferences.

The present research investigates how the intrinsic properties of the music can influence adults' musical preferences with age. In addition, it extends and further validates the MG-CT by examining how the musical dimensions of the MG-CT are related to more objective computer-extracted musical features. It also examines how the perception of the intrinsic properties of the music can moderate age trends in musical preferences.

Intrinsic Properties of the Music as Determinants of Musical Preferences in Adulthood

To date, research on the psychological determinants of musical preferences in adulthood has mainly focused on the extrinsic determinants of preferences, such as participants' gender and personality (Bonneville-Roussy, Rentfrow, Xu, & Potter, 2013; Greenberg et al., 2016; Langmeyer, Guglhör-Rudan, & Tarnai, 2012; North, 2010; Rentfrow, 2012; Rentfrow, Goldberg, & Levitin, 2011; Rentfrow & Gosling, 2003). However, as acknowledged by the extensive literature on the effects of music on emotions, individual experiences related to music can also be influenced by the perceived features of the music (Beveridge & Knox, 2009; Eerola & Ferrer, 2009; Rafael Ferrer & Eerola, 2011; Gabrielsson & Lindström, 1993; Greenberg et al., 2016; Hargreaves & Colman, 1981; Juslin & Laukka, 2003; Juslin, Liljeström, Västfjäll, Barradas, & Silva, 2008; Rentfrow, Goldberg, & Levitin, 2011; Rentfrow et al., 2012; Rentfrow & McDonald, 2009; Zentner, Grandjean, & Scherer, 2008).

The idea that musical preferences might be related to the musical stimuli themselves is not new (see Hargreaves & Colman, 1981). It is therefore surprising to see that no research to date has looked at how those musical stimuli might play a role in age trends in musical preferences. Much debate has characterised the field of the development of musical preferences in adulthood. That is, up until recently, research has appeared to show that musical preferences develop up until early adulthood and that they remain stable thereafter (or cristallize, see Holbrook & Schindler, 1989), and much of the research up until the 2010s has favoured this theory (Janssen & Murre, 2008; Krumhansl & Zupnick, 2013; North & Hargreaves, 1995; Schindler & Holbrook, 2003). This line of research has mostly looked at preferences for popular music, and has put forward the nostalgia and reminiscence bump hypotheses to explain why individuals might still prefer the popular music of their youth later in life. However, the crystallization hypothesis has exclusively focused on popular music and the “greatest hits” and has failed to take into account the breadth of musical genres that individuals might listen to. Recent advances in music psychology research have shown that musical preferences, measured with various genres and styles, might keep developing up until much later in adulthood, perhaps even develop throughout the entire lifespan (Bonneville-Roussy et al., 2013, 2017; Greasley & Lamont, 2006; Hargreaves & Bonneville-Roussy, 2016; Hemming, 2013; North, 2010), thereby confirming a hypothesis put forward by Hargreaves (1982) and Leblanc (1996). The question remains open whether the possible changes in musical preferences across the life-span are influenced by the actual contents of the music.

Little, if none at all, research has examined how age trends in musical preferences can be linked with age differences in the perceived intrinsic properties of music. Two areas of research that indirectly support changes in musical preferences in adulthood are the development of emotional regulation through music and the developmental changes in auditory threshold levels as part of normal ageing, related to specific hearing impairments that are frequent in old age. The focus of the present research is on exploring the latter, that is, how musical preferences may be related to age differences in the perception of the music. Regarding the former, research has shown an improved ability to regulate emotions with age (Charles & Carstensen, 2010; Phillips, Henry, Hosie, & Milne, 2006), and listening to uplifting and calm music may be used as a means of regulating those emotions in adulthood (Saarikallio, 2010; Schäfer, 2016). In terms of normative auditory development in adulthood, people lose the capacity to hear high pitched and quiet sounds as they age, and have an increased risk of developing hearing impairments (Gordon-Salant & Frisina, 2010). As such, older adults may be less sensitive to quiet and high pitched music. Also, people with hearing recruitment have a higher sensitivity to sound intensity that causes individuals to have an exaggerated perception of sudden changes in sound volume (such as, from soft to loud; Buus & Florentine, 2002). Hearing recruitment happens gradually and tan be experienced in individuals as young as 35 years of age (Anari, Axelsson, Eliasson, & Magnusson, 1999). Resulting from these and similar physiological changes, perception of loudness increase more quickly among individuals with hearing impairments (as a function of objective sound intensity) than they do for people with normal hearing function (Hood & Poole, 1966), and this happens gradually with age. Another hearing deficit that may affect musical preferences is presbycusis, which is the most common type of age-related hearing loss and is characterised by a decreased tolerance for certain sound frequencies (predominantly high pitched sounds that are either imperceptible or difficult to hear; Anari, Axelsson, Eliasson, & Magnusson, 1999; Gates, & Mills, 2005). In sum, as part of the normal age-related hearing loss, perceptions of pitch and intensity seem to be commonly disrupted.

These developmental differences in the auditory system can be observed in individuals as young as 32 years old (Fitzgibbons & Gordon-Salant, 2010). Research has shown that the aforementioned changes in hearing are relatively frequent, develop over time and are often implemented over a span of decades (Agrawal, Platz, & Niparko, 2008; Gordon-Salant, 2005). The majority of previous research on age changes in hearing and audition in adulthood has focused on its effects on speech perception (Gordon-Salant, Frisina, Popper, & Fay, 2010). Only a handful of studies have focused on the effects of these physiological developmental changes on musical preferences (Leek, Molis, Kubli, & Tufts, 2008; Smith, 1989). One hypothesis from these studies posits that, as people age, they tend to like softer music because they become oversensitive to perceived loud or distorted sounds. Consistent with this hypothesis, research by Smith (1989) indicates that age is negatively related to preferences for high intensity music. Although older adults (aged between 54 and 90 years) in Smith's (1989) sample were less able to hear loud sounds, they tended to listen to music at a lower volume than did the younger participants (18-53 years of age), suggesting that they may have found loud music uncomfortable. Another study found that overall changes in volume levels in music are common sources of complaints amongst older individuals (Leek et al., 2008). Indeed, high levels and drastic changes in volume can be uncomfortable for individuals with hearing recruitment (Hood & Poole, 1966).

Age differences have also been found in relation to tempo and consonance preferences, but only in childhood and adolescence. In terms of tempo, children and adolescents seem to prefer fast-paced music, and they also have faster spontaneous motor tempo than adults (Drake, Jones, & Baruch, 2000). They also like music with a clear rhythm. At 8 months, babies already display preferences for consonance and clear rhythmic patterns (Hannon & Trainor, 2007; Trainor & Heinmiller, 1998; Zentner &

Kagan, 1996), and these preferences seem to persist in adulthood. Of the properties that can be affected by developmental changes in the auditory system in adulthood, it seems that pitch, dynamics and timbre are the most likely to be affected (Anari et al., 1999; Croghan, Arehart, & Kates, 2012; Florentine, Popper, & Fay, 2011; Hood & Poole, 1966; Johnston, 2010; Punch, Joseph, & Rakerd, 2004).

In sum, research provides indirect evidence that changes in musical preferences throughout the lifespan might be associated with age-related changes in the auditory system and sound perception. Clearly, the impact of the perceived intrinsic properties of the music on age differences in musical preferences needs to be investigated further.

Description of Musical Attributes as Intrinsic Determinants of Musical Preferences

Two classes of descriptors of intrinsic musical attributes have been used in music psychology research. In subjective descriptions, listeners rate the attributes that describe their subjective experiences with respect to emotions, liking or interest (Beveridge & Knox, 2009; Juslin & Laukka, 2003; Rentfrow et al., 2012, 2011; Zentner et al., 2008). This method is not only common in research, but also in real-life settings, where individuals use social tags, short semantic labels, to describe music to others (Eerola & Ferrer, 2009; Ferrer & Eerola, 2011; Ferrer, Eerola, & Vuoskoski, 2012). In objective description, the inner, sonic features of music are directly extracted from audio files using Music Information Retrieval techniques (MIR; Dunn, de Ruyter, & Bouwhuis, 2011; Dunn, Jurgen, Jaap, & Aroyo, 2009; Eerola, Lartillot, & Toiviainen, 2009; Lamere, 2008; MacDorman, Ough, & Ho, 2007).

The subjective description of musical attributes is currently the most popular way to assess the relationship between musical properties and musical preferences. Subjective musical attributes are short words that listeners apply to music, typically to describe its content, characteristics, quality or mood (Eerola & Ferrer, 2009; Lamere, 2008; Rentfrow et al., 2011). Subjective musical attributes that relate to musical properties can be divided in several categories: music-related (e.g. slow, instrumental), psychological (e.g. sad, intelligent) and situational (e.g. music for dinner, training or work; Greenberg et al., 2016; Lamere, 2008; Rentfrow et al., 2012, 2011). Such attributes represent a rich source of semantic information (Turnbull, Member, Barrington, Torres, & Lanckriet, 2008) and are genre-independent (Lamere, 2008; Rentfrow et al., 2011). Subjective descriptors of musical attributes can be a powerful tool for classifying and exploring music (Lamere, 2008). It is worth noting that this form of description refers to how individuals perceive music. As such, the labels used usually encompass several sonic attributes at once, such as “mellow” that is commonly used to describe music with slower tempo, softer dynamics and smoother timbre (Lamere, 2008).

Objective descriptors of musical features rely on the extraction of structural properties of music using MIR, such as tempo, rhythm, melodic patterns, complexity and timbre (Gabrielsson & Lindström, 2010), typically using MIR techniques. They can be typically applied to any audio file.

Investigations of objective musical features have been used both in computer sciences to improve adaptive music recognition and recommendation systems (Schedl, Flexer, & Urbano, 2013) and in music perception research to identify the mapping between objective and subjective properties of music (Eerola, 2012). In this approach, low, mid, and high-level features are usually extracted using dedicated algorithms to estimate various characteristics (fundamental frequency, onset histogram, timbral descriptors, etc.) of the music at different time-levels. These extracted features, often aggregated across time, produce long-term/macro-level descriptors of objective characteristics of music (Vatolkin, Rötter, & Weihs, 2014; Weihs, Ligges, Mörchen, & Müllensiefen, 2007). Long-term/macro-level musical segments are described as significant and meaningful proportions of short-term features of music (Weihs, et al., 2007). They are ecologically valid (Schubert, 2004) and refer to semantic terms such as average pitch or stability of rhythm (Schmuckler, 2016; Weihs et al., 2007).

Research using computer-extracted objective musical features has blossomed over the past decade, but has yet to reach the mainstream in music psychology. Research using mapping of the objective and subjective qualities of music has provided multiple successful examples. For instance, words that are commonly used by individuals to describe music, such as ‘bright’ or ‘full’, are highly related to computer-extracted timbral properties of music (Alluri & Toiviainen, 2010). In a similar vein, affective characterisations of sounds are well mapped into the acoustic descriptors of the sounds (Eerola, Ferrer, & Alluri, 2012).

The subjective and objective descriptors and their correlates with music preferences in adulthood have seldom been investigated. As such, the empirical investigation of subjective and objective descriptors of music as intrinsic determinants of preferences has the potential to greatly improve our understanding of the factors that are linked with age trends in musical preferences.

The Present Research

The first objective of the present paper is to examine how the subjective and objective intrinsic properties of the music are associated with musical preferences in adulthood. The second objective is to examine the moderating effects of those intrinsic properties on age trends in musical preferences. From past research it is assumed that, since age-related changes in the auditory system are observed from the beginning of the third decade of life, it is possible that age trends in musical preferences could be related to these changes. This study first examines the moderating effects of self-reported preferences for intrinsic musical attributes, on age trends in preferences for excerpts of musical audio-recordings. The second part of this empirical study takes one step further and investigates the roles of the objective musical features on musical preferences.

Method

Participants

A total of 481 subjects were recruited, as part of a broader project with the aim of examining the determinants of musical taste in adulthood, on various crowd sourcing websites between 5 August and 8 August 2013. These participants were aged between 18 and 65 years old (*M* = 30.96, *SD* = 10.93). Of those who declared their sex, 56 % were females. A white ethnic background (72 %) was predominant. Most participants were full–time workers (34 %) and students (26 %), or retired/homemakers (24 %). 39 % of them had at least some college education or an undergraduate degree (28 %) whereas 22 % has less than some college education and the remainder attended a graduate program. 84 % of participants had less than six years of formal musical education.

Measures

Self-reported preferences for musical attributes

The method used to examine musical attributes was adapted from various questionnaires (Alluri & Toiviainen, 2010; Juslin & Laukka, 2004; Pratt & Doak, 1976;

Rentfrow et al., 2012). People were asked the extent to which they liked some basic properties of music, such as loudness or roughness. The instrument developed for the purpose of this investigation contains 28 musical attributes that represent important components of music: dynamics (e.g. loud, soft), tempo (e.g. slow, fast), pitch (e.g. high, low) and timbre (e.g. rough, intense, instrumental) (Gabrielsson & Lindström, 2010). The general instructions accompanying this questionnaire are: 'Think about the music you like in general, not a particular genre or song. I like': (e.g. fast music). These attributes are rated on a Likert scale ranging from 1 (*I strongly dislike*) to 5 (*I strongly like*).

To assess the dimensionality of taste for musical attributes, a series of exploratory factor analyses (EFA) were performed. A first EFA using maximum likelihood estimation with oblimin rotation on the 28 items shows that the items 'bright music' and 'low pitched music' had low communalities and were thus removed from the questionnaire. 'Complex music' and 'Electronic music' had factors of their own and were therefore retained as independent items. The remaining 24 items yielded a six-factor solution that explained 44% of the variance in the data (see Tables S1 and S2 of the Online Supplemental Material for a detailed description of the factors). The six factors were named according to past research that has used semantic tags to examine musical properties (e.g. Eerola & Ferrer, 2009; Ferrer & Eerola, 2010; Greenberg et al., 2016; Lesaffre et al., 2006; Rentfrow et al., 2011), and according to tags used in major streaming websites (e.g. last.fm), to increase ecological validity of the results: (1) acoustic attributes, which were characterised by acoustic popular music (two items: acoustic guitar and acoustic music); (2) forceful attributes, which included attributes related to loud and rough sounds (six items: yelling voices, rough music, distorted music, loud music, electric guitar, dense music); (3) instrumental attributes, which were linked with acoustic instruments mostly found in classical and non-electric music (five items: piano, woodwinds [e.g. clarinet, flute], brass [e.g. trumpet], strings [e.g. violin, cello] and instrumental music); (4) mellow attributes, which were composed of more smooth musical features (five items: soft music, light music, slow music, low-energy music, simple music); (5) energetic attributes were related to vigorous attributes (two items: high-energy music and fast music); and (6) easy-listening attributes, which were characterised by more uplifting attributes (four items: melodious music, harmonious music, vocal music, rhythmic music). In the present study, the descriptive statistics and reliability coefficients were: Acoustic Attributes $\alpha = .78$ ($M = 4.07$, $SD = .75$); Forceful Attributes $\alpha = .82$ ($M = 3.03$, $SD = .82$); Instrumental Attributes $\alpha = .81$($M = 3.74$, $SD = .76$); Mellow Attributes $\alpha = .75$ ($M = 3.46$, $SD = .64$); Energetic Attributes $\alpha = .60$ ($M = 3.94$, $SD = .70$); Easy-Listening Attributes $\alpha = .63$ ($M = 4.10$, $SD = .51$), and for the two single items Complex, ($M = 3.88$, $SD = .86$) and finally electronic, ($M = 3.40$, $SD = 1.23$).

Musical preferences

We examined musical preferences using the clips sub-test of the MG-CT Short Form (Bonneville-Roussy et al., 2017). The development and validation of the MG-CT is explained thoroughly in Bonneville-Roussy et al. (2017). The sub-test includes 51, 15-second excerpts of music audio-recordings merged into 17 genres (three clips per genre; the average rating of the three clips were taken as the average preference for the genre), and then into five musical dimensions, as validated in Bonneville-Roussy et al. (2017; see also the Online Supplemental Material of Bonneville-Roussy et al., 2017). The full list of clips is available on the open-science repository (Bonneville-Roussy, 2016). Each participant listened to a random sample of around 50% of the clips.

The first dimension comprises the classical and opera music clips (six clips in total) and is named Classical (*M* = 3.10, *SD* = 1.05). The second genres dimension includes the ambient/chillout, dance/electro and hip-hop/rap music clips (9 clips in total), and is labelled Contemporary (*M* = 2.77, *SD* = .77). The Intense dimension included heavy metal, punk and rock clips (9 clips; *M* = 2.79, *SD* = .96). The fourth dimension, Jazzy, includes the blues, funk, jazz, Latin and reggae clips (15 clips; *M* = 3.22, *SD* = .68). Finally, the Unpretentious dimension comprises country, gospel, pop and R&B/soul, with 12 music clips (*M* = 2.75, *SD* = .79).

Objective Musical Attributes Using Music Information Retrieval

Fifty-six objective musical features from the 51 clips described in the preceding section were extracted using the MIR toolbox (v.1.5; Lartillot & Toiviainen, 2007). Using a method suggested by Eerola (2011), a full set of features was reduced to a compact set of meaningful dimensions, which are described below. Some of the extracted features (e.g. attributes related to timbre) are typically extracted within extremely short analysis frames (40 milliseconds), whereas others (e.g. harmony and structure) require longer analysis frames (2 seconds) in order to be meaningful and to adequately represent the features of the music (Eerola, 2011). First, the features were split into seven major music dimensions: Complexity (longer frames), Dynamics (longer frames), Pitch (shorter frames), Rhythm (longer frames), Timbre (shorter frames), Tempo (longer frames) and Tonal Clarity (longer frames). In order to trim the possible feature set even further, if two extracted features from the same dimension were highly correlated ($r > .80$) in past research, then only one of the features was kept (Eerola, 2011). From the remaining features, a series of principal component analysis (PCA) with varimax rotation was performed separately for each music dimension. To account for the overall weight of the items, scores on the components were saved. Only features that had a communality coefficient greater than .50 were kept (the variance of the items explained by the component). As a result, the original set was reduced to 26 features across seven music dimensions: Complexity, Dynamics (change), Rhythm, Tempo, Timbre (roughness), Pitch, and Tonal Clarity. An extended description of the features and descriptive statistics are presented in the Online Supplemental Material.

Results

Perceived Intrinsic Attributes – Subjective Description

We first examined the direct associations between the self-reported measures of musical attributes and musical preferences, using multiple linear regressions. Then, we examined the moderating effects of these perceived attributes on age trends in musical preferences were examined by computing their interaction terms with age. Pearson correlation coefficients are found in Table 1. The first section of Table 1 shows several significant correlations between age and musical preferences (e.g. Intense and Unpretentious). The correlation coefficients between age and the five music preferences dimensions are comparable in their directionality and strength, to those found in previous research (Bonneville-Roussy & Rust, 2017). The second section of the correlation coefficients presented in Table 1 shows that some objective descriptors are directly related to age. In particular, as age increases, preferences for perceived instrumental and easy listening attributes increase. On the contrary, as age increases, preferences for forceful, energetic and complex attributes decrease. Moreover, the majority of the intercorrelations within the musical preferences or objective descriptors portray relatively low correlations, musical preferences being more highly related to one or two subjective descriptors, since the factors represents distinct and unique facets of the phenomena.

Insert Table 1 about here

Direct associations between preferences for musical attributes and musical preferences

Regression analysis results are displayed in Table 2. The F values of the multiple regression models of the Classical, Contemporary, Intense, Jazzy and Unpretentious music clips dimensions regressed on age and eight musical attributes yielded significant results. In general, these predictors yielded mostly strong effect sizes, with multiple correlation coefficients ranging from $r = .44$ to $r = .66$. Preferences for the Classical clips were not associated with age, but strongly related to preferences for instrumental music sounding, and positively but moderately related to the easy listening and complex attributes and negatively related to the acoustic attributes. Interestingly, preferences for Contemporary music clips were negatively linked with age but positively associated with preferences for Intense and Mellow music, and were mostly associated with liking for electronic music soundings. Intense music was strongly positively associated with forceful attributes and negatively linked with easy-listening attributes. Preferences for the Jazzy clips were related to the liking of popular acoustic, intense and instrumental attributes. Finally, Unpretentious music genres were increasingly liked with age, and were positively associated with Mellow and easy listening attributes, and negatively associated with intense and complex music.

Insert Table 2 about here

Moderation effects of perceived musical attributes on age trends in musical preferences

The significant interaction effects are presented in Figure 1. Using a series of hierarchical multiple regressions separately for each of the musical attributes, the main effects of standardised age and each of the standardised musical attributes were entered in Step 1 and the interaction term was entered in Step 2. To avoid multicollinearity, age and the eight musical attributes were standardized before computing their product terms. A significant change in F value at Step 2 would indicate a significant interaction effect.

Insert Figure 1 about here

Two of the eight musical attributes dimensions (easy-listening and forceful music) were linked with age trends in musical preferences. First, easy-listening moderated the links between age and preferences for classical music, as can be seen in Panel A of Figure 1. A positive trend was found between preferences for the Classical dimension and age for individuals who showed above-average levels of liking for easy-listening attributes (1 *SD* above the mean), whereas, individuals who scored below average in liking for easy-listening attributes, as age increased, preferences for Classical decreased (1 *SD* below the mean), F_{change} (1, 477) = 3.98, $p = .05$, $r = .42$. In panel B of Figure 1, we see that preferences for the Contemporary musical dimension stayed relatively stable for adults who scored above average in liking for easy-listening attributes, but we saw a negative trend between preferences for Contemporary music and age for individuals who had lower levels of liking for easy-listening attributes, F_{change} (1, 477) = 4.96, *p* = .03, *r* = .15. Panel C of Figure 1 indicates a slight positive trend with age for preferences for the Jazzy dimension for individuals whose scores are higher in liking for easy-listening. On the contrary, preferences for Jazzy music slightly decrease as age increases for individuals who tend to dislike easy-listening attributes F_{change} (1,477) = 4.61, *p* = .03, *r* = .28. An interaction between age and easy-listening predicted preferences for Unpretentious music, F_{change} (1,477) = 4.17, *p* = .04, *r* = .35, as seen in Panel D of Figure 1. Although we observe a general trend towards an increasing preference for the Unpretentious clips with age, the increasing slope was steeper for individuals who had above-average liking for easy-listening attributes as compared with below average.

The significant interaction effects between age and forceful musical attributes to predict musical preferences are plotted in Panels E and F of Figure 1. Panel E depicts the interaction between the forceful attributes and age as predictors of preferences for the Classical music clips. A negative age trend in preferences for Classical music was found for individuals who had above-average levels of liking for forceful attributes, whereas a positive trend was found between age and Classical music for individuals who scored below average in liking for forceful attributes, F_{change} (1,477) = 4.03, *p* = .05, *r* = .13. Finally, preferences for the Contemporary music clips dimension remained comparatively stable for individuals with high levels of liking for forceful attributes, whereas a negative age trend was found for individuals with below-average levels of liking for forceful attributes, F_{change} (1,477) = 4.59, *p* = .03, *r* = .21.

Music Features Extraction – Objective Description

Direct associations between objective musical features and musical preferences

This section aims to further validate the dimensions found in the MG-CT by comparing the extracted musical properties of the music (see Method section and the Internet Supplementary Material for a description of the extracted features) across the Classical, Contemporary, Intense, Jazzy and Unpretentious music dimensions. To do this, we conducted a multivariate analysis of variance (MANOVA 5 X 7) for the five music dimensions by the seven objective musical features, with the sample size of 51 clips.

Multivariate results show an effect of the intrinsic properties of music on the music dimensions, $F_{28, 168} = 2.79$, $p < .001$, $\eta^2 = .32$. Univariate results show main effects of *Dynamics* changes, $F_{4, 45} = 11.76$, $p < .001$, $\eta^2 = .51$; *Pitch*, $F_{4, 45} = 2.83$, $p = .04$, $\eta^2 = .20$; *Rhythm*, $F_{4, 45} = 4.89$, p = .002, $\eta^2 = .30$; *Timbre*, $F_{4, 45} = 6.27$, $p < .001$, $\eta^2 = .36$; *Tonal Clarity,* $F_{4, 45} = 2.59$, $p = .05$, $\eta^2 = .19$; but no significant effects of *Complexity*, $F_{4, 45} = 1.14$, $p = .35$, $\eta^2 = .09$; or *Tempo*, $F_{4, 45} = .50$, p = .73, $\eta^2 = .04$. Taken together, the comparison of the five musical dimensions as assessed through the 51 clips of extracted musical features shows that, when significant effects are found, the intrinsic properties of music yield moderate to large effects in explaining the music dimensions.

The results of Bonferroni post hoc analyses of simple effects are plotted in Figure 2 and detailed in Table S4 of the Online Supplemental Material. Simple effects presented show that the perceived dynamics range (Dynamics) of the Classical and Jazzy music clips is comparatively lower, and Contemporary and Intense is significantly higher. The pitch of the Intense, Jazzy and Unpretentious music clips is similarly average, whereas pitch in Classical music is higher and pitch in Contemporary music is lower relative to the other music dimensions. In terms of rhythm, Classical music has a more regular rhythm, but Intense music was less regular compared with the other dimensions. Intense music has a comparatively rougher, sharp timbre than the other dimensions. Finally, Contemporary music displays less variation in terms of tonal clarity than the other music dimensions. Although not significant, we see trends in the relationships between complexity and the musical preferences dimensions. The Classical clips tend to be more complex than the clips included in the other dimensions (a higher score on Complexity is associated with more repetition and a lower score on Complexity denotes less repetition).

Insert Figure 2 about here

Moderation effects of the objective musical features on age trends in musical preferences

To examine how the computer-extracted intrinsic attributes of music influence the relationship between age and musical preferences, a series of three regression analyses by age group (emerging [18-25], young [26-39] and middle-aged adults [40-65], see Bonneville-Roussy et al., 2017, for a similar strategy) was performed. Because of the relatively small number of clips available to us (51), we used aggregated measures of all of the music clips as a proxy for overall musical preferences, to examine which intrinsic, objective musical attributes would best predict age differences in musical preferences in general. Past research has indicated that perceptions of pitch, dynamics and timbre may be moderators of the relationships between age and musical preferences, especially from middle adulthood onwards (Gates & Mills, 2005; Leek et al., 2008; Smith, 1989). In addition, research has shown that, as a whole, hearing sounds becomes more challenging with age (Fitzgibbons & Gordon-Salant, 2010). Therefore, we expected that timbre, dynamics and pitch would be more important predictors of preferences for the music clips for the middle-aged group than for the younger group.

Mean liking for the 51 clips for the participants described above (N = 481) was first computed for each age group (18 to 25 year olds [n = 188], 26 to 39 year olds [n = 199] and 40 to 65 year olds [n = 94]). These mean scores were then regressed onto the higher-order computer-extracted musical dimensions of complexity, dynamics, pitch, rhythm, tempo, timbre and tonal clarity, using hierarchical regression. Dynamics, pitch and timbre, the three hypothesised most important predictors of age differences in musical preferences were entered at Step 1, and complexity, rhythm tempo and tonal clarity were entered at Step 2. Bootstrap robust standard errors and confidence intervals were obtained with a sampling of 1,000 iterations.

Results can be found in Table 3. Overall, our findings reveal that the three variables entered at Step 1 significantly contributed to the emerging and young adulthood models. In addition to the variables entered at Step 1, tonal clarity entered at Step 2 contributed to musical preferences for the middle adulthood group. For the Emerging group in Table 3, inspection of the beta weights indicates that timbre and pitch are significant predictors of preferences for the emerging group, with lower pitch and less rough timbre associated with a higher preference for music; this explains 33% of the variance in preferences for the 51 clips. As can be seen in the second section of Table 3, timbre and pitch (marginally) are also significant contributors of preferences for the clips in the young adulthood group, the overall model explaining 38% of the variability in musical preferences for this age group. Music with less rough or sharp timbre and lower pitch is preferred in this age group, with a slightly larger contribution for timbre and a slightly smaller contribution for pitch, as compared with the emerging adulthood group. Finally, as can be seen in the last section of Table 3, Dynamics (measured as changes in dynamics between two events) and Timbre are significant predictors of preferences in the middle-aged group, with increased importance compared with the two younger age groups. Pitch is a marginally significant predictor of global musical preferences in middle adulthood, with comparatively decreased importance. Finally, tonal clarity is positively related to preferences in the middle adulthood age group. Globally, the musical attributes explained 49% of the variance in musical preferences for the Middle Adulthood age group.

Insert Table 3 about here

As was expected we found that timbre, dynamics and pitch were more important predictors of preferences for the music clips for the middle-aged group than for the younger group. More stable dynamics, smoother timbres and lower pitch (marginally) all predicted greater preferences for music clips for middle-aged adults. Interestingly, the overall variance of musical preferences explained by the objective musical attributes was much larger for the older group (49%) than for the younger group (33%).

Discussion

In line with the MPAM, a model proposed by Bonneville-Roussy et al. (2017), this paper examined the links between the intrinsic determinants of musical preferences in adulthood, and found that those determinants were indeed predictors of age trends in musical preferences. It specifically focused on the relationships between the subjective and objective descriptors of musical attributes and five dimensions of musical preferences, as well as the moderating effects of these subjective and objective attributes on age trends in musical preferences.

This paper provides two significant results worthy of discussion. First, musical preferences were strongly related to liking for one family of musical attributes, whether measured by self-report or by feature extraction. Using self-reports, our results support the findings of past research that musical preferences are strongly linked with psychological attributes associated with the music (Greenberg et al., 2016; Rentfrow et al., 2012, 2011). For all the associations between musical taste and liking for musical attributes, the effect sizes were at least moderate, and most of them were large.

Using objective musical features extracted with the MIR toolbox, we found that the Classical music clips were more complex, had more stable dynamics and were less rhythmic; they were also higher pitched and had a clearer tonality. The Contemporary music clips had a higher dynamics range, were lower in pitch and were more blurred in terms of tonality. The Intense music clips had the largest dynamics range, were more rhythmic and had a substantially rougher timbre. Finally, the Jazzy and Unpretentious dimensions were comparatively moderate in all of the musical features. These findings are aligned with those of Dunn (2010), who found that some extracted audio features were uniquely related to nine dimensions of musical preferences. The present findings significantly advance the study of musical preferences by showing that the inner properties of music account for a significant proportion of the variance in the musical preferences of adults.

As the second result worth discussing in detail, using a cross-sectional study design, we found that the intrinsic properties of the music moderated the relationships between age and musical preferences, using both subjective and objective categorisation. On the basis of research on auditory perception, it was expected that age trends in musical preferences would be moderated by the intrinsic properties of music. From young and middle adulthood, individuals gradually experience a decreased sensitivity to high pitch, an increased vulnerability to noise and rough sounds (timbre) and large changes in perceived dynamics (Anari et al., 1999; Croghan et al., 2012; Florentine et al., 2011; Hood & Poole, 1966; Johnston, 2010; Punch et al., 2004). We therefore expected that age differences in preferences for musical properties associated with pitch, timbre and dynamics would moderate the relationship between age and musical taste.

Using self-reports, roughness of sound and changes in volume (dynamics) were included in the forceful dimension and softer attributes were included in the mellow and easy-listening dimensions. Therefore, we expected that these dimensions would moderate the relationship between age, measured cross-sectionally, and musical taste. Consistent with these predictions, the results showed that easy listening moderated age trends for the Classical, Contemporary, Jazzy and Unpretentious dimensions. Positive age trends were found for preferences for Classical, Jazzy and Unpretentious music and negative age trends were found in preferences for Contemporary music. The effects of forceful attributes also were in the expected directions: positive age trends were found between forceful attributes and Contemporary music. Correspondingly, a decrease in preferences for Classical music was seen with age in the group who showed below average liking for forceful attributes. Although these results are preliminary and collected through self-report, they provide a first insight into how musical attributes could moderate the relationships between age and musical preferences.

Stronger support for the moderating effects of the intrinsic properties of the music to predict age differences in musical preferences was found when computer-extracted musical features were used. The results of the links between the intrinsic properties of the music and musical preferences according to age show that a large proportion of variation in musical preferences can be explained by differences in the objective properties of music. Linking age-related changes in auditory perception to age variations in musical preferences, our findings reveal that dynamics, pitch, timbre and to a lesser extent tonal clarity were increasingly important determinants of musical taste as age increased. These results are consistent with Smith (1989), who showed that greater changes in dynamics were linked to lower taste in music in the middle adulthood group, but not in the emerging and young adulthood groups. In line with Bonneville-Roussy et al. (2017), in the present research, the Contemporary and Intense music dimensions, which were characterised by greater changes in dynamics, were also increasingly disliked with age (as seen in Bonneville-Roussy et al., 2013, 2017). In contrast, Classical music was found to be comparatively more stable in dynamics and increasingly liked as age increased (as shown in Bonneville-Roussy et al., 2017). Our results also support the hypothesis that middle-aged adults might prefer calm and uplifting music, with more stable dynamics and smoother timbre, as a way to regulate their emotions (Saarikallio, 2010).

In terms of timbre, our results reveal that distorted music with more noise-like sounds was increasingly disliked from emerging to middle adulthood. Intense music, characterised by greater sound distortion, was also increasingly disliked with age (see Bonneville-Roussy et al., 2013, 2017), whilst preferences for Unpretentious music, low in distorted sounds in the present research, increased with age (Bonneville-Roussy et al., 2013, 2017). Higher pitched music did not affect the musical taste of middle-aged adults (who preferred the comparatively higher pitches of Classical music) as much as emerging and young adults (who comparatively dislike Classical music, see Bonneville-Roussy et al., 2017).

In summary, our results provide preliminary indications that age-related differences in musical preferences can be related to differences in the perception of dynamics, pitch and timbre. The present findings offer new evidence from three different methods (self-report of musical attributes, musical preferences using music clips, and computer-extracted musical features) that the intrinsic properties of the music can explain a moderate but systematic amount of variability in age-related trends in musical preferences. Our present research provides further evidence of the relationships between perceived sonic features of the music and age trends in musical preferences in adulthood. Experimental research with different age groups should shed further light on the predictive direction of the effects.

A critical review of the Music Preferences in Adulthood Model

The present paper being the last of a series of three whose aim was to examine the extrinsic and intrinsic determinants of musical preferences in adulthood in line with the MPAM presented in Bonneville-Roussy et al. (2017), we can draw a clearer portrait of age trends of musical preferences, from the present investigation, and from past research. The MPAM describes the psychological determinants of musical preferences in adulthood as being extrinsic to the music (such as individual differences and social influences) or intrinsic to the music (the inner properties of the music).

In terms of the relative importance of the extrinsic and intrinsic psychological determinants in explaining musical preferences in adulthood, it seems that the psychological components that are derived from the music (i.e. that are intrinsic to the music itself) bear a much greater weight in determining preferences than psychological components that are extrinsic to music, such as individual differences and social influences. The effect sizes associated with the intrinsic determinants have been moderate and mostly high in the present investigation and in past research (Dunn, 2010; Greenberg et al., 2016; Rentfrow et al., 2012, 2011), whereas the strengths of the relations between the extrinsic psychological determinants (e.g. gender, personality and social influences), and musical preferences in adulthood have been low to moderate at most, with multiple correlation coefficients typically below .30 (Bonneville-Roussy et al., 2013; Bonneville-Roussy & Rust, 2016; Langmeyer et al., 2012; Rentfrow & Gosling, 2003). The investigation of the intrinsic properties of the music as determinants of musical preferences is an avenue of research that warrants further investigation.

In addition, in Bonneville-Roussy et al. (2017), also briefly mentioned in the present introduction, we reviewed the continuity versus change debate on the development of preferences in adulthood. Although no definitive conclusions can be drawn from the results of the present work, our results suggest that these two views can be reconciled. That is, some findings, such as the lack of interaction effects between age, individual difference, and musical preferences (Bonneville-Roussy et al., 2013), and a peak in preferences for pop music in young adulthood (Holbrook & Schindler, 1989; North & Hargreaves, 1995; Schindler & Holbrook, 2003) suggest continuity in musical taste. Other results – the most noticeable of which have come from the moderating effects of intrinsic musical features on age trends in musical preferences found in the present investigation, supported by research in auditory perception (Anari et al., 1999; Croghan et al., 2012; Florentine et al., 2011; Hood & Poole, 1966; Johnston, 2010; Punch et al.,

2004) – strongly suggest that preferences continue to evolve throughout adulthood. In light of the present results, it is likely that musical preferences evolve throughout the different decades of life, as our results, and the findings of others, suggest.

From the present findings we cannot entirely rule out that the age trends observed are an indication of changes in musical preferences between different cohorts of adults. Though our research cannot rule out this hypothesis, cohort effects would not entirely explain age differences associated with the extracted musical features shown in Table 3 (this research), that are more objective and therefore less likely to be genre- or cohort-specific. Age trends in musical preferences can also be seen in a broader historical and cultural perspective. Even in classical music, a genre that is more than 600 years old, or rock music, a genre that was born very recently (in the 40s-50s), some music can be considered more Intense or more Mellow. For instance, symphonies by Beethoven and Shostakovich have more dynamic changes and are substantially rougher than are trios by Mozart. In the same vein, Rentfrow and colleagues (2012) have demonstrated that jazz and rock music can be more or less Intense or Unpretentious. Therefore, it is possible that, even within musical dimensions, age trends in musical taste can be found. For instance, within Classical music, a young adult might prefer the intensity of Beethoven, whereas a middle-aged adult might favour the softer sounding and greater tonal clarity of a piano trio by Mozart. That is, age trends might be witnessed within musical dimensions, or even genres, as much as between dimensions. Musical taste evolves like fashion, and great differences between centuries and nations can be found. However, in light of the present results on the relationship between the intrinsic properties of music and musical taste, it is possible that these age trends reflect universal changes in the human auditory system. Therefore, it is possible that, to some extent, these trends are immune to cultural and historical variations. Much research is needed to assess this last hypothesis.

Our research bears limitations - some mentioned above - that should be overcome in future research. The two most important are our reliance on self-reports and our dependence on cross-sectional studies to measure age differences in musical preferences. Less subjective measures of preferences, and extensive longitudinal studies, should draw a clearer portrait of age trends in musical preferences in adulthood in the future.

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