Age-related Evaluations of Imageability and Subjective Frequency for 1,286 Neutral and Emotional French Words:

Ratings by Young, Middle-aged and Older Adults

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Abstract

This study aimed at providing imageability and subjective frequency ratings collected from four adult age groups ranging from 18 to 85 years old (18-25; 26-39; 40-59; 60 and over) for 1,286 neutral and emotional French words available in the EMA database (Gobin, Camblats, Faurous, & Mathey, 2017). Overall, the older adults rated words as more (subjectively) frequent and more imageable than the younger adults. Furthermore, we examined the relationships between subjective frequency and imageability, as well as those with emotional variables (i.e., valence, arousal) already available for these words, for each age group. For all age groups, more subjective frequent words were more imageable. Emotional words were more imageable and more frequent. Arousal scores were lower for low- and high-imageability words, and higher for more subjective frequent words. The strength of these links between subjective frequency, imageability and emotional ratings was found to decrease as a function of age. Finally, by using the lexical decision reaction times and accuracy rates of young adults from Megalex (Ferrand et al., 2018), imageability and subjective frequency across age were found to provide an additional contribution to visual word recognition performance as compared to objective lexical variables (i.e., number of letters, syllables, objective frequency, orthographic neighbourhood). More importantly, subjective frequency and imageability ratings from the youngest group predicted reaction times and accuracy better than ratings from the oldest group. By providing new age-adapted word characteristics, this norm should be of great use to researchers in the field of cognitive aging who use word materials.

Keywords: imageability, subjective frequency, age, emotional valence, arousal, word recognition

Many studies have shown that word characteristics are critical determinants of visual word recognition (e.g., Balota, Cortese, Sergent-Marshall, Spieler, & Yap, 2004) and recall in memory tasks (e.g., Cortese, McCarty, & Shock, 2014). In order to control and/or to manipulate such word characteristics, researchers usually rely on lexical databases that provide detailed information about words. For example, in the French language, Lexique (e.g., New, Brysbaert, Veronis, & Pallier, 2007; New, Pallier, Brysbaert, & Ferrand, 2004) provides word characteristics (e.g., number of letters, syllables, word frequency, lexical similarity) computed from a large corpus of words. Other lexical norms[1] provide subjective word estimates collected by asking participants to rate stimulus words according to given criteria. In Ferrand et al. (2008), subjective frequency ratings were provided for a set of 1493 French words by asking participants to rate how often a word was encountered. In another study, Bonin et al. (2011) collected imageability estimates for a corpus of 1493 French words. Nowadays, such lexical norms developed from estimates by young adults are available in different languages for subjective frequency, which refers to the frequency of exposure to a word in daily life, and for imageability, which refers to the ease with which a mental image of a word can be formed (Desrochers & Thompson, 2009; Gonthier, Desrochers, Thompson, & Laudry, 2009 in French; Stadthagen-Gonzalez & David, 2006 in English; Soares, Coasta, Machado, Comesaña, & Oliviera, 2017 in Portuguese), as well as for emotional valence (i.e., the degree to which a word is positive/pleasant or negative/unpleasant) and for arousal (i.e., the degree of physiological activation provoked by the word) (e.g, Bonin, Méot, & Bugaiska, 2018; Monnier & Syssau, 2014; Ric, Alexopoulos, Muller, & Aubé, 2013 in French; Citron, Cacciari, Kucharski, & Beck, 2016, in English; Ferré, Guasch, Moldovan, & Sánchez-Casas, 2012 in Spanish; Kanske & Kotz, 2010 in German). However, given the increasing evidence of age-related changes in the lexical processing system in the adult life span (e.g., Balota et

[1] As in many studies, here we use the word 'norm' to refer to lexical databases providing mean performance per word, not individual performance (see e.g., Balota et al., 2001, Citron et al., 2016; Gonthier et al., 2009).

al., 2004; Robert & Mathey, 2007; see Wulff et al., 2019 for a review), it appears fundamental to rely on age-adapted lexical norms. Up to now, age-related lexical norms in adulthood have remained scarce, generally restricted to specific word characteristics, and even more so in the French language. In the present study, we collected estimates of subjective frequency and imageability for a set of 1,286 French words for which age-related emotional indexes were already available, from four samples of adults aged from 18 to 85 (emerging adults: 18-25 years; early adulthood: 26- 39 years; middle-aged adults: 40- 59 years; older adults: 60 years and more; Gobin et al., 2017). These additional norms should be of great use to researchers looking to investigate the relationships between lexical variables, in particular between imageability, subjective frequency and emotional characteristics (i.e., valence and arousal) in the French language for different adult age groups. While the relationships between these variables have already been investigated in young adults (e.g., Bonin et al., 2018; Montefinese, Ambrosini, Fairfield, & Mammarella, 2014), they have never been examined with advancing age. Given the influence of age on estimates of imageability (e.g., Gilet, Grühn, Studer, & Labouvie-Vief, 2012; Grandy, Lindenberger, & Schmiedek, 2020; Grühn & Smith, 2008), subjective frequency (e.g., Dorot & Mathey, 2010; Robert, Dorot, & Mathey, 2012; Balota, Pilotti, & Cortese, 2001), emotional valence and arousal (e.g., Gobin et al., 2017; Grandy et al., 2020; Grühn & Smith, 2008), it appears fundamental to clarify how and to what extent these relationships change through adulthood.

Subjective Frequency across Age

Typically, the word frequency effect shows that recognition performance (such as time or accuracy) is better for words occurring more frequently than for words occurring less frequently in language (e.g., Monsell, 1991; Monsell et al., 1989). This effect has mostly been investigated using objective norms from which frequency counts were drawn from written

corpora (see Brysbaert et al., 2011; Brysbaert, Mandera & Keuleer, 2018 for reviews). Therefore, objective frequency does not take into account either the frequency with which participants have seen, heard, written and/or spoken a word (Balota et al., 2001) or the particular exposure to words from specific groups of individuals (e.g., Balota et al., 2004; Robert al., 2016). In order to better match word frequency with the use of words by specific groups of individuals, subjective estimates reflecting the frequency of exposure to a word as estimated by participants (Gernsbacher, 1984) have gradually been collected in recent decades in several languages (e.g., Balota et al., 2001in English; Gonthier et al., 2009; Robert et al., 2016 in French; Desrochers, Liceras, Fernández-Fuertes, & Thompson, 2010 in Spanish). Subjective frequency ratings are typically collected by asking participants to rate on a scale the number of times they use and/or hear the word in their daily life. The scales specify either extreme values only, such as "never encountered" vs. "very often" (e.g., Desrochers & Thompson, 2009; Gernsbacher, 1984), or all anchor points corresponding to different periods (1 = never encountered, 2 = once a year, 3 = once a month, 4 = once a week, 5 = once every two days, 6 = once a day, 7 = several times a day; e.g., Balota et al., 2001; Dorot & Mathey, 2010; Ferrand et al., 2008; Robert et al., 2012). According to Balota et al. (2001), the use of such anchor points limits the influence of additional sources of information (i.e., semantic, orthographic and/or phonological word characteristics) during subjective frequency ratings.

Several studies have also suggested that subjective frequency is a better predictor of word performance than objective word frequency (e.g., Balota et al., 2001, 2004; Dorot & Mathey, 2010; Gernsbacher, 1984). Interestingly, this was shown to be particularly salient when different age groups were compared, which is typically the case in cognitive aging studies comparing older adults who have, on average, 50 years' more practice with words than younger adults (see Balota et al., 2004; Dorot & Mathey, 2010). In recent years, norms of subjective frequency collected from young adults have become available for large numbers

of words in different languages (e.g., Bonin et al., 2018; Desrochers & Thompson, 2009; Ferrand et al., 2008 in French; Stadthagen-Gonzalez & Davis, 2006 in English; Soares et al., 2017 in Portuguese; Desrochers et al., 2010 in Spanish). On the other hand, subjective frequency estimates collected from older adults remain scarce (but see e.g., Balota et al., 2001). In French, a few norming studies have been published for subjective word frequency across age (e.g., Rico-Duarte, Gély-Nargeot, & Brouillet, 2007; Robert et al., 2012), and all of them are limited to a quite small number of stimuli and/or restricted to two age groups (i.e., young *vs*. older adults). By collecting subjective frequency ratings for 660 French words from a group of young adults (M = 22.6 years old) and a group of older adults (M = 71.2 years old), Robert et al. (2012) found that 24% of these words had a significant age-related difference in subjective frequency estimates. It therefore appears that subjective frequency ratings collected from young adults cannot be generalized to older adults, and that it is important to have estimates from different age groups for the same words. This conclusion is further supported by the inconsistent data, reported in the field of visual word recognition, on the age-related change in the effect of objective frequency (e.g., Cohen-Shikora & Balota, 2016), as well as by some evidence of a variation as a function of subjective frequency in the effect of objective frequency across age (Robert et al., 2009).

Word Imageability across Age

Since subjective frequency has been found to be correlated with other word characteristics, in particular imageability (e.g., Desrochers & Thompson, 2009), taking both indicators into account simultaneously might be important to better understand the cognitive processes underlying word processing and word memory. Word imageability, the other estimated variable collected in the present study, is defined as the ease with which a word evokes a mental image for the individual (e.g., Desrochers & Thompson, 2009; Rofes et al., 2018). Operationally, imageability is measured by asking participants to rate words on a scale

ranging from “evoke an image readily and spontaneously” (e.g., *apple*) to “evoke an image with difficulty” (e.g., *liberty*). Imageability has consistently been shown to be a strong predictor of lexical decision performance (e.g., Balota et al., 2004; Cortese & Shock, 2013), with high imageability ratings facilitating visual word recognition (e.g., Yap, Pexman, Wellsby, Hargreaves, & Huff, 2012). Also, imageability is considered to be one of the best predictors of memory performance (e.g., Paivio, 2013), with highly imageable words being recalled better. Turning to the effect of age, only a few studies have addressed this issue in word memory. While some studies have shown a decrease in the facilitatory effect of word imageability in older adults (e.g., Dirkx & Craik, 1981; Rissenberg & Glanzer, 1987), which is compatible with age-related difficulties in using imagery processes (e.g., Mason & Smith, 1977; Tournier & Postal, 2011), one has reported no change in the elderly (Bruning, Holzbauer, & Kimberlin, 1975). However, word imageability ratings were not age-adapted in these studies, which make aging differences difficult to interpret. In young adults, word imageability norms are available in different languages, such as English (e.g., Citron, Weekes, & Ferstl, 2014), French (e.g., Bonin et al., 2018; Desrochers & Thompson, 2009), German (e.g., Schmidtke, Schröder, Jacobis, & Conrad, 2014), Italian (e.g., Barca, Burani & Arduino, 2002), Portuguese (Soares et al., 2017), and Swedish (e.g., Blomberg & Öberg, 2015). Up to now, age-specific estimates regarding word imageability have been lacking in French (in German, see Grandy et al., 2020). To our knowledge, only one published norm in French (Gilet et al., 2012) provides word imageability estimates for several adult age groups (young, middle-aged and older adults) and for a specific set of French words (i.e., 835 attributes). Gilet et al. (2012) found that imageability ratings increased with age (see also Grandy et al., 2020; Grühn & Smith, 2008 in German). According to these authors, the age-related increase in word imageability ratings could result from a more developed vocabulary in older adults, and/or from their difficulties in evaluating attributes (due to problems either in

understanding the instructions for ratings, or in discriminating between attributes in terms of imageability). Providing imageability norms as a function of age across a broader set of French words that differ in a body of lexical factors would offer more possibilities for researchers interested in language and memory processes through age to select, control, manipulate or analyze word characteristics in their experimental settings.

Relationships between Subjective Frequency, Imageability, and Emotional Variables across Age

In young adults, several studies provide evidence that imageability and subjective frequency correlate, so that more subjective frequent words are easier to associate with a mental picture than less subjective frequent words (e.g., Desrochers & Thompson, 2009; Ferrand et al., 2008; Soares et al., 2017; Stadthagen-Gonzales & David,). Since both subjective frequency and word imageability ratings are found to vary with age (Balota et al., 2001; Gilet et al., 2012; Grandy et al., 2020; Grühn & Smith, 2008; Rico-Duarte et al., 2007; Robert et al., 2012), it seems important to determine whether and to what extent the relationship between these two variables varies across age. This will be examined in the present study.

Other word characteristics that have been shown to vary with age refer to the emotions provoked by words. Emotionality estimates are usually collected using scales measuring the valence (i.e., hedonic tone) and arousal (i.e., excitation level) of words (Russell, 1980). Several studies have reported that word emotionality influences word recognition (e.g., Kousta, Vinson, & Vigliocco, 2009; Kuperman, Estes, Brysbaert, & Warriner, 2014) and recall (e.g., Adelman & Estes, 2013). Moreover, the effect of emotional valence has been found to vary across age (e.g., Kensinger, 2008; Kyröläinen et al., in press, Lynchard & Radvansky, 2012). In a free recall task, Kensinger (2008) found that for low-arousing words,

distinct emotional preferences were observed among young and older adults. Specifically, a memory advantage for negative stimuli compared to positive stimuli emerged in young adults, while the reverse pattern of results was shown in older adults. In the same vein, in a lexical decision task, Lynchard and Radvansky (2012) demonstrated a negativity effect for young adults (i.e., negative words elicited a faster response than positive and neutral ones) and a positivity effect for older adults (i.e., positive words elicited a faster response than negative and neutral ones). In this latter study, participants also completed an age-contrasting perspective orientation task in which older adults had to imagine themselves as younger adults and young adults had to imagine themselves as older adults. Following this orienting task, younger and older adults reversed their earlier trend, with the presence of a positivity effect in young adults and a negativity effect in older adults. The authors concluded that emotional preferences are flexible and plastic and are not necessarily related to chronological age. Changes in emotional preferences across age seem to be particularly robust, as suggested by a recent study that found evidence for such a pattern in different languages (i.e., English, Dutch and Spanish), in both language comprehension and production (Kyröläinen et al., in press).

Relying on the socioemotional selectivity theory (Carstensen, Isaacowitz, & Charles, 1999), this age-related change in the emotional valence effect was ascribed to a better regulation of emotions with aging. In this theoretical framework, the differentiated preferences toward positive and negative stimuli are due to motivational changes across age. Specifically, when time is perceived to be limited, emotional goals would be adopted first. Older adults, who describe their future as limited in time, promote emotional goals and invest more cognitive resources to achieve them (Carstensen & Mikels, 2005). They would then engage in more motivational processes to limit the impact of negative information, by focusing their attention on pleasant emotional information and disengaging their attention

from unpleasant stimuli (Mather, 2006). These motivational processes would be dependent on the resources demanded by tasks and on the arousal of words (Kensinger, 2008), such that age differences in emotional effects are usually displayed in tasks requiring controlled mechanisms and/or using nonarousing words. While several norms in different languages provide emotional valence and arousal ratings for words collected from young adults (e.g., Bonin et al., 2018; Monnier & Syssau, 2014; Ric et al., 2013 in French; Citron et al., 2016 in English; Ferré et al., 2012 in Spanish; Grandy et al., 2020; Kanske & Kotz, 2010 in German), once again, only a few of them provide these estimates for different age groups (but see Grandy et al., 2020; Grühn & Smith, 2008). In French, the few norms that provide emotional ratings for different adult age groups (Gilet et al., 2012; Gobin et al., 2017) have highlighted several age differences in valence and arousal ratings. More precisely, words are evaluated as being more negative and having a higher arousal level with advancing age. In the present study we examined whether the relationships between emotional characteristics, word imageability and subjective word frequency are age-sensitive.

In young adults, emotional estimates (i.e., emotional valence and arousal) and subjective frequency are usually found to be related. Notably, young participants feel more familiar with positive words (e.g., Bonin et al., 2018; Citron et al., 2014; Yao, Wu, Zhang, & Wang, 2017), as well as with high-arousing words (Citron et al., 2014; Montefine et al., 2014). Considering that word frequency, emotional valence and arousal have also been found to interact in word recognition (Kuperman et al., 2014), it is important to collect subjective frequency and emotional ratings for the same set of words. Emotional words are also found to be more imageable than neutral ones (Altarriba & Bauer, 2004; Citron et al., 2014), and this is particularly the case for positive words (see Bonin et al., 2018; Citron et al., 2014; Warriner, Kuperman & Brysbaert, 2013; Yao et al., 2017). The link between imageability and arousal is less clear, with some studies reporting a low correlation (Citron et al., 2014), others no

relationship (Yao et al., 2017), and still others a negative quadratic relationship (Blomberg & Öberg, 2015; Montefinese et al., 2014; Schmidtke et al., 2014; Warriner et al., 2013). Age differences in the link between imageability and emotional estimates have been suggested in the French language (Gilet et al., 2012). More precisely, in young adults, a negative correlation was reported between imageability and emotional valence: High-imageability words were rated as more negative. In contrast, the correlation was positive among middle-aged and older adults, in that high-imageability words were rated as more positive. Also, young adults more readily imagine high-arousing words, whereas older adults more easily imagine low-–arousing words. To date, a complete examination of the relationships between valence, arousal, subjective frequency and imageability of words across age is lacking. This is one goal of the present study.

The Present Study

We had three general related goals for the present research. The first and most important aim was to provide and analyze word imageability and subjective frequency ratings collected from four adult age groups for a set of 1,286 French words. These ratings were collected for the whole set of words from the EMA database (Gobin et al., 2017) for which emotional ratings (valence, arousal) are already available for the same age groups (i.e., emerging adults:18-25 years; early adulthood: 26- 39 years; middle-aged adults : 40- 59 years; older adults: 60 years and more). By completing existing information, the present database will be the first norm to provide age-related imageability, subjective frequency and emotional characteristics for a large set of French words. This tool should be of great interest to researchers interested in selecting an age-adapted set of words. The second aim was to investigate the relationships between imageability, subjective frequency and emotional ratings as a function of age in order to get a better understanding of age-related changes in the

relationships between lexical and emotional variables. Finally, the third aim was to investigate the influence of word imageability and subjective frequency estimates from each age group on the visual word recognition latencies and accuracy of young adults, by using response times extracted from Megalex (Ferrand et al., 2018).

Method

Participants

A total of 1,238 adults volunteered to complete the survey. They were all native speakers of French or had learned to speak French at school. The participants were divided into four age groups (see also Gobin et al., 2017), such that the emerging adults were between 18 and 25 years old (N = 278; M = 21.22; SD = 1.81, 82.1 % female), the early adults were between 26 and 39 years old (N = 343; M = 31.6; SD = 3.9, 87.4 % female), the middle-aged adults were between 40 and 59 years old (N = 339; M = 48.9 years; SD = 5.47, 89.1% female), and the older adults aged 60 and over (N = 278; M = 66.43; SD = 5.50, 77.0 % female). The four age groups did not differ in years of schooling (M = 13.30; SD = 2.52), $F(3,1224) = 1.94$, $p = .12$. The vocabulary level, measured using the French version of the Mill Hill vocabulary test (Deltour, 1998), differed across age, $F(3,1224) = 83.61$, $p < .001$, $\eta^2p = .17$. The youngest group had lower scores (M = 33.73; SD = 4.30) than the adults between 26 and 39 years old (M = 34.83; SD = 4.48), $p < .001$, themselves having lower scores than the adults between 40 and 59 years (M = 36.52; SD = 3.91), $p < .001$, and themselves having lower scores than the adults aged 60 and over (M = 38.81; SD = 3.42), $p < .001$.

Materials

We used the 1,286 French words for which valence and arousal ratings by four age groups were available in the lexical database EMA (Gobin et al., 2017). In EMA, emotional

valence was rated on a 7-point scale ranging from -3 (very negative) to +3 (very positive), and the arousal level was rated on a 7-point scale ranging from 1 (calm) to 7 (very excited). The emotional valence of the stimulus words was found to range on average from -2.69 to 2.58 (M = -.11; SD = 1.20) and the arousal level ranged on average from 1.51 to 5.58 (M = 3.08; SD = 1.79). These words had 4 to 7 letters (1 to 3 syllables) and belonged to different grammatical categories (i.e., 50.5% of nouns, 13.2 % of adjectives, 36.1 % of verbs, 0.2 % of adverbs). Word frequency taken from Lexique (New, Pallier, Ferrand, & Matos, 2001; New et al. 2004) ranged from 0.35 to 91221.44 occurrences per million in Web frequency (*M* = 2502.80; *SD* = 7347.54) and from 0.03 to 398.32 in Frantext frequency (*M* = 11.42; *SD* = 34.04).

Procedure

The survey was controlled by the LimeSurvey website (Engard, 2009). The URL of the survey was released to social networks and paper materials. Before the beginning of the questionnaire, participants were informed of the confidentiality of their answers, the possibility of being informed of the main results of the study and of their right to withdraw from the study at any time. The 1,286 words were randomly divided into four lists (from 320 to 322 words in each list). Two versions of the questionnaire with the same words were constructed to collect either imageability or subjective frequency ratings, resulting in a total of 8 different list versions. Accordingly, the 1,238 participants were divided randomly into 8 groups, each group being given one version of the questionnaire, in which they were asked to rate the words in terms of subjective frequency or imageability. In short, each version of the questionnaire contained between 320 and 322 words and was completed by at least 30 participants in each of the four age groups. The order of word presentation in each list was randomized for each participant. For imageability ratings, participants were instructed to rate each word on a 7-point scale (see also Desrochers & Thompson, 2009). The response scale

ranged from (1) “very difficult to produce a mental representation” to (7) “very easily imageable”. Subjective word frequency was also rated using a 7-point scale (1 = “words that they had never encountered “, 2 = “encountered once a year”, 3= “encountered once a month”, 4 = “encountered once a week”, 5 = “encountered once every two days”, 6 = “encountered once a day”, 7 = “words that they had encountered several times a day”). Instructions were identical to those used in previous studies (e.g., Balota et al., 2001; Robert et al., 2012). Finally, the participants completed the French version of the Mill Hill vocabulary test (Deltour, 1998) and answered some sociodemographic questions.

Results

The raw data as well as the lexical database are available in .txt and.csv format via the following link: https://osf.io/vhmub/?view_only=a4f2e3ecf68e4c669fecd28e5464e989

Reliability and Validity of the Ratings

The reliability of subjective frequency and imageability was examined using two methods. First, a Cronbach’s alpha coefficient was computed for each list and for all participants. For both ratings, coefficients were between .98 and .99 in each list. Secondly, Bravais-Pearson correlations (adjusted with the Spearman-Brown correction) were computed for each list and in each age group using a split-half method. For both estimates, the correlations were high in all age groups (between .97 and .99).

To assess consistency between the ratings collected in the present norm and those from previous similar ones, we compared the imageability and subjective frequency estimates of the present study with those of previous similar studies for the French words they have in common. More precisely, correlations were computed between the present ratings and ratings drawn from shared words in six similar studies (Bonin et al., 2008; Desrochers & Bergeron,

2000; Desrochers & Thompson, 2009; Ferrand et al., 2008; Gilet et al., 2012; Robert et al., 2012). It is noteworthy that the number of stimuli shared with these studies is quite small (i.e., 152 words in common in Bonin et al., 2008; 136 words in common in Desrochers & Bergeron, 2000; 246 words in common in Desrochers & Thompson, 2009; 152 words in common in Ferrand et al., 2008; 45 words in common in Gilet et al., 2012; and 181 words in common in Robert et al., 2012), and that the estimates collected by four of the six studies come from a population of young adults, while the ratings here were collected from four different adult age groups. Bravais-Pearson correlation coefficients for the items common to this study and that of previous norms were high and significant, whether for the young adults (ranging from .76 to .92, *ps* <.001) or for the other age groups (ranging from .62 to .97, *ps* <.001). Overall, the coefficients provide evidence of the validity of the present ratings.

Descriptive Data

The mean ratings as well as the standard deviations for subjective frequency and imageability scores are shown in Table 1. Overall, there was a high proportion of low subjective frequent words (75.3% of words with a score lower than 3.5 on the 7-point scale) and highly imageable words (86% of words with a score higher than 3.5 on the 7-point scale).

Table 1

Mean Subjective Frequency and Imageability Estimates for the 1,286 Words Rated by the Four Age Groups (18-25; 26-39; 40-59; 60 and over)

	Subjective Frequency				Imageability			
	18-25	26-39	40-59	+ 60	18-25	26-39	40-59	+ 60
Mean	2.85	2.73	2.95	3.05	4.53	4.77	4.99	5.26
SD	1.00	.97	.98	.91	1.45	1.34	1.18	1.07
Minimum	1.06	1.08	1.05	1.06	1.09	1.43	1.62	1.63
Maximum	6.85	6.82	6.81	6.81	7.00	7.00	7.00	6.98
Skewness	.67	.78	.56	.48	-.10	-.22	-.25	-.43
Kurtosis	.05	.26	-.10	-.13	-1.00	-.92	-.81	-.49

Concerning the rating distributions, subjective frequency scores (see Figure 1) were skewed to the left for the two youngest groups (18-25 and 26-39 years old) and this asymmetry decreased with aging. As shown in Figure 2, imageability scores were distributed quite symmetrically in the youngest group and tended to be skewed to the right in the other age groups.

Figure 1

Distributions of Subjective Frequency Ratings for the Four Age Groups

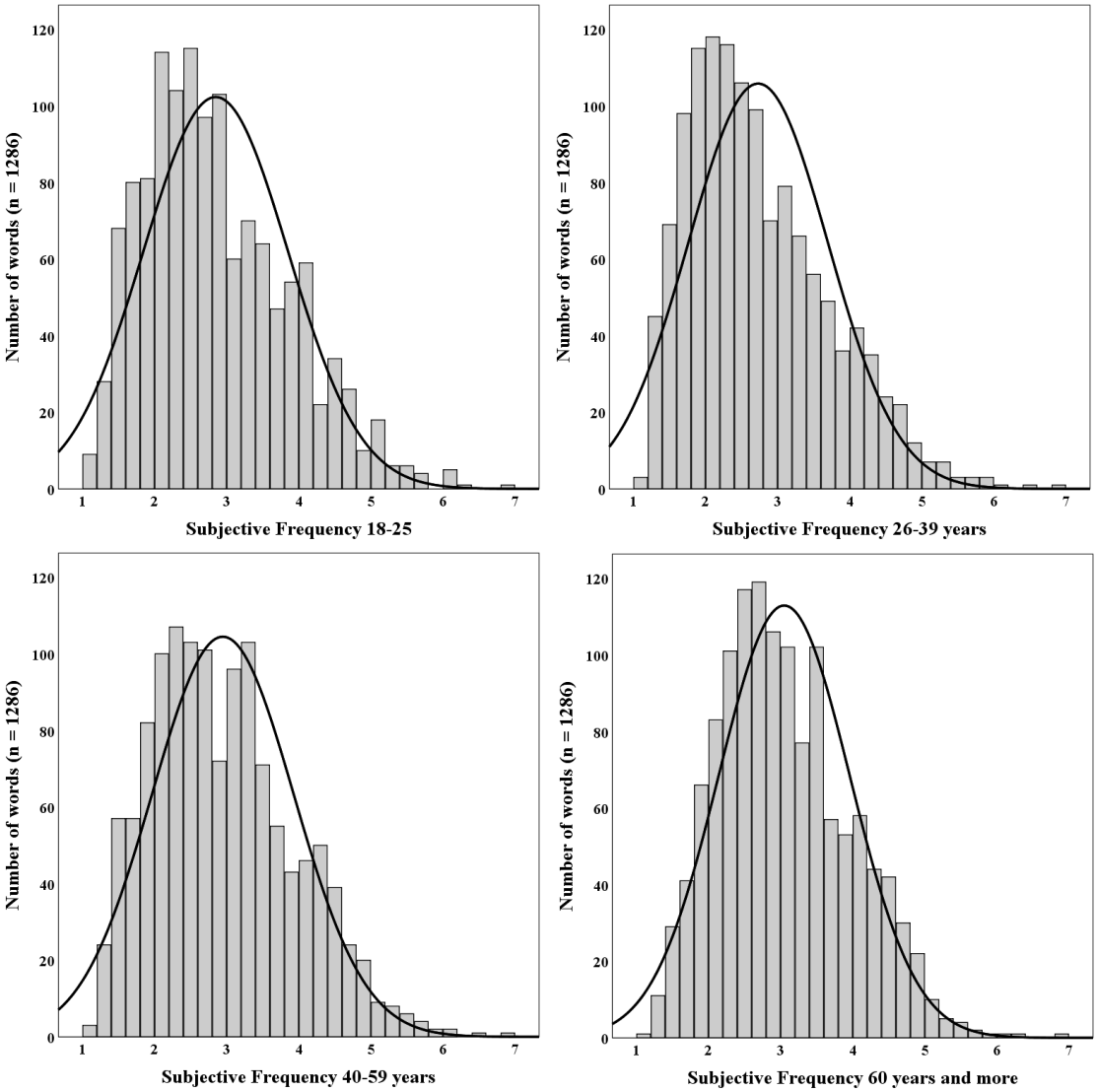
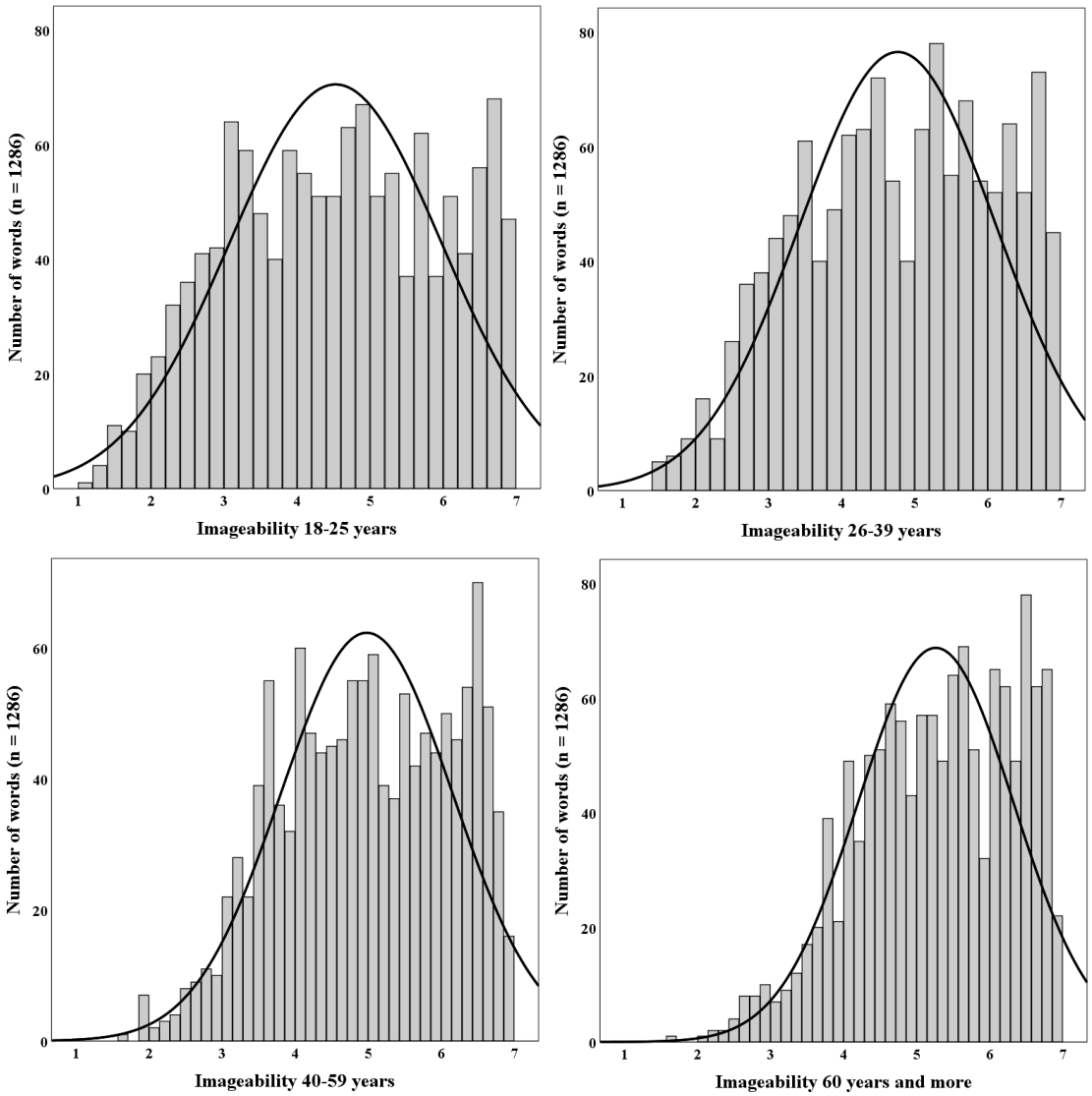


Figure 2

Distributions of Imageability Ratings for the Four Age Groups



Age Differences in Imageability and Subjective Frequency Ratings

An ANOVA with Age as a within factor was conducted on the mean word imageability scores and indicated a significant effect of age, $F(3,1285) = 559.4$, $p < .001$, $\eta^2p = .30$. Bonferroni post-hoc tests specified that the words were rated as less imageable ($M = 4.53$) for the young adults (18-25 years) than for the three other age groups ($ps < .001$). The adults between 26 and 39 years old also rated the words as less imageable ($M = 4.77$) than the

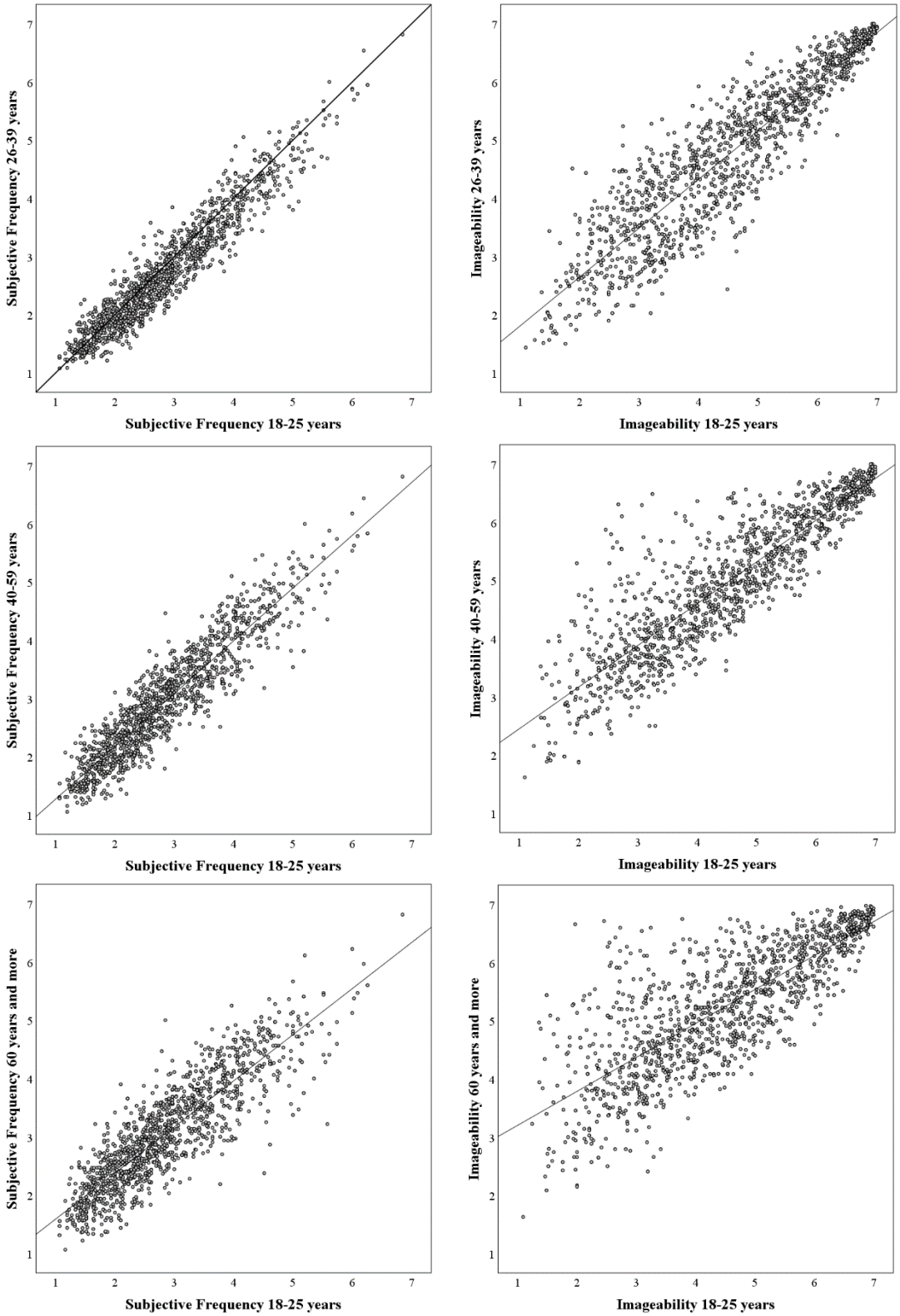
adults from 40 to 59 and those aged 60 and over (*ps* < .001). The oldest adults rated words as more imageable (*M* = 5.26) than those between 40 and 59 years old (*M* = 4.99), *p* < .001. To determine the proportion of words with statistically different ratings across age, separate ANOVAs were run for each of the 1286 words on imageability ratings with Age as a between factor. The results indicated that 38.4 % of the words exhibited a significant age difference in imageability estimates (*ps* < .05). Pairwise comparisons conducted on the words showing a reliable age effect revealed that within these words, 60.8 % were evaluated as more imageable for the oldest group than for the youngest one, *ps* <.05. In sum, the present results indicate that for imageability, older adults rated words higher than the younger adults. Correlations run between imageability ratings of the youngest adults and those of the older age groups (see Figure 3, right panels) indicated that the relation was strongest between the estimates collected in the adults from 18 to 25 years and those in the adults from 26 to 39 years (*r* =.91, *p* <.001), and weakest between the estimates collected in the adults from 18 to 25 years and those in the adults from 60 years and over (*r* =.80, *p* <.001). As can be seen in Figure 3, the distributed range of imageability ratings differed increasingly with advancing age, suggesting that as age differences increased, imageability estimates become less consensual.

Concerning mean subjective frequency scores, a significant effect of age was also found, $F(3,1285) = 314.15$, $p < .001$, $\eta^2p = .20$. Bonferroni post-hoc tests indicated that the oldest group rated words as more subjectively frequent (*M* = 3.05) than the other three, *ps* < .001. Moreover, the adults between 40 and 59 years old evaluated words as more subjectively frequent (*M* = 2.95) than the adults from 18 to 25 and those from 26 to 39 years, *ps* < .001. The youngest age group rated words as more subjectively frequent (*M* = 2.85) than the adults between 26 and 39 years old (*M* = 2.73), *p* < .001. Separate ANOVAs conducted for each word on subjective frequency ratings with Age as a between factor indicated that 27.8% of the words exhibited a significant age difference in subjective frequency estimates (*ps* <.05).

Among them, pairwise comparisons revealed that 60.5% of these words were evaluated as more subjectively frequent for the oldest group than for the youngest one (*ps* <.05). As shown in Figure 3 (left panels), the correlation between subjective frequency estimates of the youngest adults and those of the three other age groups was strongest between the estimates from the adults from 18 to 25 years and those from the adults from 26 to 39 years (r = .96, p <.001), and weakest between the estimates from the adults from 18 to 25 years and those in the adults from 60 years and over (r =.87, p <.001). As for imageability, the distributed range of subjective frequency estimates differed increasingly according to age, suggesting that the higher the age differences, the less agreement there was in the ratings. Note that subjective frequency estimates were found to correlate significantly with the objective frequency indexes available in Lexique (i.e., Frantext and Web; New et al., 2001). These correlations were moderately strong both for Frantext frequency in all four age groups (r = .42 for adults 18 to 25 years old, r = .41 for adults 26 to 39 years old, r = .41 for adults 40 to 59 years old, and r =. 40 for adults over 60, ps <.001) and for Web frequency (r = .43 for adults 18-25, r = .41 for adults 26-39, r = .40 for adults 40-59, and r = .38 for adults over 60, *ps* <.001).

Figure 3

Correlations between Ratings from the Emerging Adults (18-25 years) and Ratings from the Three Other Age Groups for Imageability (Right Panels) and Subjective Frequency (Left



Panels).

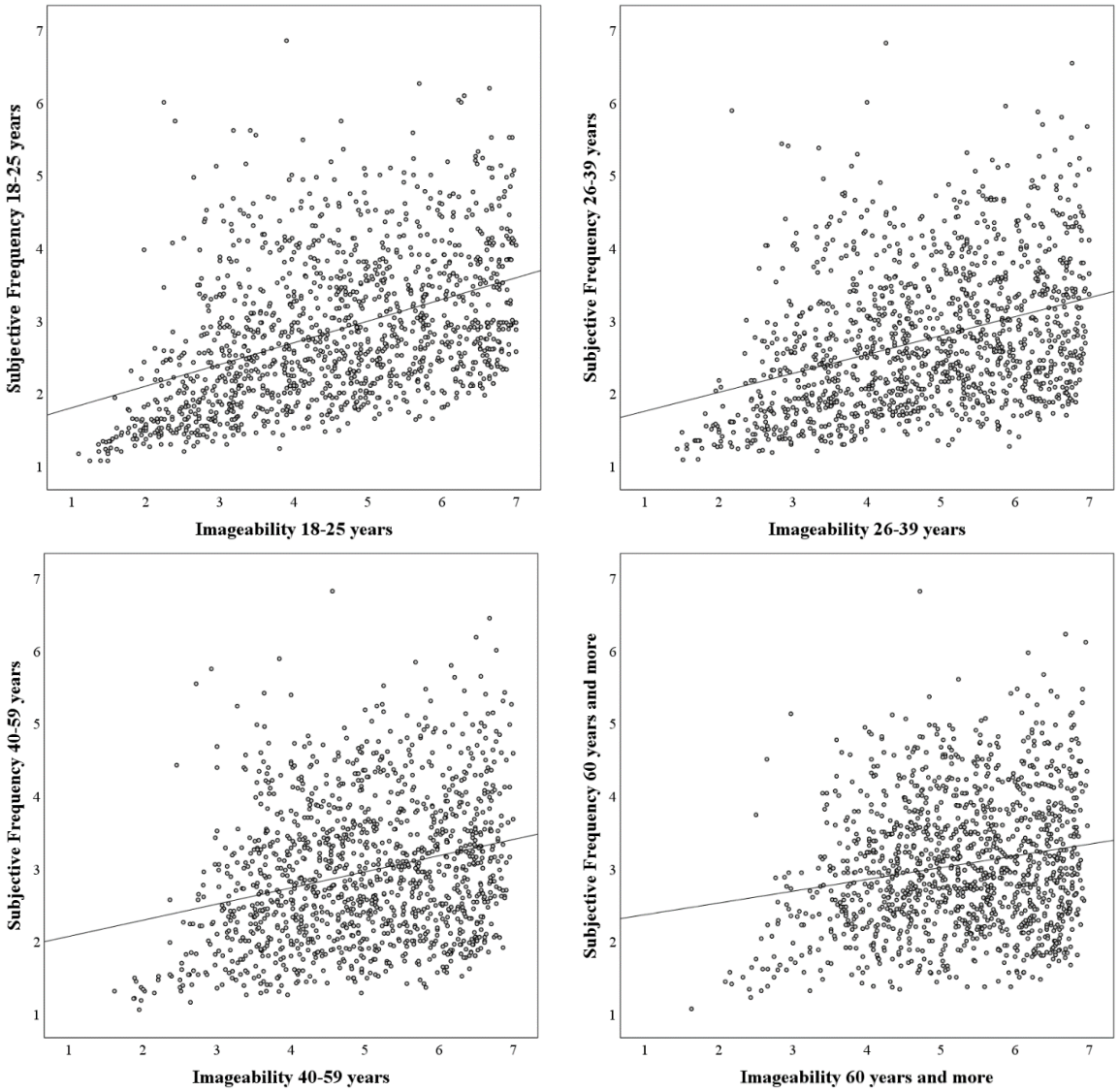
Relationships between Imageability, Subjective Frequency and Emotional Variables across Age

Relationships between Imageability and Subjective Frequency across Age

Figure 4 provides scatterplots between subjective frequency and imageability ratings for the four age groups. A significant positive correlation was found between word imageability and subjective frequency, $r = .33$, $p < .001$. More importantly, the strength of this imageability-subjective frequency relationship decreased with age. In fact, and although significant for each age group, the coefficient of correlation was highest for the adults from 18 to 25 years, ($r = .43$, $p < .001$), average for the adults from 26 to 39 years ($r = .36$, $p < .001$) and for the adults from 40 to 59 ($r = .27$, $p < .001$, respectively) and weakest for the oldest group (60 years and over, $r = .19$, $p < .001$). Fisher's transformations used to compare the strength of this relationship across age groups indicated significant differences, $2.14 < Zs < 6.78$, $ps < .05$.

Figure 4

Scatterplots between Subjective Frequency and Imageability Scores for the Four Age Groups

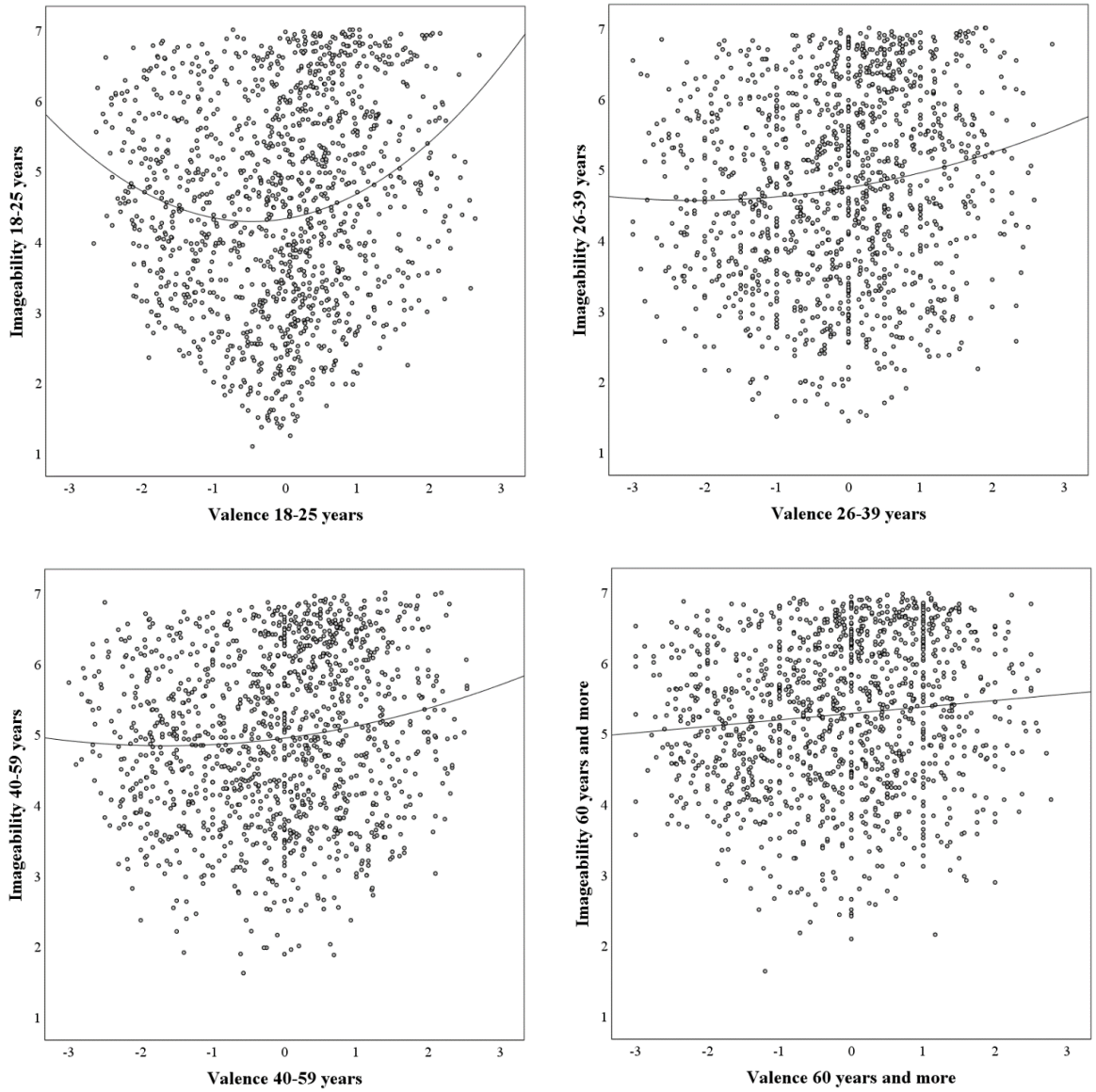


Relationships between Imageability, Subjective Frequency and Emotional Ratings across Age

Imageability, Valence and Arousal. The relationship between valence and imageability ratings was predicted better by a quadratic model (*AIC* = 4103.88, $F(2,1283) = 15.66$, $p < .001$, $R^2 = .024$) than by a linear one (*AIC* = 4114.58, $F(1,1284) = 18.42$, $p < .001$, $R^2 = .014$), both for the mean values and for the youngest age group (18 - 25 years), *ps* <.001. Emotional words were estimated as being more imageable than neutral ones. As represented in Figure 5, this quadratic relation between valence and imageability was stronger for the youngest group, $F(2,1283) = 27.86$, $R^2 = .042$, than for the adults between 26 to 39 years old, $F(2,1283) = 12.51$, $p < .001$, $R^2 = .019$, and for the adults between 40 to 59 years old, $F(2, 1283) = 10.3$, $p < .001$, $R^2 = .016$, and was weakest for the oldest group, $F(2, 1283) = 7.06$, $p < .001$, $R^2 = .011$. Fisher's transformation indicated that the strength of the relation between word imageability and valence was significantly higher for the youngest group ($r = .20$) than for the oldest one ($r = .10$), $Z = 2.59$, $p = .01$. Other comparisons were not significant, $Z < 1.82$, *ps* >.05.

Figure 5

Scatterplots between Imageability and Emotional Valence Ratings for the Four Age Groups



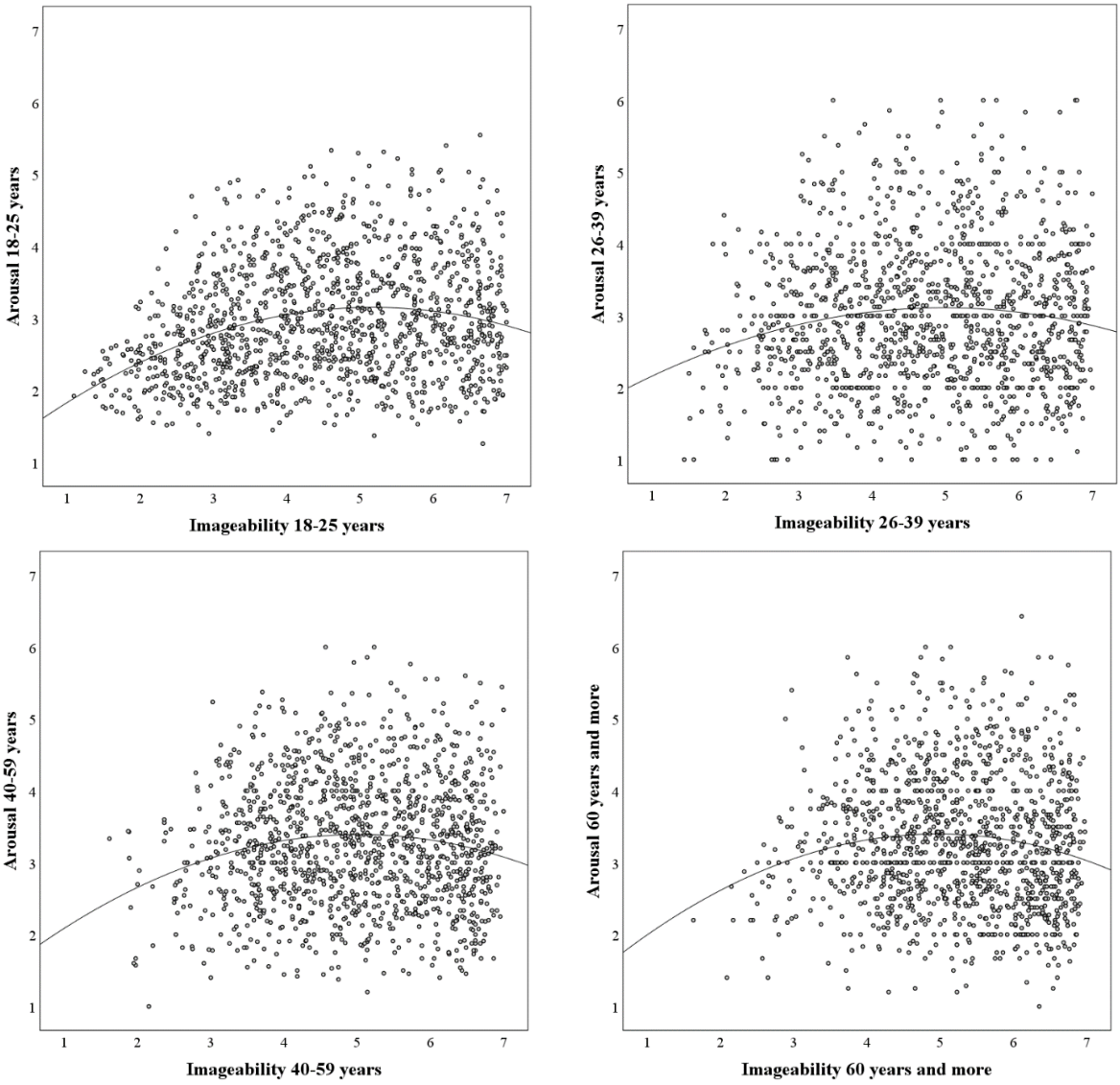
In the same vein, a quadratic relation between arousal and imageability was found to be a better model, *AIC* = 2829.03, $F(2, 1283) = 24.85$, $p < .001$, $R^2 = .037$, than a linear one, *AIC* = 2865.62, $F(1,1284) = 10.31$, $p = .001$, $R^2 = .008$, both for the mean values and for each of the four age groups, *ps* <.001. Words that were highly or hardly imageable were estimated as being less arousing. Again (see Figure 6), this relation between arousal and imageability

was stronger for the youngest adults, $F(2, 1283) = 54.69$, $p < .001$, $R^2 = .079$, than for the adults between 26 and 39 years old, $F(2, 1283) = 10.38$, $p < .001$, $R^2 = .016$, for those between 40 and 59 years old, $F(2, 1283) = 12.76$, $p < .001$, $R^2 = .019$) and for the oldest group, $F(1,1284) = 10.68$, $p < .001$, $R^2 = .016$. Fisher's transformation indicated that this relation was different for the youngest adults ($r = .28$) in comparison to the other groups ($rs = .13$ for the adults aged from 26 to 39 years and for the oldest group; $r = .14$ for the adults aged from 40 to 59 years), ($Zs > 3.72$, $ps < .001$). No other comparisons were significant, $Zs < .26$, $ps > .80$.

Figure 6.

Scatterplots between Imageability and Arousal Ratings for the Four Age Groups

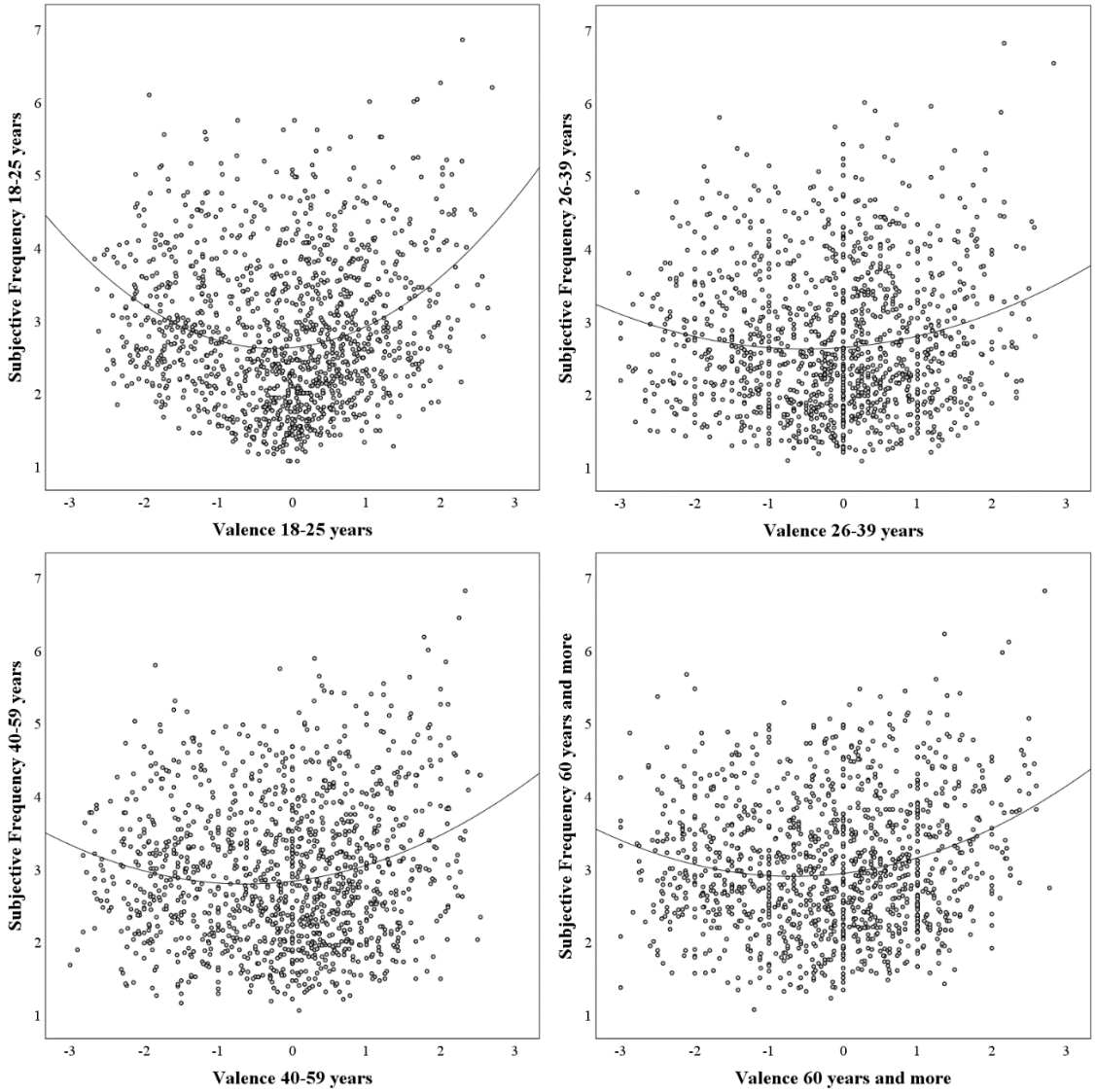
Subjective Frequency, Valence and Arousal. A quadratic model was also a better model to account for the relation between subjective frequency and emotional valence, *AIC* = 3399.52, $F(2,1283) = 48.64$, $p < .001$, $R^2 = .070$, than a linear one, AIC = 3482.84, $F(1,1284) = 8.67$, $p = .003$, $R^2 = .007$, both for the mean values and for each of the four age groups, *ps* <.001. Emotional words were rated as being more subjectively frequent than neutral ones. Again (see Figure 7), this relation was stronger for the youngest adults ($F(2,1283) = 55.77$, $p < .001$, $R^2 = .080$) than for the adults between 26 and 39 years old, ($F(2,1283) = 12.77$, $p < .001$, $R^2 = .020$), and for those between 40 and 59 years old, ($F(2,1283) = 21.95$, $p < .001$, R^2



= .033). This relation was also significant for the adults aged 60 or over, ($F(2,1283) = 26.84$, $p < .001$, $R^2 = .040$). Fisher's transformation indicated that this correlation was stronger for the youngest group ($r = .28$) than for the three other age groups ($r = .14$ for the adults aged from 26 to 39 years; $r = .18$ for the adults aged from 40 to 59 years; $r = .20$ for the oldest group), $Zs > 2.15$, $ps < .05$). No other comparisons were significant $Zs < 1.57$, $ps > .10$.

Figure 7.

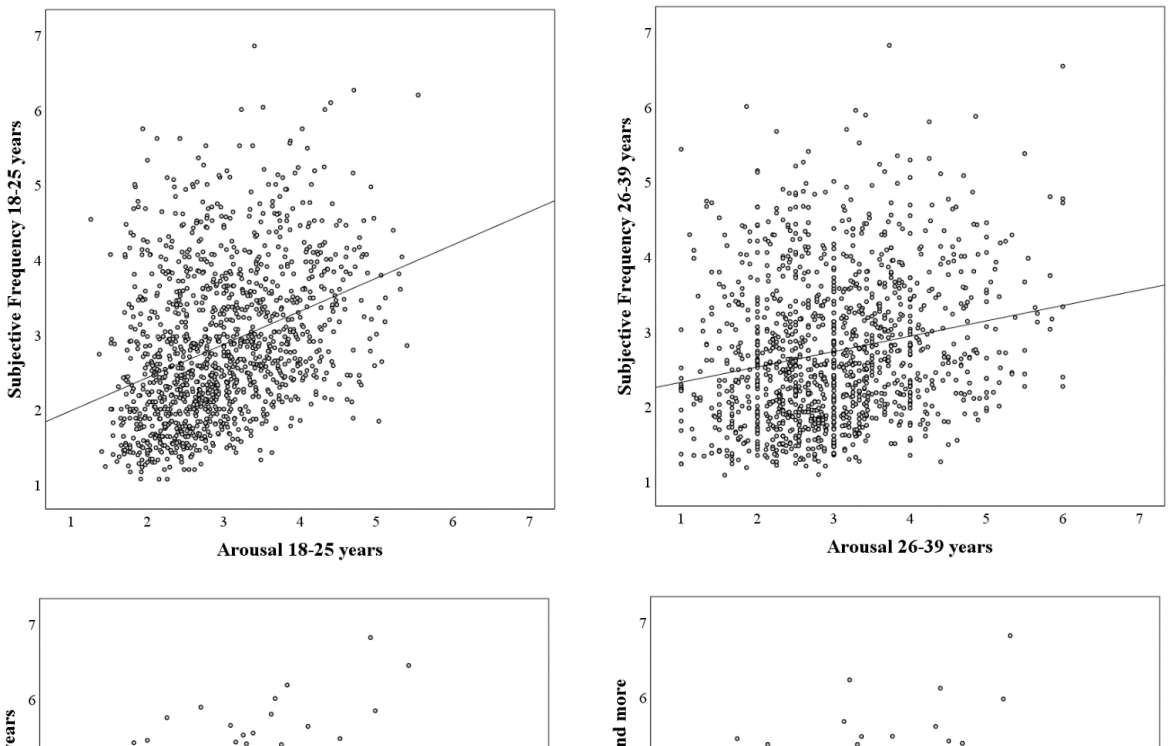
Scatterplots between Subjective Frequency and Emotional Valence Ratings for the Four Age Groups



The association between subjective frequency and arousal ratings was predicted just as well by a quadratic model as by a linear one (*AIC* = 3338.5, $F(2,1283) = 81.25$, $p < .001$, $R^2 = .12$ for the quadratic model, and *AIC* = 3340.1, $F(1,1284) = 162.21$, $p < .001$, $R^2 = .11$, for the linear model). This was the case for the mean values and for the age groups, *ps* >.54, except for the adults aged from 26 to 39 years for whom the linear model predicted the relation better ($F(1, 1284) = 57.34$, $p < .001$, $R^2 = .04$ for the linear model; $F(2, 1283) = 31.09$, $p < .001$, $R^2 = .05$, for the quadratic one), $p = .03$. Overall, more subjective frequent words were rated as being more arousing than less subjective frequent words (see Figure 8). The linear relationship was highest for the adults from 18 to 25 years, $F(1,1284) = 184.3$, $p < .001$, $R^2 = .13$ in comparison with the adults between 26 and 39 years old ($F(1, 1284) = 57.34$ $p < .001$, $R^2 = .043$), with the adults between 40 and 59 years old, $F(1,1284) = 89.16$, $p < .001$, $R^2 = .065$, and with the oldest group, $F(1,1284) = 80.54$, $p < .001$, $R^2 = .059$. Fisher's transformation revealed that the correlation in the youngest group ($r = .36$) was greater than the ones in the other three age groups ($r = .21$; $r = .25$; $r = .24$, respectively, $Z > 3.08$, $p < .001$). No other comparisons were significant (*Zs* < 1.07, *ps* >.28).

Figure 8

Scatterplots between Subjective Frequency and Arousal Ratings for the Four Age Groups



Influence of Imageability and Subjective Frequency Ratings in Visual Word Recognition

One further issue for future studies is to determine whether our age-related imageability and subjective frequency ratings predict performance from different age groups in various cognitive tasks when they are age-adapted. In the present study, some evidence was obtained by running further analyses on the set of words for which the estimates we had collected and the lexical decision performance drawn from Megalex (Ferrand et al., 2018) were both available (n = 882). Specifically, the aim was to assess to what extent the lexical decision times and accuracy provided in Megalex for young adults were explained by the imageability and subjective frequency ratings we collected for each age group. We used a three-step hierarchical approach for the item-level analyses in order to specify the respective contributions of objective lexical factors that are widely known to influence visual word recognition and the subjective estimates collected in the present study. We reported adjusted R^2 to take the number of predictors into account (for a similar procedure, see Balota et al., 2004). Step 1 included classical objective word variables (i.e., number of letters, number of syllables, Frantext and Web indexes of objective frequency, and number of orthographic neighbours; for a similar procedure, see Keuleers et al., 2010) drawn from Lexique (New et al., 2001; New et al. 2004). In Step 2, subjective frequency ratings were included in four separate models (corresponding to the estimates of each age group) to avoid multicollinearity among predictors. Finally, in Step 3, imageability ratings for each group were included in four separate hierarchical models, again to avoid multicollinearity. The dependent variables were the standardized reaction times and accuracy collected from young adults in the lexical decision task. The results of each model are presented in Table 2.

Table 2

Three-Step Hierarchical Regressions for the Four Age-Groups on Standardized Reaction Times (RTZ) and Accuracy from Megalex (Ferrand et al., 2018)

Variable	RTZ			Accuracy		
	β	R^2	ΔR^2	β	R^2	ΔR^2
Step 1: Objective word variables						
Number of letters	-.05			.14***		
Number of syllables	15***			-.07†		
Orthographic neighbourhood	-.11***	.17***	.17***	.11**	.07***	.07***
Frantext frequency	-.17***			.11*		
Web Frequency	-.19***			.13**		
Step 2: Subjective frequency						
18-25 years	-.65***	.50***	.33***	.55***	.31***	.24***
26-39 years	-.62***	.48***	.31***	.52***	.29***	.22***
40-59 years	-.62***	.48***	.30***	.52***	.29***	.22***
60 years and more	-.57***	.45***	.27***	.47***	.25***	.18***
Step 3: Imageability ratings						
18-25 years	-.18***	.53***	.03***	.20***	.34***	.03***
26-39 years	-.13***	.49***	.01***	.13***	.30***	.01***
40-59 years	-.12***	.49***	.01***	.12***	.30***	.01***
60 years and more	-.08*	.45***	.01**	.07**	.26***	.01*

Note. †$p \leq .10$. *$p < .05$. **$p < .01$. ***$p < .001$.

Objective word characteristics were found to produce a significant contribution in predicting the reaction times of young adults, and explaining 18% of the variance. Each

predictor was a significant contributor to the model (*ps* <.001), except for the number of letters, which did not predict the reaction times of young adults (*p* =.15). When subjective frequency was added in Step 2, the model explained 50% of the variance when the ratings were from the adults aged 18 to 25, 48% when the estimates came from the adults aged 26 to 39, 48% when the ratings came from the adults aged 40 to 59, and 45% when the ratings came from the adults over 60. Fisher's transformation revealed that the reaction times of young adults were predicted better by the subjective frequency estimates of the youngest adults (*r* = .65) than by the estimates of the oldest adults (*r* = .57), *Z* = 2.51, *p* = .01. Finally, when imageability ratings were added in step 3, the variance explained by the final model varied from 53% for the youngest group to 45% for the oldest one. The reaction times were significantly better predicted by the subjective frequency estimates of the youngest adults (*r* = .18) than by those of the older adults (*r* = .08), *Z* = 2.03, *p* = .04, as shown by Fisher's transformation.

Turning to the analyses of the accuracy of the lexical decision responses from young adults, the objective word characteristics included in Step 1 explained 7% of the variance. The number of letters, number of orthographic neighbours and indexes of objective frequency significantly predicted accuracy (*ps* <.01). In Step 2, the addition of subjective frequency increased the variance explained by the model for the four age groups (from 31% to 25%). Accuracy in the lexical decision task was also predicted better by the subjective frequency estimates of the youngest adults (*r* = .55) than by the estimates of the oldest adults (*r* = .47), *Z* = 2.39, *p* = .02. In Step 3, when imageability ratings were added, the variance explained by the completed model was 34% for the youngest adults, 30% for the adults aged 26 to 39, 30% for the adults aged 40 to 59 and 26% for the adults over 60. There was an 8% increase in explained variance between the estimates of the youngest adults and those of the oldest adults. Fisher's transformation revealed that the imageability estimates of adults from 18 to 25 years

predicted reaction times from Megalex (r = .20) better than the imageability ratings of the oldest group (r = .07), Z = 2.59, p = .01.

Discussion

The main findings of the present study can be summarized as follows. First, word imageability and subjective frequency ratings were found to vary across age. Older adults rated words as more imageable and more frequent than younger adults. Even though imageability and subjective frequency were significantly linked across the different age groups, the strength of this relation decreased with age. Second, word imageability and subjective frequency estimates were found to be linked with emotional ratings. Indeed, emotional words were rated as more imageable and more frequent. Moreover, high-arousing words tended to be more subjectively frequent and low-arousing words were rated as being either easily or hardly imageable. Third, word imageability and subjective frequency ratings were found to provide an additional contribution to the lexical decision performance of young adults from Megalex as compared to objective lexical variables. Importantly, the best predictors for both the reaction times and the accuracy measures in the lexical decision task were the estimates collected from the youngest adults as compared to those from the older age groups. These findings are discussed below in separate sections.

Subjective Frequency and Imageability Ratings with Age

The present study provided evidence of a variation in subjective frequency and imageability estimates across age. In particular, both ratings were found to increase generally throughout the different age groups. This age-related change is consistent with data from previous studies conducted on imageability estimates (Gilet et al., 2012; Grühn & Smith, 2008) and others on subjective frequency (Balota et al., 2004; Dorot & Mathey, 2010; Robert et al., 2012). Some authors have argued that the increase in imageability estimates across age

is a consequence of a more developed vocabulary in the elderly and/or results from difficulties in understanding the instructions for ratings (e.g., Gilet et al., 2012). Other authors have also suggested that the age-related change in subjective frequency estimates is due to a greater language experience (e.g., Robert et al., 2012). Therefore, it is likely that greater language experience with advancing age increases knowledge about words, thus facilitating the ability to create a clear and accurate mental picture of words. Future experimental studies should be designed to investigate this issue more precisely. In the present norm, we also conducted separate analyses for each of the 1286 items as a function of age, in order to identify words whose imageability and/or subjective frequency estimates are age-sensitive, and to specify the age groups involved**.**

The pattern of relationships found here between subjective frequency and word imageability ratings was consistent with previous data collected from young adults, suggesting that more subjective frequent words are easier to associate with a mental picture than less subjective frequent words (Desrochers & Thompson, 2009; Soares et al., 2017; Stadthagen-Gonzales & David, 2006). More importantly, a decrease in the strength of the relationship between subjective frequency and imageability was observed with age. This could be due to the overall increase in both estimates with age, such that variability in the estimates is increasingly reduced with advancing age and the relationships between the estimates are weakened.

Relationship between Subjective Frequency, Imageability and Emotional Ratings with Age

Another important issue in the present study was to investigate whether and to what extent the estimates collected for the four age groups were related to the emotional estimates available in the EMA database (Gobin et al., 2017) for the same age groups. As detailed below, several relationships between subjective frequency, imageability estimates, emotional

valence and arousal were observed for the four age groups. Most importantly, the strength of these relationships was found to be age-sensitive.

First, the U-shaped distributions we found between imageability and emotional valence for the four age groups were consistent with previous findings collected in English for young adults, indicating that highly valenced words tend to be more imageable than neutral words (Altarriba & Brauer, 2004; Citron et al., 2014). Additionally, the quadratic relationships between arousal and imageability observed for the four age groups were in line with prior data in young adults (Warriner et al., 2013; Montefinese et al., 2014; Schmidtke et al., 2014), and could be attributed here to several neutral words such as "curseur" [*cursor*], "casier" [*locker*], "fémur" [*femur*], or "orteil" [*toe*] which are low-arousing but highly imageable. More importantly, we observed that the strength of the associations between emotional estimates and imageability decreased with age. As already noted, this may be due to the overall increase in imageability ratings for older adults as compared with younger ones, such that the relationships between imageability and other lexical and/or emotional variables should systematically be weakened during aging. It can also be argued that word imageability plays a role in the age-related change in the processing of emotional words, as suggested by several studies conducted in the field of emotion and aging (Charles, Mather, & Carstensen, 2003; Isaacowitz, Wadlinger, Goren, & Wilson, 2006a, 2006b; Kennedy, Mather, & Carstensen, 2004; Kyröläinen et al., in press; Mather & Carstensen, 2003, 2005; Mikels, Larkin, Reuter-Lorenz, & Carstensen, 2005). In particular, the emotional regulation that is assumed to occur with age (Cartensen et al., 1999) could modify the mental images created for emotional words by older adults as compared with younger adults. Future studies should be designed to specifically address this issue.

Second, reliable relationships between emotional ratings and subjective frequency were obtained for the four age groups. The quadratic relationship found between subjective frequency and emotional valence for the four age groups is in line with findings in Chinese (Yao et al., 2017), suggesting that irrespective of the polarity of the valence, emotional words are rated by young adults as being more familiar than neutral ones. These results are also consistent with previous data indicating an interaction between valence, arousal and lexical frequency (Kuperman et al., 2014). Once again, it was found here that this quadratic relationship was sensitive to age, in that more subjective frequent words become less emotional during aging. Interestingly, subjective frequency and arousal were linearly linked for all age groups: more subjective frequent words were also higher in arousal (see also Citron et al., 2014; Montefine et al., 2014 for similar results in young adults). The age-related change we systematically found in the relationships between subjective word frequency, emotional valence and arousal ratings is consistent with a decrease in the frequency of emotional experiences with age (see Carstensen, Pasupathi, Mayr, & Nesselroad, 2000). To our knowledge, this is the first evidence of such a change across the lifespan in the relationships between subjective frequency and emotional estimates and this observation should contribute to the development of further studies in this field.

In summary, subjective frequency and imageability ratings were found to be related to emotional estimates throughout the lifespan, showing the need to simultaneously take into account these subjective indicators when selecting word materials. Furthermore, the age-related decrease in the strength of the relationships between valence, arousal, imageability, and subjective frequency could be explained by the higher scores on these variables for the older age groups. Taken together, these data suggest that the increased language experience across age enriches the lexical representation of words, making words higher in frequency and

imageability, and reducing the strength of the relationships between these variables with advancing age.

Influence of Imageability and Subjective Frequency Ratings in Visual Word Recognition

Using a three-step hierarchical regression approach, we investigated the role of imageability and subjective frequency ratings across age in the lexical decision responses of young adults drawn from Megalex (Ferrand et al., 2018). As a whole, it was found that adding subjective frequency and imageability estimates (whatever the age groups from which the ratings were drawn) to objective word characteristics increased the explained variance of lexical decision performance. The predictive power of the subjective ratings provided in the present norm was even higher than that of the objective word characteristics tested here. This finding highlights the importance of taking into account subjective estimates of words when looking at visual word recognition performance. Future studies should be designed to specify whether this conclusion can be extended to other cognitive tasks in which words are used, such as memory or attention.

More importantly, the increase in explained variance due to the addition of the subjective estimates was greater when the ratings were drawn from the youngest adults than from the three older groups. In particular, the reaction times and accuracy of the young adults in the lexical-decision task were predicted better by the subjective frequency and imageability estimates collected from adults aged 18 to 25 years than from people over 60 years, which is in line with prior research on subjective frequency (Balota et al., 2001; Dorot & Mathey, 2010) and further extends it to word imageability. Overall, these findings confirm the importance of taking into account age-adapted estimates when studying differences in word processing during aging (Balota et al., 2001; Balota et al., 2004; Dorot & Mathey, 2010; Robert et al., 2012). The consideration of age-adapted estimates could further help to clarify

inconsistencies in the literature regarding a change in the objective word frequency effect with age (Cohen-Shikora & Balota, 2016). It may also be useful to shed light on the age-related change in the effect of word imageability found in previous memory studies that focused on imageability estimates from young adults only (e.g. Bruning et al., 1975). Although our results provide further evidence of the importance of considering age-appropriate estimates, they need to be confirmed and extended in future studies by taking into account lexical decision performance in older adults. That is, as we found that the lexical decision performances of young adults are better predicted by estimates from young adults, new data should be collected to confirm that the age-adapted estimates from older adults we provide for the 1286 words from the EMA database are also better predictors of their visual recognition performance than estimates from younger adults.

Conclusion

In this study, we have provided imageability and subjective frequency ratings for 1,286 French words collected from four adult age groups ranging from 18 to 60 and over. These norms add new age-adapted lexical estimates to emotional ratings (i.e., valence and arousal) already available for this set of words (see Gobin et al., 2017). The question could be raised as to whether it is important to use word estimates that are adapted to the age of adult participants. Based on the results of the present study, we believe that this is the case. In fact, words were rated as being more imageable and more (subjectively) frequent by the older adults than by the younger ones. More importantly, the strength of the relation between word imageability and subjective frequency ratings was found to decrease with age, as were the relationships between imageability, subjective frequency and the emotionality of words. Moreover, subjective frequency and imageability estimates collected from young adults were found to be better predictors of reaction times and accuracy in the lexical decision task for young adults (Megalex, Ferrand et al., 2018) than the estimates collected from older age

groups. In sum, the results highlight the need to take age-adapted ratings into account in future studies on word processing, in any kind of cognitive activity, across age. The present norm should be very useful to researchers interested in selecting their word materials by making sure to control or manipulate subjective frequency and imageability estimates for a set of neutral and/or emotional words in experiments that involve different adult age groups. Finally, this study also provides insights into the evolution across the adult lifespan in the relationships between factors involved in word processing.

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