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From positive to negative "craziness": Changes in emotional valence of words across adulthood

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Abstract

Accumulating knowledge and experience across the lifespan are bound to have an impact on the meaning of words. Here, we investigated this idea using primarily emotional valence of words as a test-case. We used French databases that gather psycholinguistic variables including emotional valence of words, in four groups of individuals including young (18-25; 26-39 years), middle-aged (40-59 years) and older (>60 years) adults. Following the hypothesis that words may display age-related differences in their psycholinguistic properties, we computed linear regressions over all individual words as a function of age-groups. Results revealed notably that between 5 and 10% of words show significant linear changes of emotional valence as a function of age. This pattern highlights the situated and flexible nature of word meanings and suggests that self-relevance of experience affects semantic memory.

Keywords: word properties; semantic representations; emotion; lifespan changes; situated cognition

Introduction

We use words to share ideas, experiences and emotions with one another. These words are stored in our memory in a "mental lexicon" that gathers considerable information about their form (e.g. the number of syllables, letters etc.) and their meaning (Ferrand & Ayora 2007). Moreover, words are encountered in multiple, and ever changing, situational and linguistic experiences throughout life (i.e. across learning, reading, and social interaction), thus somehow their meaning must reflect this accumulated experience. Yet, despite the probable effect of lifelong experience, we often take a static perspective on semantic memory (Yee et al., 2017). For instance, many lexical databases have proposed to collect word properties in large samples of individuals as proxies to word core representations (e.g., Bonin et al., 2003; Bonin et al., 2018; Desrochers & Thompson, 2009). While these databases provide estimates of important properties like word frequency, imageability, sensory associations, emotional valence and so on, they are often confined to young adults, who may not be representative of all human beings. Most words are somehow ambiguous. A single word form can refer to more than one concept (Rodd, 2020), for example *puzzle* can refer to an *enigma* or a *toy*. Words can also mean one thing at a given point in time, and something different at a later point (Hasan, 2009). Crucially, words may mean different things to different individuals depending on their social group or their age: a *puzzle* being more of a *toy* for children, and more of an *enigma* for older adults. Although

these sorts of ambiguity seem easily addressed by speakers in conversations, it remains a puzzle for language and cognitive scientists, and it is overlooked in those databases. It is probably even more challenging for words that feature emotional content, which should be shaped by lifespan experience. For example, words like "free" or "crazy" have respectively strong positive and negative emotions attached to them, but perhaps to a different extent in early and late adulthood (see Gobin et al., 2017). In this study, we focus on this issue and investigate lifespan variations of various psycholinguistic variables including emotion associated with words.

Constructionist models of emotion particularly emphasize the roles of valence (positivity/negativity of emotions) and arousal, which are thought to reflect neurophysiological responses to emotion processing (Lundqvist et al. 2014). With regards to lifespan development, changes in emotional content associated with words are expected because the evaluation of emotional information itself is modified throughout life, especially in aging. Older adults likely express less, or experience less, negative emotions than positive emotions (Mather & Carstensen, 2003). According to the theory of Socio-Emotional Selectivity (Carstensen, et al., 1999), differential preferences for positive and negative stimuli are due to motivational changes with age. This theoretical conceptualization is based on the distinction between two goals, those related to knowledge and those related to emotion regulation. More specifically, when time is perceived to be limited, emotional goals would be adopted first. Thus, people who perceive time as limited (i.e., elderly people or people with a pathology), would regulate their emotions better, and would thus favor the processing of positive rather than negative emotions. Coherently, many studies reported a bias towards using more positive words throughout the lifespan, and older adults generally judge words as more positive than young adults (Dodds et al. 2015; Kyröläinen et al. 2021; Kyröläinen et al. 2022). More generally speaking, Barsalou (2020) suggests that every time an entity or an event is experienced, its self-relevance is assessed by establishing how they bear on individuals' goals, values or identity. Self-relevance is then assumed to induce affective and motivational states, looping over experiences under the form of a situated action cycle (Barsalou, 2020). This would likely lead to differences in the affective content of words referring to entities and events, especially across individuals who are at different stages of their life.

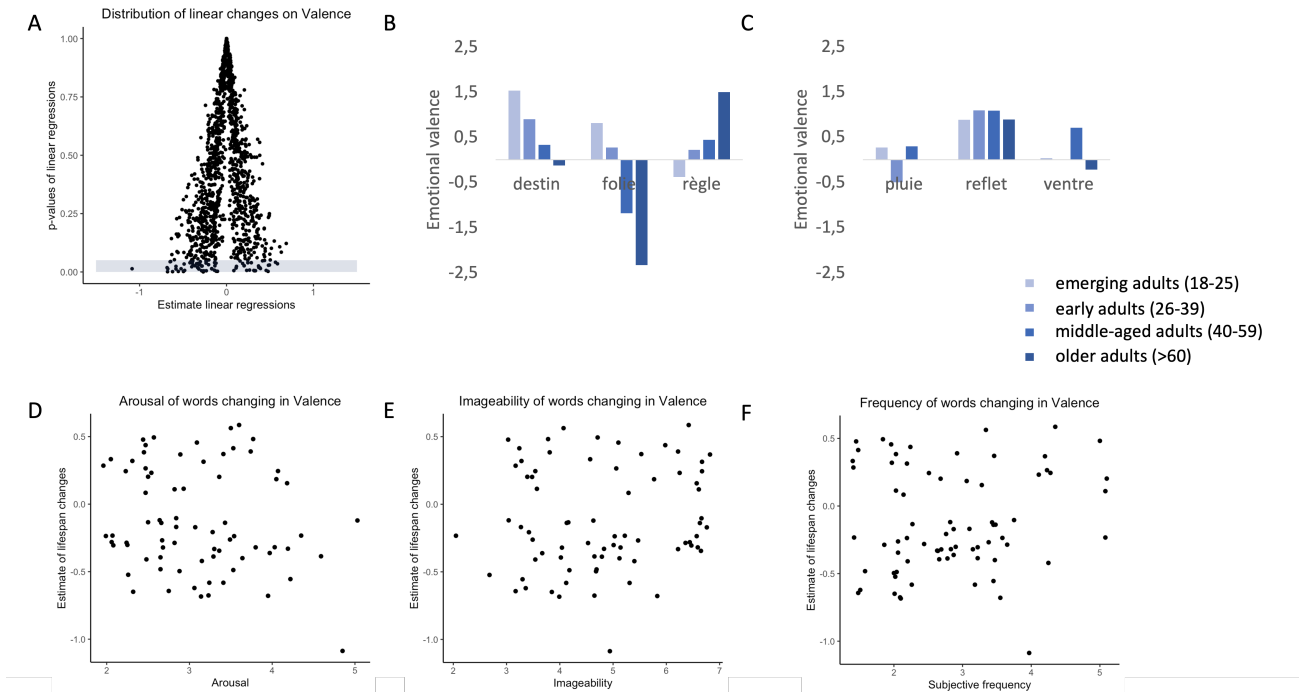


Figure 1: Summary of linear changes on Valence of words and relationships with psycholinguistic variables. A) the distribution of linear changes on Valence, B-C) examples of changes or absence of changes for six words (*destin/destiny*, *folie/craziness*, *règle/rule*, *pluie/rain*, *reflet/reflection*, *ventre/belly*), D-F) relationships between arousal, imageability and frequency with the linear changes on valence.

Most of the research in this framework uses emotional valence of words as index of the affective state of adults provoked by the word (Kuperman et al., 2014). Often, ratings of individuals from different age-groups are compared, using a given year cut (e.g. 65 years), to constitute two groups of young vs. old individuals (see Kyröläinen et al. 2022). The advantage of this approach is to gather emotional ratings for a large sample of words over a large sample of individuals, for two populations. The downsides of this approach are that adulthood is cut in two phases, and that not all words are rated by the same number of individuals. In the present work, we adopt another approach: instead of looking at age-group differences in emotional rating of words, we investigate whether some words carry age-related changes in emotion processing across adulthood, thus seeking trajectories of affective experience associated with words. We apply this strategy for a set of different psycholinguistic variables to test if the same trajectories apply to all of them.

Recently published lexical databases provided estimates of word characteristics in more widespread groups of individuals, notably in terms of age allowing us to explore this issue. For instance, the lexical databases of Ballot et al. (2022) and Gobin et al. (2017) combines evaluations of imageability, familiarity, emotional valence and arousal of a corpus of French words in individuals of four different age groups (18-25 years; 26-39 years; 40-59 years; 60 years and more). Using these databases, we computed developmental trajectories of words' properties and semantic cluster

analyses to express how words carry changes in affective experience across adulthood.

Method

Participants

The data used in the present study were taken from Ballot et al. (2022) and Gobin et al. (2017) on the same set of words. The merged database includes normative data for 1286 words on word subjective frequency and imageability (from Ballot et al. 2022) and emotional valence and arousal (Gobin et al., 2017). Data were collected on 1238 French speaking participants divided into four age-groups: emerging adults (from 18 to 25 years old), early adults (from 26 to 39 years old), middle-aged adults (from 40 to 59 years old) and older adults (above 60 years old).

Analyses

The analyses included two steps. The first step was to compute linear regressions over the four age-groups, for each of the 1286 words and each of the 4 psycholinguistic variables (emotional valence, arousal, subjective frequency, imageability). For each variable, the means per age-group and per item were used for the regressions. The outcomes of the linear regressions included, for each word, the slope/estimate of the regression, the associated standard error, the t-value and p-value. Significant linear changes were set at $p = 0.05$. The second step was a follow-up analysis on words that show significant linear changes on emotional

valence. We looked for semantic similarities between those words that show significant linear changes. For that we relied on recent approaches in natural language processing that use word-embeddings as proxy to word-meaning (Bruffaers et al., 2019). Typically, semantic information is mapped into vectors of real numbers. Words that co-occur in texts or discourse, which are assumed to be close in meaning, are expressed by similar vectors. We used a French HAL semantic space of 300 dimensions (1.6 billion words' corpus)

and computed cosine similarities using the Corpus *frwak100k* (Günther et al. 2015) to compute similarity of vectors and display semantic similarity. Seventy-four words showed significant changes in emotional valence but due to limited availability we were able to compute cosine similarities for only 70 of those words and some had to be modified in terms of morpho-syntactic components not affecting word meaning (e.g. inflections). Dendrograms were created to account for semantic similarities.

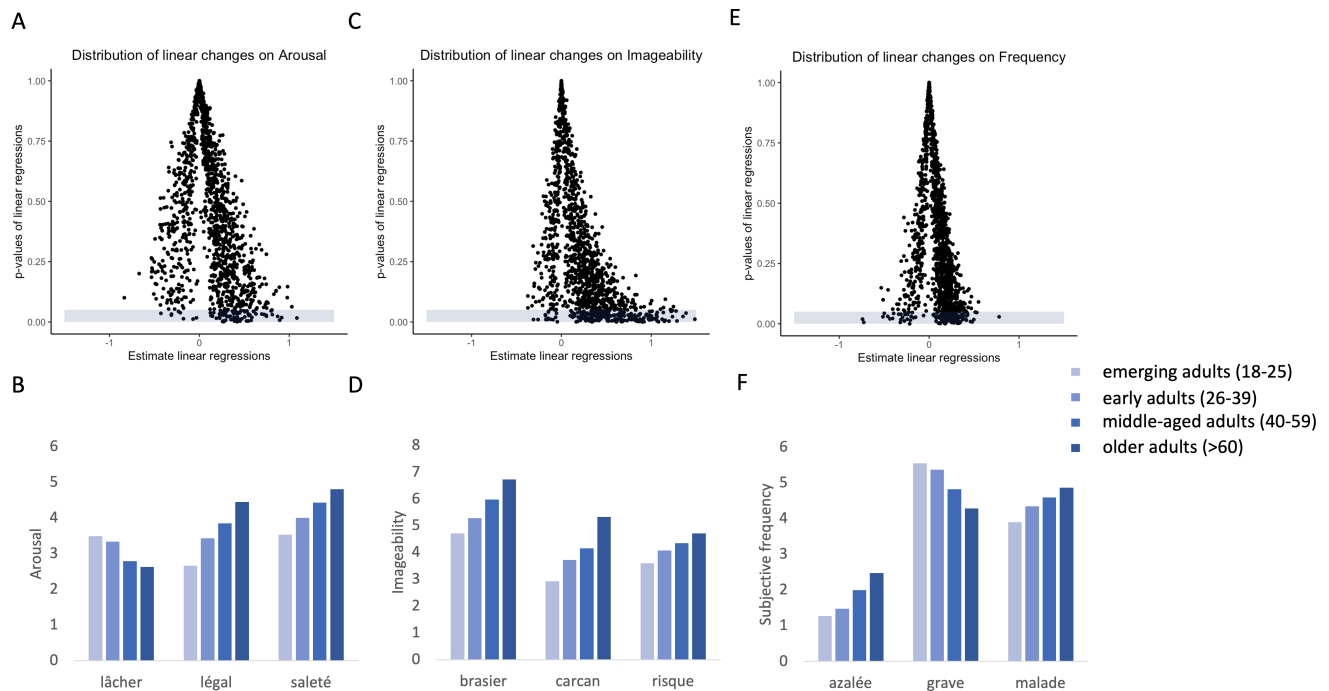


Figure 2: Summary of linear changes across the lifespan across different psycholinguistic variables: A) Arousal, C) Imageability and E) Frequency and corresponding examples of words for B) Arousal (*lâcher/let go*, *légal/legal*, *saleté/dirt*), D) Imageability (*brasier/brazier*, *carcan/shackle*, *risque/risk*) and F) Frequency (*azalée/azalea*, *grave/severe*, *malade/sick*).

Results

We computed linear regressions over the four age-groups for each word and each psycholinguistic variable to determine whether some words display significant changes and if so, how many.

For emotional valence, we found that 74 words out of 1286 display significant linear changes (corresponding to 5% of the total sample size) with slopes ranging from -1.087 to 0.586 (see Figure 1.A) with a total of 47 words displaying negative changes (from higher to lower emotional valence) and 27 words displaying positive changes (from lower to higher emotional valence). Figure 1.B shows examples of words that display significant linear changes across the four age-groups, from more positive to neutral (e.g. “destiny”) and more negative (e.g. “craziness”) or from negative/neutral to more positive (e.g. “rule”). Examples of words that do not

show changes are provided (e.g. “rain”, “reflection”; see Figure 1.C). Extending these results to marginal trends, 142 words (i.e. about 10% of the sample) show linear changes. Words that do show significant linear changes across the four age-groups seem to be very diverse as they range from low to high arousal (Figure 1.D), low to high imageability (Figure 1.E) and seem to show rather low to medium subjective frequency (Figure 1.F).

The same analysis was conducted for arousal, subjective frequency and imageability. We found that 80 words out of 1286 show significant changes on arousal (see Figure 2.A), mainly increase of arousal across the 4 age-groups (N=72; see examples on Figure 2.B). Two hundred sixteen words show significant changes on imageability (of which 201 show increase of imageability) (see Figure 2.C and 2.D). For subjective frequency, 125 words display significant changes, with mainly increase of frequency across age-groups (see Figure 2.E and 2.F). Note that slopes of linear regressions for subjective frequency are lower than for the other variables

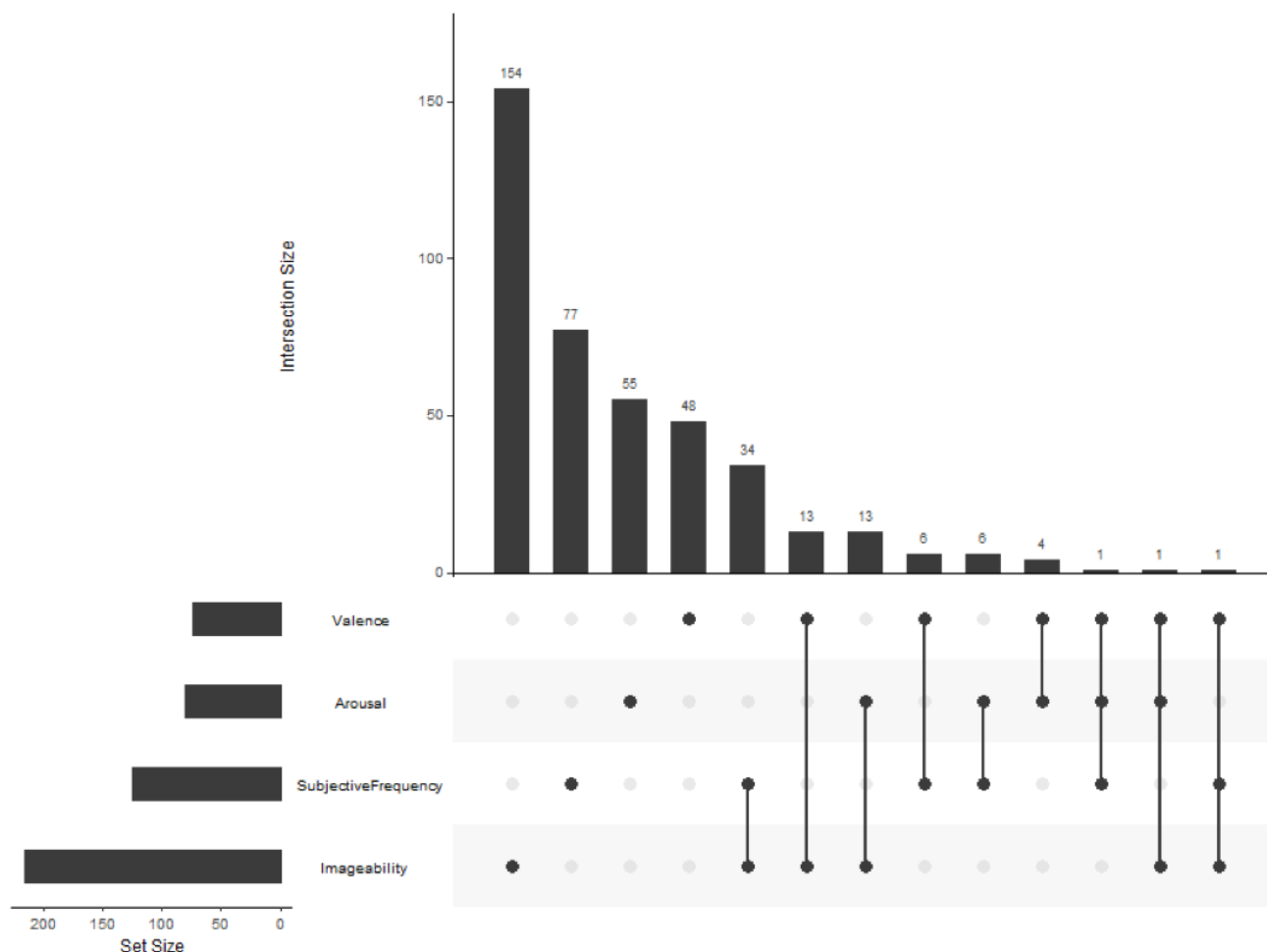


Figure 3: Summary of variation overlap in lifespan changes across different psycholinguistic variables.

To determine whether the same words show changes on all variables or whether the changes are restricted to one or some variables we computed the overlap of variation (see Figure 3). As can be seen on Figure 3, words mainly display significant changes on a given psycholinguistic variable, as only 79 words out of 413 (which show changes at least on one variable) vary on several variables. 34 vary on both imageability and subjective frequency, 13 vary on both arousal and imageability, another set of 13 words vary on both emotional valence and imageability and no word varies on all variables tested.

Changes on emotional valence seem to either be an increase or decrease of valence across the four age-groups. To follow-up on this result, we sought to link these data with other approaches to semantics. We used word-embeddings as proxy to word-meaning, where words that co-occur in texts

are mapped by similar vectors such that it is possible to plot the semantic similarity by way of a dendrogram. Figure D displays the dendrogram that has been first computed based on semantic similarities between words showing significant changes on emotional valence and then color-graded as a function of the estimate of linear changes on that variable. Words that are similar in meaning are close in the dendrogram as they pertain to the same branches. The figure shows that those branches group words that mostly show similar linear changes, that is, changes that go in the same direction (increase or decrease in red or blue respectively). For instance, on the right extreme of the dendrogram, the words “brutal”, “fatal”, “craziness” and “destiny” are clustered together as they pertain to the idea of definitive events, and all show similar trend to more negative valence across the lifespan.

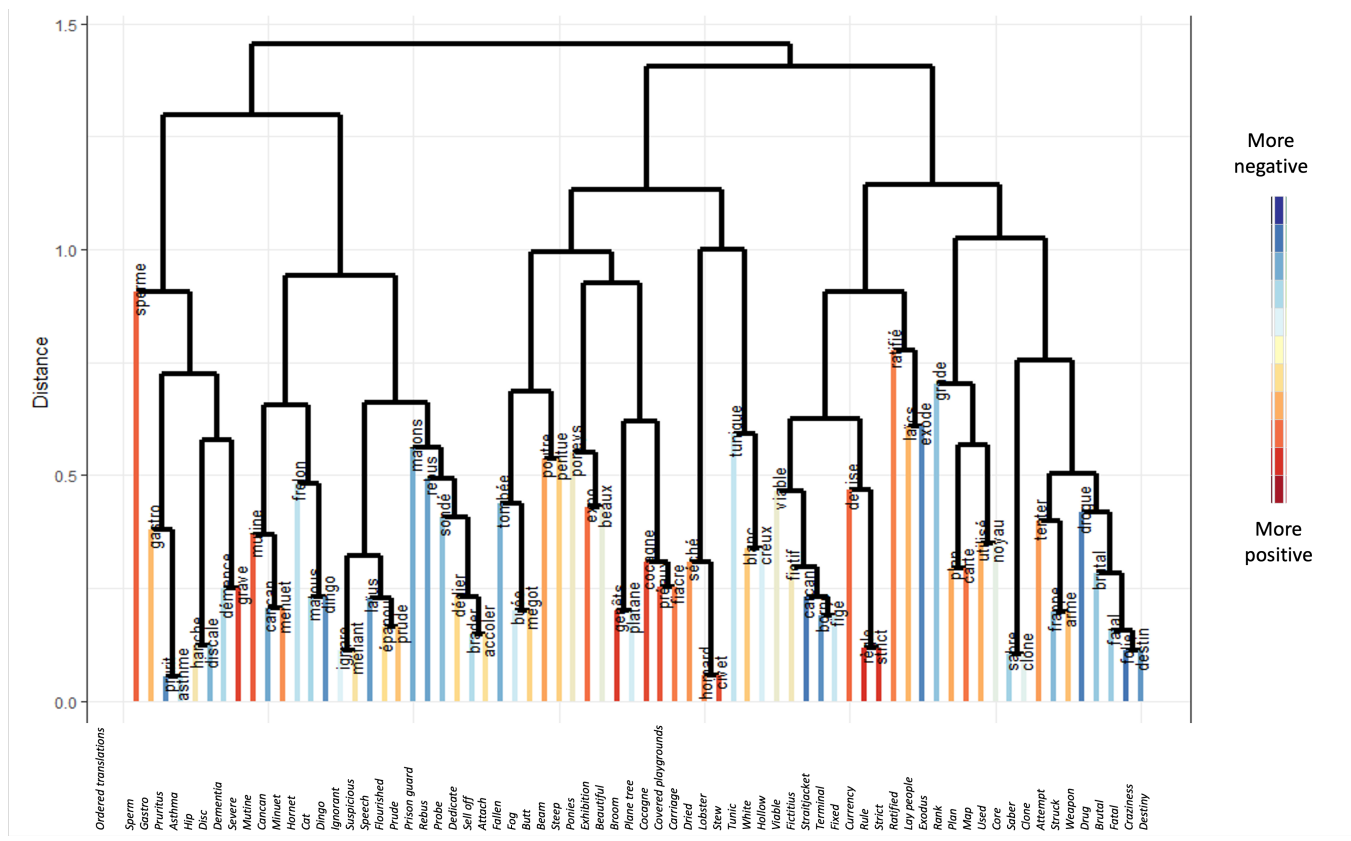


Figure 4. Semantic clustering dendrogram computed with cosine similarities using the Corpus frawk100k (Günther et al. 2015) and color-graded as a function of linear changes (slopes) on emotional valence across the lifespan. The color-grading reflect a gradient for more negative (blue tones) and more positive (red tones) changes. Actual words in French are written on their corresponding edge and English translations are given below.

Discussion

In this short article, we report lifespan changes on several psycholinguistic variables for a total of 1286 words, as obtained by computing linear regressions on means over four groups of individuals aged 18-25, 26-39, 40-59, and 60+ years old. Not all the words display changes, and those which display changes do not so on all variables. Actually, 5% of the total sample display significant linear changes on emotional valence, a number that corresponds to what has been reported in the past with different approaches (Warriner et al. 2013; Gilet et al. 2012). Those changes are either linear increase or decrease of emotional valence, for example “destiny” evokes positive emotion in emerging adults but becomes less positive across age-groups and reaches a neutral valence in older individuals. The word “craziness” shows a similar pattern of decrease in emotional valence across adulthood but corresponding to an increase of negative valence with age. By contrast, the word “rule” shows an increase across age-groups and becomes very positive in older individuals. Words also show changes on arousal (N=80) but more words show variations on subjective frequency (N=125) and on imageability (N=216).

Importantly, for these variables we mainly see linear increases, that is, words become more arousing, more frequent, more imageable. This has been previously interpreted as a consequence of increased language experience and greater knowledge with age, which would facilitate the ability to create more vivid mental images (Gilet et al. 2012; Robert et al. 2012, Ballot et al. 2022). One could thus imagine that all words show lifespan changes in the same direction, and a word that changes on a given variable should show changes on all variables. This is not the case as most words show relatively independent variations for the variables. Only 79 words out of 413 vary on several variables and the massive co-variation is seen for imageability and subjective frequency. Although creating a mental image tends to be easier for words that are perceived as more frequent (Desrochers & Thompson, 2009; Ferrand et al., 2008; Soares et al., 2017; Stadthagen-Gonzalez & Davis, 2006), it is not because a word becomes more or less emotionally charged that it is more or less arousing (and vice versa). Note that here we adopted a more conservative approach than computing two-by-two comparisons as others did (Ballot et al. 2022; Warriner et al. 2013) since we restricted to linear changes such that, if changes are seen over three age-groups but then a drastic different trend occurs, our

analysis would not capture those variations. This relates to our specific assumption that continuous experience and accumulated knowledge across adulthood shape our mental representations of words.

The primary focus was on emotional valence because whether a word evokes positive or negative emotion is indicative of its meaning and should reflect past affective experience. Despite the constraints given by the database and exploratory nature of the study, the semantic cluster analysis indicates that words with related meanings tend to display similar trajectories across the lifespan. For example, words like “brutal”, “fatal”, “craziness”, “destiny” are clustered together, while “hornet”, “cat”, “dingo” which belong to the same category of animals, form another cluster. Back to our original example of “puzzle” which could mean more of a toy for children and more of an enigma for older adults, our data highlight that words may mean different things to different individuals depending on their social group. In our case, we can speculate that *craziness* likely refers more strenuously to *extravagance* in young people (being more positively charged), and to *dementia* in older individuals (being more negatively charged). Obviously, as people apprehend and internalize entities and events over the course of their lives, they integrate the environment in which they occur, their self-relevance regarding their current state, as well as emotion and outcomes (Barsalou, 2020), which tend to be similar for related events. However, to gain in interpretability, we would probably need to better associate word meanings, emotion and situated memories to actual events over time. One potential perspective is experience-sampling (ESM) techniques or Ecological Momentary Assessments (EMA), which are used to record sensations and activities as they unfold over time, whether at random moments or at a given time (Scollon et al. 2009; Verhagen et al. 2016; Shiffman et al. 2008). This could not be done initially at a large scale, thus at odds with current trends for big data. However, tracking a subset of words could allow us to better understand the relationship between feelings and situations to which words refer, given days/times and other conditions (Scollon et al. 2009) and determine how it aligns with the Situated Action Cycle hypothesis (Barsalou, 2020). Interpreting these variations as a function of word age of acquisition was not possible either because relevant information was not available for these words in this database, although it could help us disentangle whether lifespan variations carry qualitative semantic variations.

This study focused mainly on emotional valence and there is no data to extend this approach to other experiential features such as perceptual (visual, auditory etc) and motor experience. As linguistic, sensory-motor and affective experience is likely not equivalent across people, information beyond emotion, could vary from one individual to another (see Wulff et al. 2019; Krethlow et al. 2020). In the Lancaster norms, Lynott & Connell (2020) provide data for many experiential-related semantic properties and a large sample of words, but even though age was not restricted there is hardly more than 20 participants who rated words, let alone 20

participants in a given age-range. There is thus a need to scale up these datasets to test whether our observation extends to other semantic dimensions, other communities and languages. We need more data, which would allow for the use of more conservative statistical thresholds, but also more individual factors. Education has been found to have a role on emotion associated with words (Warriner et al. 2013) and socio-economic status more generally would be an interesting proxy to variations in environment and situated experience (Hermawan & Vikaliana, 2023). Finally, we chose to study linear changes in word evaluation. However, it may be that skills, particularly emotional skills, don't just follow a linear trajectory, which would also be interesting to investigate in further studies.

The flexible nature of the lexical-semantic system has been demonstrated at multiple occasions (Yee & Thompson-Schill, 2016), and now across individuals from different age-groups. Although the piddling nature of individual differences in word representations for communication has been discussed before (see Yee et al., 2017), we challenge the triviality of these results in three respects. First, while the other ratings also show changes with age, the data on emotions reveal an interesting pool of emotional words to discuss regarding theories on emotions. The observed differences may be a consequence of how people process those words. Future work should test directly the implications of the Socio-Emotional Selectivity theory (Cartensen, et al., 1999) and Situated Action Cycle hypothesis (Barsalou, 2020) on words semantic representations. Our results suggest that the emotional regulation expected with age (Carstensen et al., 1999) cannot be generalized to all words as some words may well change in meaning. Second, theoretically individual differences generate lexical ambiguity. To what extent this sort of ambiguity is easily addressed in cross-generational communication is virtually unknown: do old and young people have more misunderstandings when referring to *craziness* than to *rain*? Third, this work questions the quality of lexical-semantic models as well as their psychological validity for individuals beyond (undergraduate) young adults. The quality of those models is of paramount importance in contemporary research as they are more and more used to infer the spatial and temporal cognitive and brain correlates of semantic processing (Bruffaerts et al., 2019). Interestingly, age-appropriate models of the lexical-semantic network outperform models solely based on young adults to predict language production performance (Krethlow et al. 2020), thus calling for increased inclusivity in psycholinguistic studies.

Obviously, cross-sectional work comes with cohort limitations. Emerging and older adults who participated to these word ratings did not experience the same events. Every decade comes with unique emotional societal contexts such that it is yet impossible to determine how much of the reported changes are driven by generational vs. typical experiential and aging changes. We are considering updating these norms in the next decade, and adopting the same strategy as here would allow us to shed light on this issue.

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