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Differences related to aging in sensorimotor knowledge: Investigation of perceptual strength and body object interaction

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ABSTRACT

Embodied approach postulates that knowledge and conceptual representations are grounded in action and perception. In order to investigate the involvement of sensorimotor information in conceptual and cognitive processing, researchers have collected various norms in young adults. For instance, the perceptual strength (PS) assesses perceptual experience (i.e. visual, auditory, haptic, gustatory, olfactory) associated with a concept and the body-object-interaction (BOI) assesses the ease with which a human body can interact with the referent of a word. The importance of both BOI and PS in the multimodal composition of word meaning is today well recognized. However, given the sensorimotor development of the individual from childhood to later life, it is likely that different age periods are associated with different perceptual experience and capacity to interact with objects. The purpose of this research is to investigate exploratory the effect of age on PS and BOI by comparing the evaluation of 270 French language words by young adults and healthy older people. The results showed that older adults presented similar or even higher PS for some modalities (e.g. gustatory and olfactory) and in particular for certain categories of words, while the BOI decreases. In addition to the importance of adjusting the verbal stimuli used in aging studies when dealing with multimodal representations, our results will lead us to discuss the evolution of sensorimotor representations with age.

1. Introduction

During their development, human beings acquire knowledge about the world and the objects that surround them. This experience occurs through a number of modalities which may be sensory (i.e. vision, smell, taste, touch, hearing), motor (via the functional aspect and the use of objects), linguistic (via verbal experience) or associated with emotional content. Each of these modalities contributes to enrich our multimodal conceptual representations (Dilkina & Lambon Ralph, 2013;Dove, 2011; Reilly, Peelle, Garcia & Crutch, 2016;Vigliocco, Meteyard, Andrews & Kousta, 2009). This view of concepts grounded in different modalities is illustrated in the literature by considerable research within the theoretical framework of embodied cognition (Barsalou, 1999,2008;Buccino, Colagè, Gobbi & Bonaccorso, 2016;Wilson, 2002) and is opposed to the theory of semantics which proposes a complete independence between semantic and sensorimotor systems (Collins & Loftus, 1975 ; Fodor, 1987;Levelt, 1993). There is now growing and undeniable empirical behavioural and neurophysiological evidence of strong interactions between these systems (for reviews see Binder, 2016;Martin, 2007;Meteyard & Vigliocco, 2008;Meteyard, Cuadrado, Bahrami & Vigliocco, 2012;Patterson, Nestor & Rogers, 2007;Thompson-Schill, 2003).

Researchers have developed materials that measure the sensorimotor basis of word meaning in order to investigate the involvement of sensorimotor information in conceptual and cognitive processing. Many norms have therefore test been created to capture the relevant dimensions of sensorimotor knowledge (e.g. Bonin, Méot, ferrand & Bugaïska, 2015;Fernandino et al., 2016;Juhasz & Yap, 2013). Of particular relevance to the present work are studies that collect norms of Perceptual Strength (PS) in order to capture sensory dimensions of semantics (e.g. Lynott & Connell, 2009;Miceli et al., 2021;Morucci, Bottini & Crepaldi, 2019) and body-object interaction (BOI) in order to capture

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the motor dimension of semantics (Bennett, Burnett, Siakaluk & Pexman, 2011;Pexman, Muraki, Sidhu, Siakaluk & Yap, 2019;Tillotson, Siakaluk & Pexman, 2008). The PS variable represents the extent to which a word can be experienced by separate sensory modalities and is obtained by asking participants to rate the extent to which they experience a word in each of the five sensory modalities on a scale of 0 (not experienced at all) to 5 (highly experienced). It was first collected by Lynott and Connell (2009) in English before being developed in other languages and in different word categories (e.g. Dutch: Speed & Majid, 2017; Mandarin: Chen, Zhao, Long, Lu & Huang, 2019; French: Miceli et al., 2021 ; Russian: Miklashevsky, 2018). In the same view, the BOI is a measure evaluating the ease with which a human body can physically interact with a word's referent on a Likert scale (Tillotson et al., 2008). Numerous studies carried out in young adults highlight the importance of both BOI and PS in the multimodal composition of word meaning. Their role has been shown in predicting performance in various conceptual tasks. For instance, the modality-switching cost paradigm shows that checking a property in one modality (e.g. auditory: *rustle* for "leaf") will take less time after having checked another property in the same modality (e.g. *noise* for "mixer") than in another modality (e.g. visual : *green* for grass) showing the re-allocation of attention from one modality-specific system to another (e.g. Pecher, Zeelenberg & Barsalou, 2003;Van Dantzig, Pecher, Zeelenberg & Barsalou, 2008;Vermeulen, Niedenthal & Luminet, 2007). Studies have also demonstrated that the performance in lexical and naming decision tasks can be predicted by PS (e.g. Connell & Lynott, 2012,2014;Lynott, Connell, Brysbaert, Brand & Carney, 2019). It has also been shown that words with a high BOI (e.g. belt) are faster and more accurately processed than words with a low BOI (e.g. ship) in lexical decision tasks (e.g. Tillotson et al., 2008;Van Havermaet & Wurm, 2014), phonological decision tasks (e.g. Siakaluk et al., 2008) and in several variants of semantic categorization tasks (e.g. Bennett et al., 2011;Hansen, Siakaluk & Pexman, 2012; Ian Scott Hargreaves et al., 2012; Siakaluk, Pexman, Aguilera, Owen & Sears, 2008; Yap, Pexman, Wellsby, Hargreaves & Huff, 2012). Although some studies have shown no effect of BOI (e.g. Hargreaves & Pexman, 2014; Taikh, Hargreaves, Yap & Pexman, 2015), its facilitating effect has also been shown in sentence reading (Xue, Marmolejo-Ramos & Pei, 2015), printed word naming (Wellsby & Pexman, 2014) and auditory word naming (Inkster, Wellsby, Lloyd & Pexman, 2016). Data from the literature also showed that BOI and PS variables are strongly correlated with other semantic variables (i.e. concreteness, imageability, age of acquisition) that are known to affect word processing (Chedid et al., 2019; Juhasz & Yap, 2013;Miceli et al., 2021;Miklashevsky, 2018;Pexman et al., 2019). Taken together, these studies are particularly relevant for appreciating the richness of conceptual representations and understanding how our knowledge is grounded.

Currently, these norms have only been collected in the young adult population and investigations are gradually being extended to children for the BOI (Inkster et al., 2016;Wellsby & Pexman, 2014). To our knowledge, no study has collected these data in the older adult population. In fact, very few studies investigate the potential effects of aging on the relationship between the sensorimotor and conceptual systems (see Boutet, Dawod, Chiasson, Brown & Collin, 2019;Greene & Naveh-Benjamin, 2020;Korkki, Richter, Jeyarathnarajah & Simons, 2020;Vallet et al., 2017;Vallet, Hudon, Simard & Versace, 2013). Before considering these investigations in aging using the PS and the BOI variables, it seems important to have appropriate norms available for the reference population. Indeed, it is commonly accepted that representations change dynamically with our experiences, current goals and available resources (Barsalou, 1999;2008;Connell & Lynott, 2014; Glenberg, 1997;Glenberg & Robertson, 2000; Lynott & Connell, 2010; Vigliocco et al., 2009;Wilson, 2002). Concepts are therefore subject to constant change across the lifespan (Connell & Lynott, 2014) and it is likely that the sensory and motor experience associated with these concepts changes with age (see Vallet, 2015). Connell and Lynott (2014) consider that « because concepts alter with the accumulation of direct and vicarious experience, and with the act of retrieval itself, the representations that draw on such conceptual content are also inevitably mutable » (Connell & Lynott, 2014 p.399). Much evidence in the literature points to individual experiences as determining our semantic knowledge (e.g. Beilock, Lyons, Mattarella-Micke, Nusbaum & Small, 2008;Chrysikou, Casasanto & Thompson-Schill, 2017;Fourkas, Bonavolontà, Avenanti & Aglioti, 2008;Holt & Beilock, 2006;Kiefer, Sim, Liebich, Hauk & Tanaka, 2007;Lyons et al., 2010). These studies mainly investigated knowledge related to a specific expertise. For example, it has been shown that ice hockey players showed greater activation of the left premotor cortex for sentences referring to hockey-related actions, compared to non-players, whereas these differences were not present for everyday actions for which they had the same level of experience (Lyons et al., 2010). Because of their life experience, older adults are a privileged population to investigate the evolution of semantic knowledge. Indeed, it is widely accepted that semantic knowledge is higher in older persons (e.g. Arbuckle, Cooney, Milne & Melchior, 1994; Bahrick, 1984; Bowles & Poon, 1985; Brysbaert, Stevens, Mandera & Keuleers, 2016; Burke & Peters, 1986; Mitchell, 1989; Perlmutter, 1978). As a matter of fact, older adults'general knowledge continues to increase with age, often reflected by higher language performance in comparison to young adults (e.g. Verhaeghen, 2003; Verhaeghen & Salthouse, 1997). It has also been established that the accumulation of prior knowledge (i.e. facts, habits, routines, schemas) has an impact on cognitive functioning across the lifespan (Spreng & Turner, 2019). For instance, older adults are able to use their prior knowledge to their benefit in many situations such as, in decision-making and problem solving (e.g. Agarwal, Driscoll, Gabaix & Laibson, 2009; Li, Baldassi, Johnson & Weber, 2013). Moreover, reorganizations of neural networks supporting semantic cognition have been extensively demonstrated with aging and support the implication of lifetime experience (e.g. Davis, Dennis, Daselaar, Fleck & Cabeza, 2008; Grady et al., 1994; Persson, Lustig, Nelson & Reuter-Lorenz, 2007; Pistono et al., 2020; Spreng & Turner, 2019; Spreng, Wojtowicz & Grady, 2010; voir Hoffman & Morcom, 2018 pour une méta-analyse). Recently, Vignando et al. (2018) were particularly interested in the importance of our life experiences on the organization of semantic knowledge in elders by investigating participants' dietary habits. They showed, in centenarians, better performance in recognition tasks of natural food (e.g. apple) compared to processed food (e.g. hamburger) suggesting that these effects are related to their experience, given their acquired eating habits. These differences in experience contribute to shaping the content of the lexicon and semantic representations of young and old (Johns, Jones & Mewhort, 2019). However, the way in which representations are shaped by experience is unfortunately still little explored (see Wulff, De Deyne, Jones, Mata & Consortium, 2019 for a review). Even so, data implicating experience in shaping our representations might suggest that older adults would have more sensorimotor experience than younger adults and that, in the light of embodied cognition (placing the sensorimotor components at the core of the language), this would shape the conceptual system of older adults and potentially result in higher PS and BOI ratings in the elderly.

On the other hand, it has recently been suggested that the concomitant sensory, motor and cognitive disruptions encountered with aging could impact their representations (Costello & Bloesch, 2017; Vallet, 2015). In other words, given the effects of age on sensory processing and bodily factors (kinesthetic, proprioceptive), some researchers formulate the hypothesis that older adults are less embodied (Costello & Bloesch, 2017). In addition to bodily and motor changes, deficits in sensory modalities in aging are well documented in the literature (e.g. Correia et al., 2016). Interactions between perceptual and cognitive decline have been widely documented with aging. The sensorimotor decline in aging is in fact at the center of a great debate in the identification of factors that may cause cognitive decline (for the different hypotheses discussed in the literature see Roberts & Allen, 2016 and Monge & Madden, 2016, focusing on visual perceptual decline). Vallet (2015) suggest that if knowledge is embodied in its sensorimotor components, then the degradation of these components should impact on how that knowledge is retrieved (see also Mille, Brambati, Izaute & Vallet, 2021). It is to consider that the evaluation of PS and BOI requires the recovery of a sensorimotor experience associated with knowledge. From this point of view, the potential impact of sensorimotor decline on knowledge could manifest itself, in our study, by a downward evaluation of PS and BOI in the elders. This hypothesis is thus contrary to the first one involving the positive impact of experience, but is just as important to consider, or at least to discuss. Indeed, the current studies showing an impact of sensorimotor decline in aging through high and low level neurophysiological sensory changes concern exclusively episodic memory tasks that involve investigations of the visual modality (the other modalities have not yet been explored) (see Mille et al., 2021 who depict neurophysiological and cognitive changes occurring in aging and their interactions with low and high perceptual processing and memory). We therefore remain cautious about applying this hypothesis to our current study because it does not involve a specific experimental task that would allow inference about high-level neurocognitive mechanisms, but requires “basically” a judgment of experience. However, we do not know whether a judgment of perceptual and motor experience can be impacted by sensorimotor declines in aging.

In any case, these elements of the literature raise the question of whether norms such as the BOI or PS are stable across the lifespan or whether differences appear in aging. The aim of this study is to investigate this exploratory question by comparing French PS and BOI data collected in young adults with those collected in healthy older adults. We will compare available French-speaking PS data in young adults (Miceli et al., 2021) with those collected in 55 older participants in the present study. Since no BOI norms are available in French, we will make available the BOI data for these same youths and compare them to the assessment of the same 55 elders.

1.1. Material and method

1.1.1. Participants

Fifty-five older participants with French as mother-tongue (37 women), aged between 65 and 89 (mean age= 74.38; SD= 4.93) with a socio-cultural level of high school (socio-cultural level= 4.16; four corresponding to high school[1]) took part in this study and have completed the PS and BOI questionnaire. They were compared with 141 French-speaking young participants (100 women), aged between 18 and 50 (mean age= 25.75; SD= 7.43) with a socio-cultural level of higher education (socio-cultural level= 5.12; five corresponding to the bachelor level) from our PS previous study (Miceli et al., 2021). The same young participants from this previous study also completed the BOI rating presented in the current study. However, 10 subjects did not complete the questionnaire and the final BOI assessment was therefore performed on 131 young participants. The two groups were statically equivalent in gender ($U = 3331$; $p = .294$) but differed in socio-cultural level, which was higher among the young ($U = 1879$; $p < .001$). Nevertheless, we made sure that these socio-cultural differences did not impact the participants' rating for either the PS or the BOI through regression analyses ($p > .05$).

To estimate whether the number of participants was sufficient to compare the results of the young and old, we estimated the effect size of the 2 groups (N1 = 141, N2 = 55) with G-Power 3.1. (Faul, Erdfelder, Buchner & Lang, 2009). A Wilcoxon-Mann Whitney test was performed with a post hoc power analysis. A moderate effect size (d=0.5) was chosen, according to Cohen's convention (Cohen, 1987; Prajapati, Dunne & Armstrong, 2010) with the α error probability to 0,05. The power (1-β error probability) was estimated at 0.86, meaning that the sample size was sufficient.

Older participants were recruited through word of mouth, social media ads as well as through presentations of the study in a senior workshop. For the inclusion criteria, older adults must have normal or corrected-to-normal vision and high overall cognitive functioning as assessed by the Mini-Mental State Evaluation score (MMSE, Derouesne et al., 1999 ; min. = 28, max. = 30, mean = 29.23, SD =.77). They should also present a low level of anxiety and depression as assessed with State Anxiety Inventory (STAI-Y, Spielberger, Gorsuch, Lushene, Vagg & Jacobs, 1983 ; min = 20, max. = 45, mean = 31.91, SD = 7.41) and Geriatric Depression Scale (GDS-15 ; Clément, Nassif, Léger & Marchan, 1997 ; min = 0, max. = 7, mean =1.82, SD =1.73). All participants gave their consent before participating to the study. The study was approved by the ethical board of the Psychology and Educational Sciences Faculty of the University of Mons (Mons, Belgium).

1.1.2. Stimuli

The same material as our previous study in young adults was used and concerns 270 common nouns of the French language (see Miceli et al., 2021). Except for 10 words with a concreteness rating below 3, all stimuli were concrete words. See table 1. for the descriptive characteristics of the stimuli.

The data collected in this study are available to the scientific community in the supplementary materials.

1.1.3. Procedure

After completing the consent form and answered questions about personal information (see Table 1), they received the words' list and were asked to rate, on a Likert-like scale, ranging from 0 (*not at all*) to 5 (*greatly*), the extent to which they experience each word through a specific modality. Separate lists of the 270 words were proposed for each modality in the following order: visual, auditory, haptic, gustative and then olfactory. Participants could complete the task in a single session or divide the rating across two or more sessions. The instructions and examples for PS were similar to those used in Miceli et al. 2021 and were as follows: “To what extent, in your opinion, is this word associated with a visual/auditory/haptic/gustative/olfactory sensory experience?” (*in French: « A quel point, ce concept est-il associé, selon vous, à une expérience sensorielle visuelle/auditive/tactile/gustative/olfactive »*)(see Appendix A for the complete instructions). For the BOI, participants were asked to rate on a Likert-like scale, ranging from 0 (*null*) to 5 (*very high*) the extent to which their body can physically interact with what the target concept represents. The instructions and examples were similar to those from Tillotson et al. (2008) and Bennett et al. (2011). The only difference is that we decided to ask to focus on assessing the interaction with their own body and not the overall human abilities (see Appendix B). This will allow to obtain specific data to each subject and to compare the groups considering their own perceptual experiences but also their own interaction abilities. This particular precaution was important in order to investigate lifespan effects.

The youth completed an online questionnaire in which they had to follow web links to continue the evaluation, while the elders completed the assessment in the same written questionnaire. Each question started with an instruction page. Participants were informed that they could

Table 1
Descriptive characteristics of the 270 words.

	Min	Max	M(SD)
Books frequency*	0.00	461.55	31.06 (62.43)
Film frequency*	0.00	470.30	29.31(67.86)
Concreteness	2.04	5	4.54(0.79)
Imageability	2.44	5	4.63(0.69)
Conceptual familiarity	1.32	5	3.11(1.22)
Age of acquisition	2.44	9.41	5.92(.01)

* From New, Brysbaert, Veronis & Pallier, 2007.

[1] 1. less than 6 years of primary education; 2. 6 years of primary education; 3. 6 years of primary school + 2 to 4 years of secondary school; 4. 6 years of high school education; 5. 3 years of superior studies; 6. Master; 7. PhD

complete the assessment in several sessions and were encouraged to split it up over several days. While sensory and motor impairments were an exclusion criterion in data collection among the young (see Miceli et al., 2021), this was not the case among the elders, who had also to complete a questionnaire evaluating the presence of sensory and motor disturbances (see appendix C) in order to additionally control if these had an impact on their rating.

1.1.4. Data analyses

All analyses were conducted using SPSS 21. Significance level was set at $p \leq .05$ throughout analyses. First, outliers were identified the mean score of a participant fell outside ± 2.5 standard deviations from the group mean in each modality (see also Miceli et al., 2021). After this screening, no participant has been excluded.

For intra and inter-study reliability, Spearman correlation coefficients were computed because the distribution of the variables of interest did not meet the normality assumption, as well as Cronbach's alphas for inter-item and inter-rater consistency.

Finally, Mann-Whitney tests were used to compare the ratings of the older adults from those of the young adults (the distribution of these ratings did not meet the normality assumption). Regression analyses were also conducted to determine whether the sensory or motor disorders mentioned by some participants could influence their results.

Participant ratings for PS (older adults group) and BOI (young and elders group) are available to the scientific community in supplementary material.

2. Results

2.1. Intra-and inter study reliability

2.1.1. Perceptual Strength

As our previous study in young adults (Miceli et al., 2021), we first measured the internal consistency of the ratings for the older adults. This split-half reliability coefficient is obtained by splitting the ratings of the participants into two groups (according to even and odd participant numbers), and by computing a Spearman correlation between the two groups' data for each variable separately. If the ratings of the two groups are well correlated, they should provide similar results, meaning that the ratings have good internal consistency reliability. The results show significant corrected Spearman correlations for the 5 PS (visual: $\rho = .813$, $p < .001$; auditory: $\rho = .936$, $p < .001$; haptic: $\rho = .930$, $p < .001$; gustatory: $\rho = .776$, $p < .001$; olfactory: $\rho = .992$, $p < .001$).

Results also showed a high reliability for all modalities, as shown by the Cronbach's alphas for inter-item consistency (visual: $\alpha = .989$; auditory: $\alpha = .990$; haptic: $\alpha = .989$; gustatory: $\alpha = .969$ and olfactory: $\alpha = .980$). Participants also showed high inter-rater reliability for each modality, according to Cronbach's alphas for inter-rater agreement (visual: $\alpha = .948$; auditory: $\alpha = .981$; haptic: $\alpha = .967$; gustatory: $\alpha = .992$; and olfactory: $\alpha = .985$).

2.1.2. Body object interaction

The split-half reliability analysis showed significant corrected Spearman correlations for both young ($\rho = .981$, $p < .001$) and old ($\rho = .952$, $p < .001$) participants. Results also showed a high reliability as shown by the Cronbach's alphas for inter-item consistency (young group: $\alpha = .995$, older group: $\alpha = .988$). Participants also showed high inter-rater reliability, according to Cronbach's alphas for inter-rater agreement (young group: $\alpha = .989$; older group $\alpha = .970$).

2.2. Comparison of ratings between young and old

Descriptive statistics for the PS and BOI rating for both groups are presented in Table 2.

As we observed for the young (Miceli et al., 2021), the profile of PS averages among the elderly is identical to the one observed in the younger population. Indeed, words were rated as primarily experienced in the visual modality, while the gustatory one was the least experienced. This pattern is consistent across different languages (e.g. Lynott & Connell, 2013; Lynott et al., 2019; Miklashevsky, 2018; Speed & Brysbaert, 2020; Vergallito, Petilli & Marelli, 2020). As it was achieved for young adults in the Francophone data (Miceli et al., 2021) and in other languages (e.g. Chen et al., 2019; Lynott & Connell, 2009; Morucci et al., 2019; Speed & Brysbaert, 2020), we examined the relationships between PS modalities in the elders group through principal components analysis (PCA) with an orthogonal Varimax rotation and Kaiser normalisation. The five modalities have been reduced to two factors, jointly explaining 74.86 % of the original variance. The first with an eigenvalue of 2.49, accounts for 49.71 % of the variance and is composed of gustatory and olfactory strengths. The second, with an eigenvalue of 1.26, accounts for 25.15 % of the variance and is composed of visual, haptic and auditory perceptual strength. The loadings of the dimensions in the two components are shown in Table 3. See also Fig.1 illustrating how noun concepts (plotted by dominant modality) overlap in perceptual experience.

Although the composition of the factors is different from that of young adults, the correlation matrix between different modalities (reported in table 4) show a similar pattern of results to the French-speaking young adults and to the wider literature (Chen et al., 2019; Lynott & Connell, 2009, 2013; Lynott et al., 2019; Morucci et al., 2019; Speed & Majid,2017; Speed & Brysbaert,2020; Vergallito et al., 2020), that is, a strong positive correlation between visual and haptic modality and between taste and smell modality. Other moderate positive correlations between haptic-gustatory, haptic-olfactory, visual-gustatory, and visual-olfactory experience were also observed and were similar to those of young adults (see Miceli et al., 2021), indicating that age does not alter the relationships between perceptual modalities.

The result of the comparison of the means between young and old showed no significant difference between the young and the older group for visual, haptic and auditory perceptual strength. However, the olfactory and gustatory PS is significantly different between the 2 groups; the older adults's ratings are higher ($p < .05$). See table 5 for examples of words representing this difference.

Since only these 2 modalities showed significant results, we wondered if the differences in average between young and old could be item-specific. Although our corpus of words was not designed by category, we were able to conduct analyses for a group of 57 animals, 18 fruits and vegetables and 133 manufactured objects. While the manufactured objects gave no results, we observed significant differences in the animal category for the auditory (p=.009), gustatory (p<.001) and

Table 2
Mean ratings (M) of perceptual strength (0-5) across five modalities and BOI for 270 words, with standard deviations (SD), and results of group comparison.

	M (SD)Older adults group	M (SD)Young group*	Results *p value*
Visual	2.62 (.83)	2.66 (.84)	.953
Haptic	1.99 (.83)	1.86 (1.00)	.287
Auditory	1.19 (.65)	1.09 (.87)	.338
Olfactory	.89 (.41)	.77 (.96)	.031
Gustatory	.69 (.28)	.62 (1.13)	.012
BOI	2.11(.79)	2.49 (1.11)	.025

Table 3
Component matrix obtained from PCA with a Varimax rotation.

	Factors 1	2
Visual	.412	.796
Haptic	.416	.725
Auditory	-.331	.718
Olfactory	.876	.183
Gustatory	.902	.045

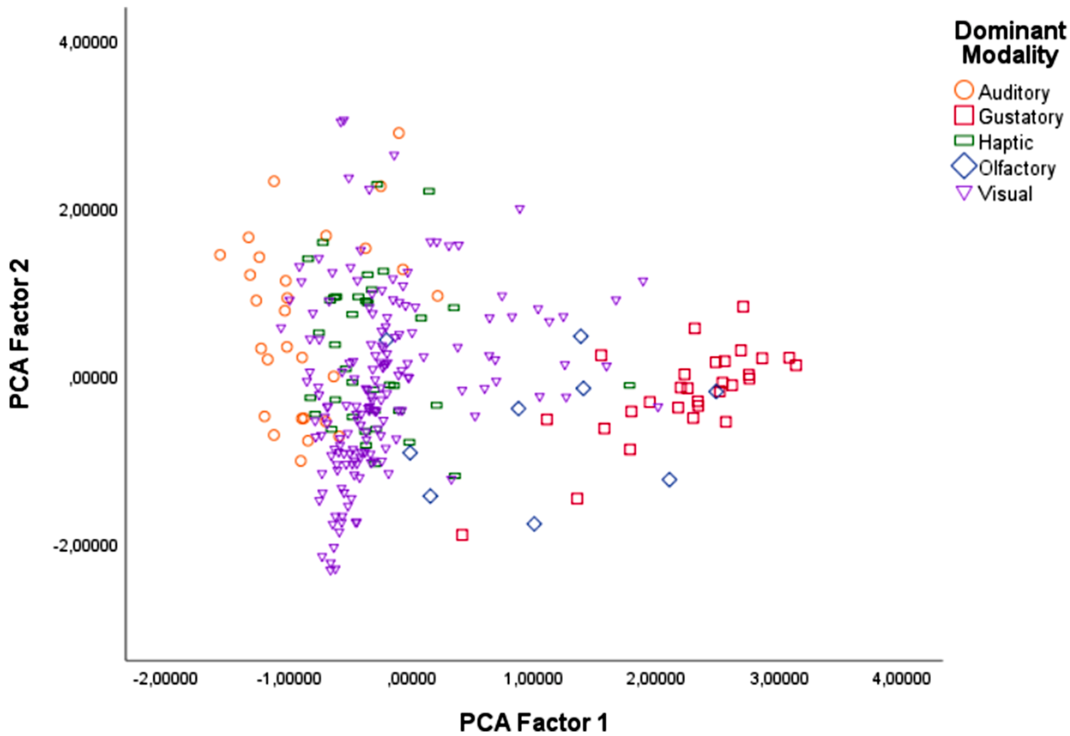

Fig. 1. Clustering of words, labeled by dominant modality, with perceptual strength on the five modalities reduced to two PCA factors for the elders group.

Table 4
Correlation matrix between modalities for mean ratings of perceptual strength.

	Visual	Auditory	Haptic	Gustatory	Olfactory
Visual	–	.267**	.720**	.341**	.432**
Auditory	–	–	.145*	-.094	-.003
Haptic	–	–	–	.310**	.377**
Gustatory	–	–	–	–	.752**

*the Spearman correlation is significant at the .05 level.
** the Spearman correlation is significant at the .01 level.

Table 5
Sample of words rated by young and elders with their mean (and standard deviation) for gustatory and olfactory modalities.

	Gustatory		Olfactory	
	Young	Elders	Young	Elders
Cherry	3.3(1.63)	4.14(1.08)	2.17(1.63)	2.7(1.58)
Croissant	3.34(1.59)	3.86(1.27)	2.7(1.58)	3.23(1.38)
Duck	1.95(1.69)	2.89(1.64)	0.91(1.3)	1.63(1.58)
Flower	0.65(1.04)	1.05(1.26)	3.34(1.54)	3.88(1.52)
Horse	0.76(1.23)	1.23(1.75)	2.06(1.69)	2.26(1.78)
Pineapple	3.05(1.66)	3.79(1.26)	2.58(1.52)	3.32(1.57)

olfactory (p =.001) modalities, with higher older adult ratings. The analysis of fruits and vegetables showed significantly higher scores for the haptic (p=.044), gustatory (p=.014) and olfactory (p=.031) modalities.

Regarding the BOI, the comparative analysis showed a significant difference between the 2 groups. Older participants had significantly lower BOI scores (U = 2851.5; p = .025). In order to observe whether differences between young and old appeared for one category in particular, we selected words belonging to the category of natural (i.e. animals, fruits, vegetables and plants) and manufactured objects. Indeed, it has been demonstrated the existence of different types of functional affordances between natural and manufactured objects, the manipulable objects evoking a motor information (Godard, Wamain & Kalénine, 2019). 31 words were excluded from the analyses either because they could not be easily manipulated (e.g. hospital) or because they would not have been relevantly included in one of the categories (e.g. thief). The results of the analysis performed on 106 natural and 133 manufactured items are significant for both natural (U = 2888.5; p = .033) and manufactured (U = 2841; p = .023) items meaning that this difference in BOI between young and old appears regardless of the category of objects.

2.3. Investigation of the impact of sensory and motor disturbances

Given the hypotheses suggesting an impact of low or high level sensorimotor disorders encountered in aging on their representations (Vallet, 2015), we aimed to control the potential impact of sensory and motor disturbances encountered by the participants on their ratings. Among the older participants, 50 had a corrected visual impairment; 22 reported having a hearing disorder, of which 8 had an estimated effective hearing correction; 4 participants reported having haptic disorders. Regarding motor disorders, 11 reported gait disorders, 4 of which required crutch or rollator assistance, 3 reported upper limb disorders and 4 reported "other" motor disorders. Linear regression analyses excluded an impact of sensory disorders on perceptual variables in our study. Participant ratings for visual PS cannot be predicted by the presence of visual corrected disorders ($F_{(1,54)}$=.057 ; p=.813 ; R^2=.001), auditory PS cannot be predicted by the presence of hearing disorders ($F_{(1,54)}$=.865 ; p=.356 ; R^2=.016) and haptic PS cannot be predicted by the presence of tactile disorders ($F_{(1,54)}$=.162; p=.689 ; R^2=.003). Analyses concerning olfactory and gustatory disorders were not conducted given the absence of gustatory and olfactory disorders in the participants. Although the participants' sensory disturbances did not cover all 5 perceptual modalities, we can exclude, in our study, an impact of these low-level impairments on the participants' ratings. Moreover, BOI ratings cannot be predicted by the presence of motor disorders ($F_{(3,54)}$= .039; p = .989 ; R^2 = .002). A direct influence of motor disturbances on participants' ratings can therefore be excluded in the present study.

3. Discussion

The objective of our study was to compare in an explorative way the PS and BOI data between young and older adults in order to determine whether differences existed with age and, if so, to have appropriate stimuli available for the reference population studied. We also investigated in an original way the question of the evolution of sensorimotor representations with age. Indeed, the perceptual and motor experience which composes our representation (among other dimensions) of the concepts was investigated from two distinct variables via explicit measures collected from young and older people. The comparison between the two age groups was relevant to determine the direction in which this representation could evolve with age.

The results showed no difference between the young and the older adults' group for visual, auditory and tactile PS, but revealed a higher PS with age concerning gustatory and olfactory modalities meaning that some modalities are more sensitive to life experience (see below for details on word categories). In contrast, the BOI ratings were significantly lower in the elderly indicating that the ability to interact with the concepts is considered weaker in the elderly. Some researchers have hypothesized an impact of age-related sensorimotor decline on knowledge (Mille et al., 2021). According to Vallet (2015, p.4), « if knowledge remains embodied in its sensory-motor components, the degradation of these components should directly impact how that knowledge is retrieved and used ». This hypothesis has been investigated to date in the context of episodic memories. A phenomenon of reduced distinctiveness of the memory trace in the elderly would explain the recuperation disorders (Korkki et al., 2020). Indeed, memories would be less distinct and confused and this lower resolution of representations would induce interference in memory (see Mille et al., 2021). If data exist to support an age-related sensorimotor decline on representations, they concern only episodic tasks. However, we do not yet have information on the potential impact of sensorimotor decline on the semantic system. Our study provides some initial insights on this issue.

In light of the results of de PS comparison between young and older, we have no arguments in favor of a decrease in perceptual semantic representations in aging, assessed in this case in the framework of an explicit rating. On the contrary, we notice that the PS is identical and even higher for some modalities and certain category of words. As discussed in the introduction, the accumulation of experiences by the older adults may have reinforced their conceptual knowledge/representations. In this case, the older adults should present higher ratings than those from younger adults. However, only the gustatory and olfactory modalities showed a higher evaluation in the present study. Taste and smell are integrated within the same neural pathway and share overlapping brain networks (de Araujo, Rolls, Kringelbach, McGlone & Phillips, 2003; Delwiche & Heffelfinger, 2005; Rolls, 2008). Also, strong positive correlations between the gustatory and olfactory PS modality have been shown in the literature (Chen et al., 2019; Lynott & Connell, 2009, 2013; Lynott et al., 2019; Morucci et al., 2019, 2019; Speed & Brysbaert, 2020; Speed & Majid, 2017; Vergallito et al., 2020) and the present study showed that this is also the case in the older adult population. These simply recall the evidence that concepts that can be tasted and smelled correspond in majority to foods. Therefore, we could suppose that it is possible that certain categories of words have influenced these results. Indeed, while the analysis on all words showed a greater evaluation for the gustatory and olfactory modality, a more detailed analysis showed that this increase was specific to certain word categories. The category of animals showed a greater PS for the auditory, gustatory and olfactory modality, the category of fruits/vegetables showed a greater haptic, gustatory and olfactory PS, while the manufactured objects showed no difference. Therefore, it seems that the increase in PS in the older adults varies according to certain types of words (in this case animals and fruits/vegetables) and that some perceptual modalities are more sensitive than others to the experience accumulated over the lifespan. As demonstrated by Vignando et al. (2018), processing of tasks involving food was influenced by the dietary habits of the elderly. Hence, it is possible that older people with potentially different eating habits from youth are more familiar than young people with the foods (here fruits/vegetables) that compose our corpus of words, causing a higher PS for haptic, taste and smell modality. Concerning the animals, it seems that the auditory modality is sensitive to lifetime experience. Note that many animals were also edible (e.g. chicken, horse, duck), which may also explain that the evaluation of taste increases with age. Although this was not the initial objective of our study, our results showed that it is relevant to further investigate this question by selecting word categories beforehand.

Concerning the BOI, the results suggest weaker sensorimotor embodiment in the older adults (see Costello & Bloesch, 2017), at least for the motor aspects. With age, there is decreased muscle mass, strength, tone, and flexibility that affect all motor behaviors (Rossi, 2018). There is also a decrease in mobility that includes activities such as walking, standing, turning in bed, and climbing stairs that are nonetheless essential for performing activities of daily living (Lowry, Vallejo & Studenski, 2012). Researchers suggest that these motor disturbances encountered in aging may have an impact on their action representations. Motor imagery studies have been highlighted as being particularly relevant for studying action representation processes (Jeannerod, 2001; Munzert, Lorey & Zentgraf, 2009). Indeed, it is a subtype of mental imagery involving a mental simulation of the action (Kosslyn, 1987) and it is perceived as an off-line recruitment of the same neural networks involved in perception and action (Jeannerod, 2007). Various research studies investigating motor imagery show that performance is poorer in older people (e.g. Gabbard, Caçola & Cordova, 2011; Mulder, Hochstenbach, Van Heuvelen & Den Otter, 2007; Personnier, Ballay & Papaxanthis, 2010; Saimpont, Pozzo & Papaxanthis, 2009; Skoura, Personnier, Vinter, Pozzo & Papaxanthis, 2008). For example, Gabbard et al. (2011) observe weaker abilities to estimate whether or not targets presented in peri-personal and extra-personal space are within reach of their dominant limb while participants are sitting. The results therefore suggest that there is a decline in the ability to mentally represent the action with advancing age. This decline is also evidenced when it concerns simply observing an action performed by other people, such as visually estimating the weight of objects lifted (Maguinness, Setti, Roudaia & Kenny, 2013) or estimate the time elapsed during a video interrupted while the actor was performing an action (Diersch et al., 2013). Some researchers attempting to understand this decline suggests that the decreased ability to motor simulate possible actions with objects may possibly be the result of their actual or even perceived loss of muscle strength (Potter, Grealy & O'Connor, 2009). This resonates with Glenberg view of the embodied approach: « how we think depends on the sorts of bodies we have » (Glenberg, Witt & Metcalfe, 2013, p.573). Indeed, it is recognized that our thinking is influenced by our body interacting in its environment. For example, in the case of pathology, Gilpin, Moseley, Stanton, and Newport (2015) showed that participants with osteoarthritis had distorted representations of the size of their painful hand, compared to the control group. The presence of osteoarthritis therefore alters their body schema. However, even when the participants do not have any particular pathology, Bhalla and Proffitt, (1999) show that the simple variable of age influences action perception abilities. In their study, participants were asked to estimate hill slopes under various conditions. They showed that the perception of the slope of a hill is influenced by the physical ability of the participants to climb it; the hills appear steeper in older participants. Our results therefore seem to be interpreted in this regard. The BOI score, reflecting the body's ability to interact with an object, was lower for the elderly and may reflect their lesser representation of their physical ability to interact with the word referent, compared to young adults and suggest an impact of older adults' actual or perceived motor disruptions on their action representations (Costello & Bloesch, 2017). Our results resonate with proposals from embodied theories suggesting that the mind and body are interconnected. The consideration of embodied dimensions in the investigation of aging-related changes is relatively recent and this new perspective may have a beneficial impact on clinical research in gerontology. Indeed, it permits the establishment of models for understanding the effects of aging by taking into account bodily characteristics, action skills, and bodily signals (i.e., tactile, proprioceptive, vestibular, and visceral sensations) that have a great impact on our perception of the environment (Kuehn et al., 2018) and consider relevant avenues to limit decline in aging. For example, Rejeski and Gauvin, (2013) suggest taking seriously mindfulness-based activities that promote proprioceptive abilities and body schema, some of which have been shown to be effective in demonstrating plasticity changes in the proprioceptive system of older adults (see Goble, Coxon, Wenderoth, Van Impe & Swinnen, 2009 for a review).

With regard to both variables studied, it seems that we have obtained opposite results concerning the perceptual and motor representations of the elders. Although we do not exclude the possibility that representation evolves in opposite directions on the sensory and motor level, it is possible that this sensory and motor scission are related to the nuance of the instruction of the BOI. Indeed, whereas the PS asks to estimate the extent to which participants experience the word referent, the BOI instruction asks to estimate the ease with which participants can physically interact with what the word represents, thus emphasizing the *ability* to interact rather than the *experience* of interacting with. From this point of view, the PS measure would pick up on cumulative sensory *experience*, while the BOI measure would capture weaker sensorimotor *abilities* in older adults. Considering the ability to interact with the referent of a word probably involves mentally simulating the action of manipulating it. As motor imagery abilities have been shown to be weaker in aging (e.g. Personnier et al., 2010), it is not so surprising, from this point of view, that the BOI scores of older people are lower. It is therefore interesting to ask whether estimating a PS experience also involves a form of mental imagery. Some evidence from the literature focusing on visual features seems to suggest that word access involves visual simulation even if participants' attention is not explicitly tuned to visual properties (Rey, Riou, Vallet & Versace, 2017). It can therefore be assumed that the explicit instructions to estimate a PS in various dimensions also involves this simulation. This would mean that regardless of the nuance of the instruction, a difference between the evolution of motor and sensory systems would be present in aging.

Finally, we highlight the good psychometric properties of these two variables studied. The ratings had a good internal consistency reliability and also showed high inter-item consistency and inter-rater agreement. However, some limitations of the study should be considered. The small number of words selected and the use of a different procedure between the two populations can be pointed out. We encourage the exploration of this issue on a larger scale and with a greater number of words. Nonetheless, it could be pointed out that all participants evaluated all the items which reinforce the internal validity of the rating whereas studies using larger items pool require to subsets the evaluation. It would also be useful to create groups of words (tools, fruits, vegetables...) to observe if differences appear according to the categories. In this case, a minimum number of words in each specific category should be required, in contrast to our study which was not originally designed to compare categories. It would also be relevant to observe whether differences between young and older adults are expressed taking into account certain psycholinguistic variables such as the frequency with which intergenerational differences have been highlighted (Robert, Dorot & Mathey, 2012).

Notwithstanding this, these investigations show that it is worthwhile to question the use of stimuli and adapted variables capturing sensorimotor dimensions in the study of aging. Future studies investigating sensorimotor representations of concepts in aging should take these discrepancies into account when designing their studies. Although the PS and BOI capture semantic dimensions, we pinpoint the fact that this study was exploratory and our interpretations are based only upon these ratings, which are very explicit measures. It is therefore quite possible that implicit tasks involving these variables will provide other results about the conceptual representations of older adults. For instance, if we investigate the effects of semantic richness (i.e. words associated with more semantic information are processed faster and more accurately given their richer semantic representations, see Pexman, Siakaluk & Yap, 2013) in aging by contrasting words with high vs. low PS or BOI, will these differences in PS and BOI relative to youth influence the results? Will these results be modulated by word category? Will the type of processing (i.e. lexical decision, semantic categorization, naming) be more sensitive to potential effects? These are many questions that remain to be answered and we hope that our studies will lead to further investigations involving various semantic tasks.

Credit Author Statement

AM and ISL had the initial ideas. AM and EW collected the data. AM and ISL analyzed the data and prepared the manuscrit. The results were discussed at length with ISL, GV and AM. EW, GV, LL, LR and ISL revised the latest version of the document. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare no conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.archger.2022.104715.

Appendix A

Instructions for Perceptual strength – English traduction

You are invited to estimate the perceptual (i.e. sensory) experience you have with a concept (represented by a word). This perceptual experience, based on different sensory modalities (visual, auditory, olfactory, gustatory, tactile), is part of our knowledge. Everyone has a different sensory experience of concepts, objects and things.

Read the following words and consider each according to the level of sensory experience it evokes for you. By sensory experience we mean an actual sensation (taste, touch, sight, sound or smell) that you have experienced.

For example, you may have experienced an "orange" by seeing it, smelling it, touching it or tasting it and the level of each modality may vary according to your own experience.

The word "orange" might have a very strong visual perceptual strength, because you see oranges very often (the fruit basket is always full of them), but you rarely eat them, so the gustatory perceptual strength will be judged to be very low.

The word "dog" could have a strong auditory perceptual strength because you have often heard the neighbour's dog barking. On the other hand, if you have never had a dog and have touched few dogs in your life, the tactile perceptual strength will be considered low.

The word "cheese" might have a strong olfactory perceptual strength because you always have strong cheese in your fridge and smell it every time you open it. On the other hand, the olfactory perceptual strength will be considered weak if you never eat cheese.

Your ratings will be made using a scale of 0 to 5.

A score of 0 or 1 indicates no or little sensory experience and a score of 4 or 5 indicates strong or very strong sensory experience. Values from 2 to 4 indicate intermediate scores.

Feel free to use all the scoring possibilities in your different ratings.

Evaluate each of the modalities and concepts independently.

Try to be as accurate as possible, but do not spend too much time on one word. There are no right or wrong answers. We are interested in your own judgement.

Example of a sub-question for the visual modality:

We are going to ask you to rate how much the following concepts are associated, in your opinion, with a visual sensory experience.

For each word presented below, please indicate, by ticking the corresponding case, the answer that best suits you.

As a reminder:

0 or 1 = No or little visual experience
2 to 3 = Intermediate visual experience
4 or 5 = Strong or very strong visual experience

Consigne de force perceptuelle-Version francophone

Vous êtes invité à estimer l'expérience perceptuelle (c'est-à-dire sensorielle) que vous avez avec un concept (représenté par un mot). Cette expérience perceptuelle, basée sur différentes modalités sensorielles (visuelle, auditive, olfactive, gustative, tactile), fait partie de nos connaissances. Chacun a vécu différemment son expérience sensorielle vis-à-vis des concepts, des objets, des choses.

Lisez les mots suivants et considérez chacun selon le niveau d'expérience sensorielle qu'il évoque pour vous. Par expérience sensorielle, nous voulons dire une sensation réelle (goût, toucher, vue, son ou odeur) que vous avez expérimentée.

Par exemple, vous pourriez avoir expérimenté une « orange » en la voyant, en la sentant, en la touchant ou en la goûtant et le niveau de chaque modalité peut être variable selon votre propre expérience.

Le mot « orange » pourrait avoir une force perceptuelle visuelle très forte, car vous voyez très souvent des oranges (la corbeille à fruits en est toujours remplie), par contre vous en mangez très rarement donc la force perceptuelle gustative sera jugée très faible.

Le mot « chien » pourrait avoir une force perceptuelle auditive forte parce que vous avez souvent entendu le chien du voisin aboyer. Par contre, vous n'avez jamais possédé de chien et en avez touché peu au cours de votre existence, la force perceptuelle tactile sera jugée faible.

Le mot « fromage » pourrait avoir une force perceptuelle olfactive forte parce que vous avez toujours du fromage fort dans votre frigo et sentez l'odeur à chaque fois que vous l'ouvrez. Par contre, la force perceptuelle olfactive sera jugée faible si vous ne mangez jamais de fromage.

Vos évaluations seront faites à l'aide d'une échelle de 0 à 5.

Un score de 0 ou 1 indique une expérience sensorielle nulle ou faible et un score de 4 ou 5 indique une expérience sensorielle forte ou très forte. Des valeurs de 2 à 4 indiquent des scores intermédiaires.

N'hésitez pas à utiliser toutes les possibilités de scores lors de vos différentes évaluations.

Evaluez chacune des modalités et chacun des concepts indépendamment.

Essayez d'être aussi précis que possible, mais ne passez pas trop de temps sur un seul mot. Il n'y a pas de bonnes ou mauvaises réponses. Nous sommes intéressés par votre propre jugement.

Exemple de sous-question pour la modalité visuelle

Nous allons vous demander d'évaluer à quel point les concepts suivants sont associés, selon vous, à une **expérience sensorielle visuelle**.

Pour chaque mot présenté ci-dessous, veuillez indiquer, en cochant la case correspondante, la réponse qui vous convient le mieux.

Pour rappel:

0 ou 1 = Expérience visuelle nulle ou faible
2 à 3 = Expérience visuelle intermédiaire
4 ou 5 = Expérience visuelle forte ou très forte

Appendix B

Instructions for body object interaction – English traduction

You are invited to estimate the degree of body-object interaction.

The words differ in the extent to which they refer to objects or things that a human body can physically interact with or not. Some words refer to objects or things that a human body can easily physically interact with, while others refer to objects or things that a human body cannot easily physically interact with.

The purpose of this questionnaire is **to assess how easily your body can physically interact with what the words represent.**

For example, the word "chair" refers to an object that the human body can easily interact with physically (we can sit on a chair, or stand on a chair, or move it from one room to another), whereas the word "ceiling" refers to an object that a human body cannot easily interact with physically (we would have to jump to touch the ceiling).

Any word (e.g., "chair") that you think refers to an object or thing that you can easily physically interact with should have a high body-object interaction rating.

Any word (e.g., "ceiling") that you think refers to an object or thing that you cannot easily physically interact with should have a low body-object interaction rating.

It is important that you make these ratings based on how easily you can physically interact with what a word represents, not how easily it can be experienced by the human senses (e.g., vision, taste, etc.). Also, because words tend to trigger you to think of other words associated with them, it is important that your evaluations are not based on this and that you judge only the ease with which a human body can physically interact with what the word represents.

All words are nouns (i.e., objects or things) and you must make your assessments based on this fact.

Your body-object interaction ratings will be made using a scale of 0 to 5.

A score of 0 or 1 indicates no or low body-object interaction and a score of 4 or 5 indicates high or very high body-object interaction. A value of 2 to 3 indicates an intermediate score.

Feel free to use all of the scoring options in your various assessments.

Try to be as accurate as possible, but don't spend too much time on one word.

There are no right or wrong answers. We are interested in your own judgment.

Consignes d'Interaction Corps-Objet-Version francophone

Vous êtes invité à estimer le degré d'interaction corps-objet.

Les mots diffèrent dans la mesure où ils se réfèrent à des objets ou des choses avec lesquelles un corps humain peut interagir physiquement ou pas avec ceux-ci. Certains mots désignent des objets ou des choses avec lesquelles un corps humain peut facilement interagir physiquement, tandis que d'autres désignent des objets ou des choses avec lesquelles un corps humain ne peut pas interagir facilement physiquement.

Le but de ce questionnaire consiste à **évaluer la facilité avec laquelle votre corps peut interagir physiquement avec ce que représentent les mots**.

Par exemple, le mot « chaise » fait référence à un objet avec lequel le corps humain peut facilement interagir physiquement (nous pouvons nous asseoir sur une chaise, ou nous tenir debout sur une chaise, ou la déplacer d'une pièce à une autre), alors que le mot « plafond » fait référence à un objet avec lequel un corps humain ne peut pas facilement interagir physiquement (il faudrait sauter pour toucher le plafond).

Tout mot (par exemple « chaise ») qui, selon vous, fait référence à un objet ou une chose avec laquelle vous pouvez facilement interagir physiquement devrait avoir une cote d'interaction corps-objet élevée.

Tout mot (par exemple « plafond ») qui, selon vous, se réfère à un objet ou à une chose avec laquelle vous ne pouvez pas interagir facilement physiquement devrait avoir une faible cote d'interaction corps-objet.

Il est important que vous basiez ces évaluations sur *la facilité avec laquelle vous pouvez interagir physiquement avec ce qu'un mot représente*, et pas sur la facilité avec laquelle il peut être expérimenté par les sens humains (par exemple, la vision, le goût, etc.). De plus, parce que les mots ont tendance à vous faire penser à d'autres mots qui y sont associés, il est important que vos évaluations ne soient pas basées sur cela et que vous ne jugiez que la facilité avec laquelle un corps humain peut interagir physiquement avec ce que représente le mot.

Rappelez-vous, tous les mots sont des noms (c'est-à-dire des objets ou des choses) et vous devez baser vos évaluations sur ce fait.

Vos évaluations d'interaction corps-objet seront faites à l'aide d'une échelle de 0 à 5.

Un score de 0 ou 1 indique une interaction corps-objet nulle ou faible et un score de 4 ou 5 indique une interaction corps-objet élevée ou très élevée. Une valeur de 2 à 3 indique un score intermédiaire.

N'hésitez pas à utiliser toutes les possibilités de scores lors de vos différentes évaluations.

Essayez d'être aussi précis que possible, mais ne passez pas trop de temps sur un seul mot.

Il n'y a pas de bonnes ou mauvaises réponses. Nous sommes intéressés par votre propre jugement.

Appendix C

Subjective sensory questionnaire

1 Do you have a visual disorder (e.g. myopia, astigmatism, etc.)?

If so, can you please specify which visual problem it is?
Do you wear glasses to correct this disorder?

1 Do you have a hearing problem (e.g., hearing loss or hearing impairment)?

If so, can you please specify which hearing disorder it is (e.g. left ear hearing loss, complete deafness since birth, hearing loss since the age of...) ?
Do you wear a hearing aid?
Is it globally effective?

1 Do you have a taste disorder? (e.g. loss of taste). Disregard a temporary loss of taste due to a cold, for example.

If so, can you please specify which type of disorder disturbs your taste?

1 Do you have a sense of smell disorder? (e.g. loss of smell). Disregard a temporary loss of smell due to a cold, for example.

If so, can you please specify the cause of your loss of smell?

1 Do you have a sensory disorder that affects your perception of touch? (e.g. loss of sensitivity, hypersensitivity,...).

If so, can you please specify ?

Subjective motor questionnaire

1 Do you have difficulty walking?

If so, check one of the following :

- I use an aid such as a cane, rollator,...
- I use a wheelchair
- I do not need any help
- Other : …

1 Do you have difficulty moving your arms/hands?

if yes, please indicate the nature of your difficulties.

1 Do you have any other motor difficulties?

If so, can you please specify the part of the body concerned

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