

Words for Odours

Words for Odours:

Language Skills and Cultural Insights

Edited by

Melissa Barkat-Defradas
and Elisabeth Motte-Florac

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FOREWORD

JOËL CANDAU

In the humanities and social sciences, any research on odours comes up against four preconceived notions, all the more robust as they are considered interdependent: that *Homo sapiens* is, from a functional perspective, a microsmatic species; that we make little use of our sense of smell, considered the lowliest of the senses; that the consequence of this is that we live in societies evolving towards “olfactory silence”, and, lastly, that a defining characteristic of natural language on odours is its paucity.

Although the three first propositions, contrary to the fourth, only have indirect links to the contents of the present volume, I feel it necessary to briefly point out the fragility of their foundation because they are often called upon to bolster the theory that humans lack the words to speak about smells.

It is commonplace to oppose our species, with our supposedly poor sense of smell for which we are labelled microsmatic, to the numerous macrosmatic animal species, naturally gifted to make use of this chemical sense. Abundant literature describes these exceptional olfactory capacities, among eusocial species of course, but also among most mammals, homing pigeons, salmon, sharks, etc. One could perhaps consider that this dominance of the sense of smell on the behaviour of other animal species is the reason behind the success of the scientific vulgate which, throughout the 19th century, upheld that humans came to their full dignified state when, by standing on two legs, they distanced themselves from the olfactory messages wafting at ground level. This made it possible not only to create a firm border between our species and the rest of the animal kingdom but also, within the former, to ground in nature inequality between so-called lesser evolved peoples, i.e. “savages”, “natives”, imperfectly rid of the olfactory imperium (and its sexual and bestial connotations), and so-called “civilized” societies, largely sheltered from such influence. For certain 19th century anthropologists and psychologists, actions performed under the influence of olfactory perception were characteristic of “primitives”, “supposed to follow their noses in pursuit of both women and animals” (Dias 2004, 47).

In fact, with the exception of certain pathologies (anosmia, hyposmia, dysosmia, etc.) and notwithstanding variation across individuals, as observed for all cognitive, emotional and sensory abilities, human are actually quite good at detecting odorous substances, both quantitatively (as noted by M. Barkat-Defradas and E. Motte-Florac in their introduction) and qualitatively, in terms of thresholds. Whereas calculations carried out in the 1920s (Crocker and Henderson 1927) led researchers to estimate that humans could perceive at most 10,000 smells, recent work in psychophysics (Bushdid *et al.* 2014) concludes that our species could distinguish between at least one trillion olfactory stimuli. If one looks at the perception threshold, among the volatile sulphur compounds we are capable e.g. of perceiving furfurylthiol, one of the components in the smell of coffee, at the remarkably low threshold of 5 ng.L. In laboratory settings, young subjects are able to distinguish between the smell of elderly people (between 75 and 95) and younger people (Mitro *et al.* 2012). Other experimental studies suggest an ability to smell fear (Ackerl *et al.* 2002) and hint that we are emotionally sensitive to the smell of tears (Gelstein *et al.* 2011), and even that we can discriminate between people's smells based not only on their gender but also on their sexual orientation (Martins *et al.* 2005). Again in laboratory settings, we are able to follow a scent with great precision, not as well as a dog, but nonetheless to a comparable degree (Porter *et al.* 2007). Such performances could appear surprising because, as regards our olfactory receptors, they are fewer in number and cover less surface area than in many other species. However, as pointed out by Schaal, Wathélet, and Ferdenzi (2013), our sense of smell is doubly amplified (i) through cognition, olfactory information being “maximized” through precise analysis and the powerful and complex integration of other sensory messages using our highly performing neocortex; and (ii) through culture. By essence, cultural amplification varies across groups. For example the Tsimane peoples of the Bolivian Amazon detect n-butanol at significantly lower concentration levels than German subjects living in Dresden (Sorokowska *et al.* 2013) for reasons linked, for the Tsimane, to education and environmental pressures, and, for the Germans, to the effects of pollution. However, to a certain extent, this amplification is to found everywhere, because of our aptitude for “signifying” our olfactory perceptions and giving them “thick” content, namely through language. In sum, to call *Homo sapiens* a microsmatic species is clearly excessive.

From a functional perspective, like its most-distant ancestors and many animals, our species can excel at using olfactory information. Newborns are able to smell within the first week after birth, where the smell of the

maternal breast, armpits and neck, even at low intensities, have a directional effect on the baby's behaviour: at day 6 the baby distinguishes between the smell of his mother's breast and that of another suckling mother, showing a preference for turning to the first. The selective processing of maternal odours (especially that of her breasts vs. all others') actually happens much earlier, in the first hours following birth (Schaal 1995). In fact, throughout our lives (even though age, as always, has a deleterious effect), odour deciphering plays an important role in our daily activities (eating, cosmetics, sexuality, social interactions, rituals, therapy, identifying toxic substances), and our ability can be improved with learning. Many empirical data thus contradict the idea that, in broaching the world, our species makes little use of the sense of smell.

Whether the cause or the effect of this supposedly minor sense, some believe we will soon live in an environment from which all odorous substances have been banished. We will forgo the proximate senses and more particularly the sense of smell, with "odoriphobic" societies progressively gaining over "odoriphilic" societies, to the point that the world will become anosmic. Our destiny would be "the olfactory silence of a deodorized environment" (Corbin 1982, 270). Once again, observation contradicts this preconceived notion that some societies are odoriphobic, even among Western societies. The sense of smell is undoubtedly often neglected and, therefore, little known. But that does not mean that it is despised.

Historically speaking, humans have had an ambiguous attitude towards the sense of smell, hesitating between belittling it and rehabilitating it. Two factors have worked against this sense. First, since Archaic Greece, academic mistrust of the sensory qualities, thought to mislead scientists away from the true essence of things. Second, the emergence of a cult for vision, culminating in the "*iconorrhée*" (Candau 1996), the overload of images we experience today. This distantness from the sense of smell is also founded in moral imperatives. For Plato, heavy perfumes were associated with luxury, frivolity and "unbridled" pleasures. Instinct, desire, superficiality, regression, culpable voluptuousness, animality and even bestiality, are some of the terms one finds in the writings of a large number of philosophers, and which are considered reasons for the lowly rank of smell in the hierarchy of the senses.

And yet, contemporary olfactory practices have overturned the hypothesis that odours are despised. The magnificent research carried out by Alain Corbin is more than convincing on the historical periods he has studied. It is true that, beginning in the 18th century, at a time of collective hyperesthesia, people began tracking "bad" odours. This tracking however

has nothing to do with the olfactory silence said to be prevalent today. In 2011, the perfume and cosmetic industries showed a world turnover of 260 billion euros (Seeruttun 2012). This “buoyant market”, as the saying goes, shows strong growth: between 400 and 500 new scents are marketed each year. In many areas of social life, to the indubitable signs of odour repression (e.g. deodorants) respond the profuse signs of odours' importance, in the aisles of supermarkets, the opening of new perfumeries in cities, the abundance of detergents promising a “clean smell”, scented books, aromatherapy, olfactory ambiances in art exhibitions, olfactory design, olfactory technology, etc. In studies I carried out on olfactory knowledge and knowhow, I established that the sense of smell is often subjected to elaborate training, whether explicit or implicit, making it a first-ranking instrument in many professional contexts. In truth, far from olfactory silence, we are bombarded with smells; one must simply forget current ideas on the worthlessness of smell which is in no way the logical consequence of the uncontested primacy of sight.

I now come to the last preconceived notion, which the present work happily contributes to dissipating. This notion pervades the scientific literature on odours, which I have largely called upon myself. The sense of smell is said to be “mute”. It is true that during an olfactory experience, communicating the description of the perception is not easy, for at least two reasons. First of all, many smells remain at a sub-verbal level. Of course this is true for other sensory stimuli (audio, tactile, gustatory as well as visual), but as the authors of *La Logique de Port-Royal* well realized – we think of sensory qualities, in the words of Arnauld and Nicole, using “confused and obscure ideas” (1992, 64) – and Cabanis, strongly influenced by Condillac's sensualism, in his *Rapports du physique et du moral de l'homme*, writes “*Les matériaux des idées, existent bien certainement [...] avant les signes*” [The matter of ideas very certainly exists [...] before their signs] (1980, 96). This phenomenon is particularly powerful in the case of the olfactory exploration of the world. Smells are sensed in a massively holistic manner, they are apprehended as a whole, a salient entity, without there necessarily being any verbal encoding.

Cabanis further notes that these sensations can only be well understood “*qu'en leur attachant des signes qui les représentent et les caractérisent ; on ne les compare qu'en représentant et caractérisant également par des signes ou leurs rapports ou leurs différences*” [by attaching signs to them which represent or characterize them; they can only be compared by also representing and characterizing them by signs in their resemblances or differences] (1980, 95). He adds that in particular these signs – i.e., for him, language – allow us to fix our own sensations. “*Ils les retracent, et*

par conséquent ils les rappellent; c'est là-dessus qu'est fondé l'artifice de la mémoire. [...] Les signes rappellent donc les sensations ; ils nous font sentir de nouveau. Il en est qui restent, pour ainsi dire, cachés dans l'intérieur ; ils sont pour l'individu lui seul. Il en est qui se manifestent au-dehors ; ils lui servent à communiquer avec autrui" [They retrace them, and in consequence recall them; that is what the artifice of memory is based on. [...] Signs thus recall sensations; they make us feel again. In a manner of speaking, some remain hidden within; they are for the individual only. Others are manifested without; they serve to communicate with others] (1980, 96). The question this raises is whether, during such communication, signs really allow us to turn sensations experienced, which are deeply subjective (*qualia*), into shared intelligibility?

If one considers the verbal encoding of colours, this appears quite true. If I write that the curtains in my office are "red", each reader will have a pretty precise idea of the luminous impression they give, with negligible cross-individual variation (excepting pathological cases) which probably do not alter intersubjective communication. In many other domains of sensory experience, describing the attributes of a stimulus in order to communicate them is not obvious. As Lévi-Strauss observes "*le monde des sonorités s'ouvre largement aux métaphores*" [the world of sounds is largely open to metaphors] (1964, 30) which is amply illustrated in literature, from the famous long sobs of autumn's violins (Verlaine) to the "golden sound of bells" which, in Proust's universe, contains "the bland taste of jams" (Proust 1987, 78). The ability to evoke these metaphors is very strong, but the manner in which the evocation is oriented varies quite freely from one individual to the next, which is the nature of symbolic thought (Sperber 1974, 149). At the outset, one is never sure of conveying a meaning, even though multiple factors (social frameworks, the context, capacity for social cognition, the pertinence of the discourse, etc.) aid towards this goal. Much work on olfactory experiences show that the phenomenon is heightened in the presence of odorous signals. If I write that this morning at the butcher's I smelled a "thick" odour, what meaning will my readers ascribe to this descriptor? Shared understanding, one guesses, will be less easy to reach than when I noted that my curtains were "red" in colour. This is an important specificity of the verbal encoding of odours. While we are very good at distinguishing between olfactory stimuli, and categorizing them more or less precisely, abilities which are without doubt useful for the survival of our species, we have much more difficulty describing them. In many languages, including English, the olfactory lexicon is imprecise and unstable (the same descriptor can have several referents, and several descriptors may be used for a given

stimulus). Contrary to the colour lexicon, the constance of the meaning-stimulus from one speaker to the next, which characterizes what Quine calls “observation sentences” (Quine 1977, 80), is often absent from the natural language of odours.

However, this is not true for all languages. In fact, a number of ethnographic and linguistic investigations have shown that there are cultures which have descriptors exclusively reserved for odours, which could be the olfactory equivalent to the “basic colour terms” in colour perception. The most recent study is that of Majid and Burenhult (2014) on the Jahai of the Malay Peninsula, an ethnolinguistic group of about 1 000 individuals. These individuals find it equally easy to name odours and colours. They are able to isolate basic odour properties, very similarly to how we are able to conceptualize the colour white independently of milk. For example, all the Jahai who were questioned agreed on describing the odour of cinnamon using *cɨʔas* (pronounced “cheng-us”), a term also used in describing the smell of garlic, onion, coffee, chocolate and coconut. Thus they are able to identify and abstract a single olfactory property from all of these foods, without having to refer to the source of the odours. This lexical competence is also observed in other Austro-Asiatic languages (Burenhult and Majid, 2011) and, for other groups, in specific fields such as e.g. body odours, this appears to be the case for the Waswahili (Wawrzyniak, this volume) and, concerning “bad” odours, for the Fang (Medjo Mvé, this volume).

In consequence, the preconceived notion as to the paucity of the olfactory lexicon must be moderated, as thoroughly as for the three preceding ones, especially as we are a far cry from knowing what there is to know about natural language of odours in the 6 000 to 7 000 languages spoken today. The olfactory lexicon is not a cultural invariant, and, moreover, in many languages where it is unstable and imprecise, it is not necessarily poor. Indeed, as the reader will discover throughout the rich and varied contributions in this volume, it is often metaphorical, poetical, exuberant, and always denotes complex interactions between, on one hand, physiological, cognitive and cultural resources, and on the other, purely linguistic resources.

I will not go into the details of the contributions as M. Barkat-Defradas and E. Motte-Florac have done a beautiful job in their introduction. I simply wish, in a few words, to show how their presentation in four parts, each with its own theme, clearly lays out the crucial issues in the study of the natural language of odours.

One can define perception as a judgment, whether verbalized or not but always tightly linked to a given context, determined on one hand by the

supposed source of a smell and, on the other hand, by intensity, familiarity and the hedonic valence of the stimulus. A fundamental question raised in the first part of the book is to determine, in the chronology of perception, what the effects are of everything that precedes verbalization on how the perception is expressed? To what extent do the molecular structure of the odour, the potential and limits of the sense of smell, the primary sensations, emotions, imagination, olfactory memories, multisensory integration, social and cultural contexts modify its expression? The second part builds on this investigation, with the papers examining interactions between the verbalization of odours and their categorization, the latter being largely based (i) on the hedonic valence of the imagined source of the odour and the stimulus itself, (ii) on the cultural classification of the various senses and the relative importance awarded to each. Does putting things into words, each society doing it in its own way, attest to cultural variability in olfactory experiences, or does this linguistic diversity mask the existence of experiential invariants (universal categories) in all humans? This question, at the heart of the third section, leads to another, to which the conclusion of the book is devoted: all in all, what are the linguistic properties of olfactory descriptors? Have they anything in common with “basic color terms”? Is there such a thing as an odoronym? Does the Rosch hierarchy (superordinate, basic, and subordinate levels) apply?

I am convinced that, in the chapters that follow, the reader will discover with as much pleasure as myself the answers provided to these questions, and the new questions they raise. Before concluding this foreword, I will risk mentioning one question, which is touched upon in several chapters.

It would seem that the denomination of olfactory experiences has scope over the last of the three terms of the chain of perception: (i) aerial dissemination of a smell from a source, (ii) functional processing of the stimulus by the sense of smell, (iii) mental event called “odour”. When put into words, denomination transforms the mental event, which is intrasubjective, into a public, and therefore intersubjective, representation. What is important in my view is to determine to what extent mastery of the descriptors on one hand and their publicisation on the other retroactively effect the preverbal perception of the odour, thereby contributing to its socialization and culturalisation. From a Whorfian perspective (Candau 2003), the possibility that verbal encoding influences perception cannot be excluded. When two descriptors are associated with the same stimulus by two different speakers, could this mean that the verbalization induces a difference, even very slight, in their perception? Or

when a wine-taster describes a white or red wine by referring to products associated with their colours (Morrot *et al.* 2001), does he look for vocabulary in keeping with the wine's colour so as to, after the fact, describe a perception that was first formed as an olfactory image, or does the vocabulary resonant of the colour instead structure the olfactory perception, which would in that case first be formed as a verbal representation?

That is just one example of the many musings inspired by the pages that follow. It is trivial to stress that we expect language to help us overcome intrasubjectivity to attain intersubjectivity, for example by helping us share our sensory experiences. Does the natural language of odours always reach this goal? The question remains open and of course “Words for Odours: Language Skills and Cultural Insights” does not pretend to have the last word on expressing odours. I have no doubt however that this book will heighten intersubjective understanding of that strange language which is, in the words of Huysmans, the idiom of fluids.

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¹ <http://www.margaret-dunham.com/index.php/accueil.html>.

LIST OF ABBREVIATIONS

Abbreviations

Adj.	adjective
Adv.	Adverb
C(1, 2, 3, 4)	(first, second, third, fourth) consonant
Det	determiner A syntactic category that includes the definite article “the”, the indefinite article “a” and its variant “an”, the demonstratives “this” and “that”, and ordinary and reflexive pronouns.
DP	determinant phrase
N	noun
N1.....N2	first noun ... second noun
NP	noun phrase
V	verb

Linguistic symbols

* asterisk indicates a sentence’s syntactic ill-formedness (agrammaticality).

? or (?) question mark indicates a sentence which abides by the grammatical rules of a language but which native speakers/hearers speakers consider unfit for use (acceptability).

pound sign indicates a sentence's semantic or pragmatic ill-formedness.

[t] square brackets mark phonetic/allophone boundaries.

{ } curly brackets denote alternatives; morphemic elements, morphemic junctions or roots.

INTRODUCTION

VERBALIZATION OF OLFACTORY PERCEPTION

MELISSA BARKAT-DEFRADAS
AND ELISABETH MOTTE-FLORAC

“For some inexplicable reason the sense of smell does not hold the high position it deserves among its sisters. There is something of the fallen angel about it.” (Helen Keller, *The World I Live In*, 1908, 33)

Although the sense of smell has long played an important role in literature and poetry (Ovid, Baudelaire, Proust, Zola, Huysmans, Shandy, Sterne, Calvino, des Esseintes, Suskind...)¹, it has mostly been the “ignored sense” (Howes 1986) and was rarely studied until recent decades. In philosophy, with the exception of the *Treatise on Odours* by Theophrastus, it has not been the subject of any major work; one only finds allusions to it (Lucretius, Democritus, Pascal, Condillac, Montaigne, Buffon, Rousseau...). It was not until the 1980s that researchers in the humanities began to take an interest in the sense of smell. For the philosopher C. Jaquet (2010, 5), it is A. Corbin who

“à travers son ouvrage *Le miasme et la jonquille*, paru en 1982, a puissamment contribué à briser ce qu’il appelle le silence olfactif. [...] *Les anthropologues, les sociologues et les chercheurs en sciences de l’information et de la communication lui ont emboîté le pas*”. [through his work *Le miasme et la jonquille*, published in 1982, powerfully contributed to breaking what he calls the olfactory silence. [...] Anthropologists, sociologists and researchers in computer and information sciences followed in his footsteps.]

Subsequently, many studies of this sense were published, particularly in anthropology (e.g. Howes 1986; Classen 1993), psychology (e.g.

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Richardson and Zucco 1989; Béguin and Costermans 1994) and history (e.g. Le Guérer 1998). It quickly became clear that a multidisciplinary approach was indispensable; fields which had long been separate, such as linguistics, neurophysiology (Buck and Axel, Nobel Prize 2004), applied chemistry (especially in the perfume, pharmaceutical and agro-food sectors), etc., got together to better understand it, more particularly in its linguistic and cognitive dimensions of interest to us here.

Colour naming has been the object of in-depth studies since H. Zwaardemaker (1925, 178) wrote,

“Odours have no proper names. In ordinary language we simply refer to the material they originate from. We speak of odours as we used to speak of colours, that is by comparing them with well-known objects.”

In 1969, in their innovative work on colour denomination, B. Berlin and P. Kay posit that a set of fundamental colours is at the base of all the human terminologies inventoried. This work of universalist scope gave rise to numerous reactions and criticisms and helped further both theory and study protocols. It also had the effect of drawing attention to other sensory stimulations. Unfortunately, work on odours cannot benefit from the methodologies used for colours and their improvements; it is impossible to use experimental mechanisms analogous to e.g. the Munsell² colour wheel.

The human sense of smell was long considered underdeveloped, however research has shown its remarkable capacities³ and the way in which it guides – consciously or not – our behaviour. That being said, although humans are remarkably able to detect smells, their ability to identify them is limited – even though it can be improved through comparisons and multiple choice tasks (Dubois and Rouby 1997, 10-11). The first reason behind this limitation rests on three major technical obstacles: (i) a lack of a shared relevant reference: there are no measurement methods to objectively describe the stimuli (Dubois and Rouby 1997, 12); (ii) there is no range of odours (Howes 1986, 43); (iii) result biases (in olfactory identification performances) due to the experimental protocols: sensory analyses are generally carried out in a non-ecological setting, using smelling cards or by sniffing smelling sticks (Plümacher and Holz

² The Munsell colorimetry system is a three dimensional colour space composed, around a chromatic circle, of five basic hues and five intermediate hues, defining ten principal hues.

³ The large number of genes devoted to the olfactory function alone is indication of its importance and complexity (Holley 2006).

2007, 4). The second reason behind this limitation is that identification indicators are essentially verbal and in many languages there are no lexicalized denominations for odours.

The earliest works on how languages denominate odours (David *et al.* 1997) show that there are much fewer and less stable specific terms than for the emblematic sense which is sight, with a much less systematic lexicon. One of the main hurdles to research is the difficulty and complexity of translating olfactory experiences into words. There are thus many gaps, all the more so as the first crosslinguistic studies show that odour lexica vary widely across languages and cultures (Boisson 1997). Contrary to colours, invariants are rare. To make progress in the area of understanding and verbalizing olfactory experiences it is thus essential to multiply investigations in highly diverse contexts and to compare results. The “13th Congress of the International Society of Ethnobiology” held in Montpellier, France, in June 2012 provided the occasion to bring together researchers wishing to contribute to filling these investigative gaps.

Based on interdisciplinarity, ethnobiology brings together researchers and actors from a broad range of academic backgrounds and horizons with a variety of objectives, making it easier to explore the innumerable possible interactions between human societies and their natural surroundings. This is why the ethnobiology congress was chosen to propose a session (“Speaking of odours: Mutual understanding in the context of culture contact”) where it would be possible to confront research carried out on how olfactory experiences are put into words across languages, societies, natural and social environments as well as across different professions. This meeting had the further advantage of implementing a spirit of interculturality among the researchers themselves (of different nationalities and with a wide range of scientific cultures and backgrounds) to foster healthy questioning of the methodology employed as well as the representations and conceptions upon which the working hypotheses, models, etc., are based.

The papers presented during this session to address the proposed theoretical and/or pragmatic questions⁴ make up this book. This presentation of the contents aims to further explore the verbalization of olfactory experiences despite the heterogeneous nature of this type of work and the inevitable recurrence of some of the notions broached (methodological constraints, lexical voids, the question of universals, the importance of hedonic valence, etc.). The papers are divided into four themes where some fields of study are more or less prevalent. The first

⁴ See the website: “13th Congress of the International Society of Ethnobiology”. Academic Sessions. S06.

part of this work is devoted to the tight links between olfactory perception, emotions and cognition, and explores the stages by which one moves “From Olfactory Perception to Verbalization”. The human necessity of performing sorting operations before naming a smell leads naturally to the second part, where the main elements used to render similarities and differences are analysed. This shows that “Categories and hedonic Valence” dominate the foundations upon which not only societies construe their olfactory experiences in keeping with the representations of the universes they create and the beings which inhabit them, but which also enable humans to stay alive and in good health. Every culture, social group, profession has its own particular manner (lexical, grammatical, semantic) of broaching smells and positioning them on a hedonic scale. In the third part, the verbalization of olfactory experiences is centred on “Lexica and cultural Variation”, showing us how humans in various languages (from Africa) express smell perception, in accordance with their natural surroundings, the particularities of the human group(s) they belong to, and the sociocultural conceptions they adhere to. The fourth and last part, “Putting Odours into Words”, shows in detail how two Indo-European languages (French and Greek) shape and modulate the lexicon through various mechanisms of how languages take odours into account.

From olfactory perception to verbalization

Research on the cognitive representation of the olfactory field (e.g. Dubois 2000) has shown the usefulness of linguistic analyses in the area just as research on olfactory perception in cognitive science (e.g. Sicard *et al.* 1997) has furthered linguistics. Interdisciplinary studies are thus necessary, but it is difficult to materialise mental representations. Because they cannot be observed directly, they must be reconstructed using abductive logic. Representations triggered by smells are even more difficult to grasp given their particularly close ties to emotions. In French, the verb *sentir* (both “sense” and “smell”) is fundamentally anchored in subjectivity (Franckel 2004); it is associated (as in other Indo-European languages) with the notions of perception and intuition. It bears testimony to the “subjective space” that intervenes between olfaction and its expression (Pfeffer 2004, 106), given that perception is subject-specific, the sense of smell being both introverted and intimate. The nose, with its position half way between the face’s top and bottom, signals individuals’ interiority, feelings, emotions, passions (Hegel, *Esthétique*, quoted by Ricaud 2004). Because of this subjectivity, languages (or at least those of Western civilisations) have no - or few - invariants based on collective