"Emotional Nose": The Hedonic Character of Olfaction and its Epistemological and Clinical Implications

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***Abstract*— The olfactory system is the oldest device that most organisms have to perceive their physical and social environment. However, progressing in the evolutionary tree, the importance of the olfactory perception has decreased, and the sight has taken dominance. Notwithstanding, the olfaction still plays a fundamental role, as it is strictly associated with emotions, which are a medium between perception and behavior. The current work aims at addressing the hedonic character of the olfaction, showing its strong clinical implications for clinical psychology, neuropsychology, and CogInfoCom.**

Keywords—Olfaction; Emotion; Clinical psychology; Neuropsychology.

I. INTRODUCTION

The olfactory system is the most acute and phylogenetically oldest device that the organisms with a nervous system have to knowing their physical and social environment. The functions of olfaction are related to social and sexual communication and behavior, to finding food, and to avoiding predators and other environmental dangers, contributing to survival and adaptation of the individual and the species [1]. In going up the evolutionary scale, the importance of the olfactory perception decreases; consequently, while olfaction plays a key role for the survival of insects, fishes, and numerous mammals, in humans this sense has increasingly weakened and has partially lost its importance.

As stated by MacLean [2], in superior mammals the evolution of the brain entailed a shift of the influence on sexual and social behavior and on communication from olfaction to sight. This change implies not only a "dominance" of one sense over another in driving behaviors, but also a broader psychological change in the relationship with the physical and social environment.

However, the olfaction is also strictly associated with emotions, representing a medium between perception and behavior. For instance, the function of the emotional embodiment of odors in animals guided mainly by olfaction seems that of narrowing the decision-making space to the degree of inducing a specific behavior. In the current work, we will specifically address the hedonic character of the olfaction and its implications for clinical psychology and neuropsychology, as well as for CogInfoCom's goals. Indeed, we will argue that odors represent fundamental environmental elements able to promote emotional well-being or foster psychological distress.

II. PHENOMENOLOGICAL FEATURES OF THE OLFACTION

Olfaction is a chemical sense, particularly because the stimuli to which smell is sensible are chemical volatile elements. The chemical nature of olfaction has a fundamental neurobiological implication, as its receptorial structure expresses a sensibility toward thousands of different chemical elements that are presents in the environment.

Some authors have particularly insisted on the unitary feature of the olfactory experience. For instance, Stevenson and Attuquayefio [3] argued that: (a) olfactory conscious experience appears to be mainly singular, with one odor event perceived at a time; (b) an olfactory percept cannot be broken into different parts; and (c) the olfactory experience is a whole that has some sense of (internal and qualitative) coherence. This means that olfactory perception has the capacity to synthesize the various solicitations of the diverse odorants

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which affect the receptorial apparatus in a unitary, qualitatively one-dimensional, all-saturating conscious manner.

All these phenomenological features of the olfactory experience have a neuropsychological explanation that clarify their behavioral, communicative, and psychological implications. The conscious experience of an odor takes place in the olfactory bulb [4], whose most relevant work consists in inhibiting the major part of the different receptorial inputs that affect the olfactory epithelium, thus consolidating in a unique odor perception the action potentials of a certain odorant or set of affine odorants. This means that the inhibitory processes represent the major determinant of the receptor input strength [5]. In other words, the neuropsychological construction of an odor perception entails that, in the path from the receptorial area to the olfactory bulb, all the receptorial signals not related to the perceived odorant must be extinguished and inhibited. Summarizing, differently from the sight where the perception of the background is extremely necessary to the object perception, in olfaction it happens in the exact opposite way [6].

In the majority of animal species, olfaction plays a key role in mating, communication, avoidance of predators, maternal care, territorial control, feeding, and prey hunting; in other words, in the social life regulation [7]. Through olfaction, animals are able to extract from chemical elements a variety of crucial information essential for the survival of the individual and the species. Thus, in animals in whose olfaction is the predominant sense there is a direct and immediate connection between some chemical elements present in the environment, the olfactory perception, and the related behaviors. For instance, an olfaction-related behavior could be that of a mouse that flees after smelling traces of cat urine [8]. In this case, it is possible to hypothesize that the mouse perceives a chemical cue that, produces a physiological reaction of fear, and this physiological condition produces a specific behavior, that is the flight [9]. This means that the flight behavior represents an immediate consequence of the neurophysiological arousal produced by the perception of the predator's kairomones [10].

III. Hedonic features of the olfaction

Engen [11] stated that "Functionally, smell may be to emotion what sight or hearing is to cognition" (p. 3). This statement entails that (a) emotion is a structural element that accompanies and characterizes olfaction, differently from sight or hearing, in which perception is less embodied; (b) emotion is functionally related to olfaction—and to the olfactory-centric experience of the environment—while thinking is functionally related to vision, that is, to the human visuo-centric experience of the environment; and (c) the psychological features that distinguish olfactory-centrism and visuo-centrism could be better discerned if we pay attention to the role of the intermediate elements between perception and behavior, which are indeed emotion and thinking.

With regard to the first point, neuroscientific research has widely demonstrated the structural connections between the olfactory system and the limbic system [12], a subcortical structure that is responsible, among other things, for the consolidation of olfactory memories and emotional arousal associated with olfactory perception. He argued that the functions of the limbic brain deal with self-preservation and the preservation of the species, and in that species olfaction plays a key role in of cognition and behavior,

This means that the evolution of the brain, with the sizable growth of the neocortex, had the effect of giving more importance to visual perception, and consequently to support the development of thinking and more flexible behaviors, while in lower mammals, where the limbic system guides cognition and behaviors, olfaction is the major perceptive system, and consequently behaviors are rigid and cognition is emotionally embodied. But why does an emotionally embodied perceptive system, such as olfaction, give rise to a rigid and inflexible cognitive and communicative structure?

A recent theory of emotion is proposed by Damasio [13]. He has argued that emotions play a crucial role in cognition and behavior, especially in decision making, by virtue of emotions' embodiment. He has claimed that the function of emotions consists in giving a hedonic connotation to a situation or a representation, which inclines an individual toward a limited set of behaviors. According to this hypothesis, emotions should be considered as "somatic markers" that have the role of narrowing the range of decision making, and for this reason they perform a cognitive and behavioral task. Damasio discussed this hypothesis in relation to human secondary emotions and decision making, arguing that the human decision-making process takes place in the ventromedial prefrontal cortex and that the function of emotional somatic markers is due to the connection between this cortical region and the limbic system, in particular with the amygdala. This means that in a visuo-centric experience of the world, typical of human beings, emotions could *incline* toward a certain behavior or set of behaviors but could not *determine* a behavior.

It is conceivable that in organisms where the perceptive process is more emotionally embodied, such as in lower mammals, the role of emotions in narrowing the decision-making space is more pressing and inflexible. Which means that olfactory perception is so much embodied that it often induces and *determines* a set of specific behaviors, instead of inclining toward it, as the case of the perception of pheromones shows [14]. In the case of olfaction, the precision of the perception often corresponds with the precision of a behavior, and that is the reason why an olfactory perception must be unitary, qualitatively one-dimensional, and all-saturating. Doing a mental experiment, if a mouse perceives cat urine in the same way that we perceive the moon, its behaviors would probably be less adaptive. In relation to the background, the moon appears sometimes bigger and other times smaller, sometimes motionless and other times in movement [15]. It could be difficult to imagine a mechanistic behavior that is "moon dependent," because the moon could appear sensibly different in different contexts. The cat urine, instead, is perceived without ambiguity and this guarantees a mechanistic and affordable response.

In the case of olfaction emotions represent a medium between perception and behavior. The function of the emotional embodiment of odors in animals guided mainly by

olfaction seems to be narrowing the decision-making space inducing a specific behavior, differently from sight. In the human visuo-centric experience, instead, the information derived from visual perception is richer and more complex, there is a co-presence of different objects and a figure-ground organization, and consequently there is always the possibility to perceptually organize in different ways this material derived from vision in order to perform a behavior, to solve a problem, or to make a decision,. This means that the decision-making space is less restricted because the visual perception offers a space richer in possibilities [16]. The visual object, actually, is "made" by relations (i.e., levels of luminance, figure-ground, etc.) and "stays" in relation with other objects in a dynamic organization. Gregory [17] called this dynamic organization "intelligent eye," because the the visual system organizes the sensory data in representations that are mere "hypotheses" about the external material world, that is, interpretations that could change in relation to the context.

Thus, if on the one hand there is an "emotional nose," that is, an olfactory system whose function is detecting one odor at a time, an odor that is often emotionally embodied and therefore gives rise to determined behavioral responses, on the other hand there is an "intelligent eye," that is, a system that dynamically organizes relations among a plurality of sensory elements and therefore gives rise to less embodied "interpretations of" or "hypotheses on" the environment. The behavioral response to an environmental challenge presented by means of sight needs a different medium between perception and behavior: emotion could be a good medium when a mono-dimensional and unitary perceptive datum *must* lead to a determinate behavior. But in the case of the complex and dynamic organization of the visual object, evolution has provided individuals with the medium of insight and productive thinking.

This is probably the most important psychological difference between olfactory-centrism and visuo-centrism: insights and productive thinking can develop only if a perceptive system makes it possible. Emotion could be a good medium between perception and behavior for the olfactory-centric organisms, but not for the visuo-centric ones, that need a more flexible and sophisticated medium.

IV. Clinical and ICTs implications

The relation existing between emotions and olfaction has important implications for clinical psychology and neuropsychology. In fact, although the role of pheromones in determining some human behaviors is still debated [18, 19], it is known that odors often have a hedonic value in humans [20, 21]. The hedonic value of odors is represented in different areas of the brain [12], but in particular in the amygdala, and several studies have demonstrated that exposure to particular odorants, for instance to particular essential oils, affects the modulation of the central neurotransmitter system [22], and this represents evidence for the effect of specific odorants in determining affects and emotions. Some studies reported that the inhalation of essential oils producs effects, in animal models, on mood-related behaviors that might be comparable to the effects produced by psychoactive drugs [23, 24, 25]. There is therefore a relatively broad consensus on the idea that specific odorants could affect animal and human behavior and mood, by virtue of their hedonic, emotional, and affective effects [26, 27, 28, 29].

These data show that certain odorants might have effects on emotions, but the contrary could also be possible; that is, emotions and atypical conditions in processing emotions could affect olfaction. Some research, for instance, correlated alexithymia with physiological responses to odor identification and thresholds [30]. The results showed that alexithymic subjects express abnormal physiological responses to odors, and that the different alexithymia components were differently associated with performance on olfactory testsand reaction times in the rating tasks.

Recent systematic reviews have shown that a close relationship between olfaction and mood disorders exists [31, 32]. Specifically, depressed subjects generally exhibit decreased scores in olfactory threshold, discrimination, and identification tasks.

In addition, it is noteworthy that olfactory dysfunctions are observed also in important neuropsychological disorders, such as Alzheimer disease [33], Down syndrome [34], and Parkinson disease [35]. Nevertheless, mechanisms responsible for olfactory dysfunctions in such diseases are partially unknown, even if the olfactory impairment seems to depend on their neurological and genetic modifications.

Research activity on olfaction features and its peripheral and central mechanisms has relevant implications also for the development of new IC technologies and engineering outputs, and more generally for the scope and goals of CogInfoCom [36]. To this end, several electronic devices have been already implemented to detect organic and inorganic chemical elements that are presents in the environment (the so-called *e-nose*), in order to identify biological hazards in food, beverage, and atmosphere [37, 38]. *E-noses* represent a strengthening of the human olfactory system, whose main function remains the detection of biological hazards, especially in relation to the ingestive behaviors [39]. A deeper comprehension of the different cognitive, emotional, and behavioral aspects characterizing the olfactory perception may be helpful in implementing more and more complex and refined electronic devices, that could detect environmental information no longer accessible to human olfactory system.

V. Conclusions

In conclusion, there is a close two-way relationship between olfaction and emotions that makes odors very useful tools for clinical psychology and neuropsychology.

However, olfaction has almost never been taken into consideration as a channel to promote well-being in our everyday life settings. This represents a missed opportunity, because odors are important environmental elements that could promote emotional well-being or could foster psychological distress [40, 41]. Future research in the field of clinical psychology and clinical neuropsychology should pay more attention to the role of olfaction in promoting our psychological well-being and to the role of odors in making everyday life settings more "emotional-ergonomic" places.

This research field could also give new insights to CogInfoCom, because it refers to the different ways in which humans and other living organisms use their perceptive systems to obtain information from their living environments, and to human capability to create artificial devices for strengthening their own perceptive capabilities, in particular olfaction.

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