Converging Evidence in Language and Communication Research (CELCR)

Over the past decades, linguists have taken a broader view of language and are borrowing methods and findings from other disciplines such as cognition and computer sciences, neurology, biology, sociology, psychology, and anthropology. This development has enriched our knowledge of language and communication, but at the same time it has made it difficult for researchers in a particular field of language studies to be aware of how their findings might relate to those in other (sub-)disciplines.

CELCR seeks to address this problem by taking a cross-disciplinary approach to the study of language and communication. The books in the series focus on a specific linguistic topic and offer studies pertaining to this topic from different disciplinary angles, thus taking converging evidence in language and communication research as its basic methodology.

Volume 8

Speaking of Colors and Odors
Edited by Martina Plümacher and Peter Holz

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Speaking of colors and odors

Martina Plümacher and Peter Holz

1. Introduction to the topic

We are confronted with a huge manifold of diverse sensory impressions which we have to classify and interpret in regard to our former experiences and intentions in acting. We also have to coordinate our sensory impressions with other individuals in order to perform purposeful joint actions and meaningful interactions. Categorization is a cognitive activity that serves both to develop personal experience to an extent that makes quick orientation in new situations possible and to establish inter-individual understanding in processes of joint action. Language is involved in these processes of categorization. What exactly is its specific part? This is the central question of this book. Most of its contributions start from the assumptions that language is complementory to other forms of communication, such as joint attention, regular forms of joint action, gestures and other non-verbal semiotic forms, and that linguistic forms of categorization are based on perceptual discernment and non-linguistic forms of classifying things, events and properties.

The articles of this book originate from an international and interdisciplinary conference dealing with the question "How can language cope with color and smell?". 'Color' and 'smell' were chosen as subjects to compare the extensively studied field of color perception and color categorization with the less investigated fields of perception and categorization of odors. The neurobiological and neurophysiological conditions of color perception are known to a large extent, and cross-linguistic research on color categorization and lexical coding of color has developed since the 1950s. The sensory system of olfaction and categorization of odors have been of comparatively minor interest. – This can be asserted at least with regard to science. Within the large fields of industrial production of perfume, scents of cosmetics and flavor of food, the interest is immense, and a huge amount of money is spent on research, evaluation and advertising. – We supposed that comparing these differently investigated fields of sensory systems and linguistic representation of sensory impressions could broaden the view on the issue. It might help to clear controversies, especially as to the prevailing theses that colors

Die Summe hiervon ist diese:
Die Sache der Sinne ist, anzuschauen;
die des Verstandes, zu denken.
Denken aber ist Vorstellungen
in einem Bewußtsein vereinigen.
(Immanuel Kant,
Prolegomena zu einer jeden künftigen Metaphysik,
die als Wissenschaft wird auftreten können, 1783)

Olfactory and visual processing and verbalization

Cross-cultural and neurosemiotic dimensions

Tatiana V. Chernigovskaya and Victor V. Arshavsky

The paper discusses the neurological basis for olfactory and visual preferences governing human behavior, with the right cerebral hemisphere (RH) playing the dominant role, both in individuals and in types of culture in which olfaction is an important part of the semiosphere. Subjects with RH reactions showed a reliable cross-correlation of biopotentials in the RH when stimulated by odors preferable for them. Classification and verbalization of colors also demonstrates significant differences in the types of strategies used by RH vs. LH subjects. Most professional testers of odors appear to be RH personalities. The important role of cultural, as well as of linguistic, backgrounds is stressed. Right hemispheric sensory processing correlates with adaptation and resistance to stress and somatopsychic diseases.

There is a poor relationship between language and the olfactory world: identification by name of odors is very difficult, and there is not a vast vocabulary for orders within the human mental lexicon. In fact it is synthetic by nature – we either use vocabularies for taste, or for color, or even for tactile and auditory sensations. The visual – especially color – semiosphere is probably the most thoroughly elaborated by the majority of human languages, while olfactory is the less verbalized of all sensory modalities, probably due to its subconscious nature and cultural prohibitions. Other modalities, such as tactile, auditory, and gustatory, occupy intermediate positions on this scale. Olfactory information is known to be complex, uncertain (fuzzy) and extremely difficult to verbalize (Harper et al. 1968; Zellner & Kautz 1990). It should be emphasized that we face the difficulty of 'translating' olfactory Gestalt messages into discrete linguistic terms. Color is a spatial sign, sound is a temporal sign, odor and taste are probably both (Chernigovskaya 1995). Synesthetic perception is most expected in this context. The iconicity of synesthesia is evident; the iconicity of olfaction can be described as a kind of cognitive synesthesia, as it has no vocabulary of its own. It involves memory, associations with past images, and reveals episodes of personal experiences (cf. Shibuya et al. in this volume: a cognitive psysiological = psychological model of synesthetic expression).

In spite of the fact that humans are believed to have lost the signal-values of olfactory stimuli (Hoffmeyer 1996), behavior is still partly regulated by them, even if it is not conscious ly understood what these signs mean to us (Hoppe 1977; Hanisch 1982; Steiner & Neumann 1982; Ugolev & Chernigovskaya 1989; Arshavsky & Goldstein 1994; Schaal et al. 1998; Weinstein 2003).

There are gender and age differences in both perception and naming of odors: females and younger individuals do it better than males and older subjects. Categorization of olfactory stimuli is also not an easy task for humans: the grouping of odors might be driven by different multimodal factors, such as personal experience, personal memories and broader Gestalts, emotional backgrounds, and current states (Ugolev & Chernigovskaya 1989; Chernigovskaya & Arshavsky 1994). Moreover, the grouping of odors is different across different situations and across different testing sessions. They are personal, emotional, and very unstable. Associations are also very 'old' – carrying the memory of generations, possibly not only human generations.

As we know, in other species behavior – not only sexual – is to a great extent guided by olfaction, for many species it is the main language for communication. Recent data show that the amazing ability of animals (much worse in humans) to discriminate an individual olfactory stimulus in the mixture of unfamiliar stimuli might be caused by a large number of independent channels, with elements of binary coding allowing a rough approximation of the level of each channel arousal, and even the possibility of separate transfers of information about stimulus quality and intensity (Minor & Krutova 2001)

The question of the neural organization of human olfactory processing is not new. Reminiscences and even *déjà vu* or vivid olfactory hallucinations caused by temporal lobe epilepsy were first described more than a century ago by John Hughlings Jackson. Even in a normal situation we can find 'fits' of anosmia, hypo- or a hyperosmia, which appear to be associated with emotional states, endocrine status, and personal experiences, very often of a subconscious and limbic nature. Hypersomia is also seen in patients with hyper-dopaminergetic states and in patients with Tourette's syndrome (Sacks 1987). Smells are almost never neutral if the intensity is well above threshold. Still more amazing is when an olfactory stimulus is below the conscious threshold and is as if 'not perceived', causing either changes in behavior and/or specific and very personal (often sexual) associations. – Olfactory memories can be so vivid that one could almost talk of controlled hallucinations. Olfactory hallucinations coming with epileptic seizures are most often met in patients with focal right-sided lesions (Whitton 1978; Kupertman 2003; Kuperman & Zislin 2003).

As Holz suggests (this volume), smells cannot be categorized in terms of classical logical semantics or in terms of lexemes, rather they should be discussed in prototype theoretical perspective. We also agree with Dubois when she argues that in cases of audition and olfaction the gap between linguistic and cognitive categories is much larger than in visual domain (Dubois 2000 and this volume). One of the most important features of odor recognition memory is that it is only slightly influenced by the length of retention intervals relative to that for pictures and words. Odors are poorly remembered initially and well retained over time, and they seem to be acquired holistically, in a Gestalt fashion. Zucco's main hypothesis lies on the assumption that odors do not give rise to a conscious representation and could be stored in memory at a subconscious level. Conscious access to the olfactory trace is not possible except for acquisition and non-intentional retrieval. Storage and access to olfactory stimuli in memory, then, should not imply an effort but be automatic. Odor labeling and verbal rehearsal has no effect on subsequent recognition memory (Zucco 2003; Engen 1982, 1991). Danthiir et al. (2001) have shown that an olfactory memory ability is independent from other higher-order abilities.

It is established that different smells can stimulate or tranquilize and therefore regulate interpersonal relations and different types of behavior, including sexual. It is explained by direct connections of olfaction with the limbic system, causing evident emotional effects as well as those of autonomic nervous system (Economides 1986; Hanisch 1982; Staubli 1987; Steiner & Neumann 1982).

In the process óf psychological adaptation odors can have well-expressed signal meaning. On the contrary, damage to this sphere can cause alarm or even depressive states. It was shown that individuals with different types of hemispheric reactions to external stimuli demonstrate various alarm levels and different compensation. Alarm in its turn can cause a whole set of psychosomatic pathologies and neuroses. As a consequence a kind of aromo-correction might be necessary.

There are reasons to suggest that opposite cognitive styles are differently distributed in populations of different cultures (Chernigovskaya 1993, 1994, 1999; Rotenberg & Arshavsky 1997). According to Ornstein (1972), it is Western civilization that stimulates the development of left hemispheric functions, while Eastern civilization is more dependent on the abilities of the right hemisphere. This is the reason why the altered states of consciousness (yoga, meditation) which, according to Ornstein, are based on the right hemispheric skills, are mostly used in the Eastern civilizations. As an example: the native population of Chukotka lives in a cultural context which is quite different from the average European. There are many hunters and reindeer owners. Although young and middle-aged generations have received education of different levels, the style of life is generally almost the same as centuries ago. All cultural traditions are strong, most representatives of the native population are highly skilled in spatial orientation, in non-verbal communication and in special kinds of art, such as bone carving. The proportion of individuals with low levels of education (fewer than 8 years) engaged in comparatively simple agricultural jobs is significantly higher in the native population than among immigrants. Communication is also rather specific: verbal communication is limited, laconic, and rigorous, with many non-verbal ritualized actions.

It was observed that olfaction plays a very important role which is reflected in their behavior – from young children to adults. In spite of the diminishing signaling role of olfaction in behavioral coordinates of modern societies where it occupies mostly hygienic and esthetic niches in comparison with its evident behavioral roles in the wild, in some populations – mostly in traditional, or archaic societies – olfactory functions are still of the primary importance. Individuals of such societies were shown to have predominantly right hemispheric types of information processing. In natural adaptation smells have well expressed signaling value. Illustrations of it were vividly described in Arshavsky's book (2001). Deprivation and loss of the olfactory factor, characteristic to left-hemispheric individual and populational types can hardly be appraised as a positive tendency: actual alarm that can develop as a result of it most often is at the bottom of psychosomatic disturbances. However, it should be stressed that the adaptive value of olfaction is associated mostly not with ethno-cultural specificity of a certain group but with individual psychophysiological characteristics; such individuals form a predominant right-hemispheric type of mentality in a given population as a result of group selection.

Studies of cerebral hemispheric patterns for sensory and cognitive functions indicate that differential processing strategies influence the perception of all kinds of stimuli. In apparent contrast to numerous lines of research in other sensory modalities, the role of hemispheric functional differences in the chemoreception, evaluation, and verbalization of odors is much less known.

The right hemisphere is shown by some authors to be involved in processing odors. This was observed in brain injured patients and in normal subjects (cf. Abraham & Mathai 1983; Zucco & Tressoldi 1989; Ugolev & Chernigovskaya 1989; Chernigovskaya & Arshavsky 1994). It has been demonstrated by many investigators that there are cultural differences in the perception of odor, and it is also associated with hemispheric specificity (cf. Zatorre et al. 1992; Zucco & Tressoldi 1989).

Differential characteristics of hemispheric involvement in olfactory perception have been described as a relevant feature for space orientation, especially, in the wild. Similar to binocular vision and binaural hearing, birynal perception is much more effective in speed and accuracy in comparison with monorynal. At the same time higher left-sided sensitivity was revealed in 71 % of adult subjects contrary to almost no asymmetry in children (Toller et al. 1980). Such asymmetry leads to the hypothesis that the right hemisphere should have specialized mechanisms for olfactory analysis, such as the temporal lobe which can discriminate and identify smells (Abraham & Mathai 1983).

A systematic psychophysiological investigation of the hemispheric functions in representatives of different cultures has shown types of physiological activation of the brain hemispheres under different functional conditions. It is accepted that the percentage of EEG alpha-waves, the alpha-index, reflects the level of non-specific activation caused by the brain stem reticular formation: there is a negative correlation between it and the degree of involvement of the corresponding cortical area in mental activity. However, the alpha-index is increased during successful processing of the solution of a creative task performed by a creative person (Butler & Glass 1987; Arshavsky 1988). During altered states of consciousness (meditation) alpha-index and alpha wave amplitude are also increased in comparison with the ordinary state of consciousness (Hirai 1974), although mental activity in meditation is present (Ornstein 1972).

It is reasonable to compare the alpha-index and spatial synchronization of brain biopotentials (a cross-correlation analysis of the first EEG derivative) under functional loads addressed predominantly to the one or the other hemisphere. The increase in the spatial synchronization of brain biopotentials recorded from different points of the scalp reflects the contribution of definite cerebral mechanisms in the functional system which ensure the performance of the corresponding functions. Usually there are no differences in the amount of spatial synchronization between the two hemispheres in the baseline state but such differences are obvious if the subject is involved in mental activity: spatial synchronization is increased in the right or in the left hemisphere depending on the quality of the task and characterizes the functional activity of the corresponding part of the brain.

To see cerebral involvement in olfactory and color perception and its association with behavioral features we used Lüscher's color preference test and analogous free choice odor preference test (Amoore 1963). Standard degustatory templates of basic odors were also presented to subjects for 3 minutes each item with airflow velocity of 0.1 m3/ per hour during EEG monitoring. Subjects were clinically normal 73 adults and 20 professional testers. The level of innate alarm level and actual alarm level was evaluated according to Spilberger's 40-score scale.

It was shown earlier (Arshavsky & Goldstein 1994; Chernigovskaya & Arshavsky 1994) that both preference for and rejection of odors and colors are highly

Table 1. Changes in alarm level (Spilberger test) in subjects with different hemispheric types after preferable or rejected odors' presentation

Hemis-		Baseline level		after presentation of odors			
pheric	n		Preferable		rejected		
type		IAL	AAL	IAL	AAL	IAL	AAL
RH	26	38.9±1.3	43.3±1.6	39.8±1.1	35.9±0.8	40.1±0.8	46.1±0.8
LH	47	42.1±2.7*	49.9±1.3*	42.3±1.9	49.6±1.7*	42.7±1.9	52.3±2.6**

* $P < 0.05$, ** $P < 0.01$; *RH = right hemisphere; LH = left hemisphere; IAL = innate alarm level; AAL = actual alarm level*

correlated (r = 0.6–0.9): if a certain color is chosen in a certain situation a certain odor also tends to be chosen. This suggests internal associations of color and odor classifications. Color and odor rejection was associated with actual alarm level. Black, brown and gray ($\sum f > 0.834$) were rejected together with acid, tart and neutral ($\sum f > 0.812$) in the low alarm level condition, while in high alarm level condition any dominance of odor or color rejection is absent ($f = 0.164$; $P < 0.001$ for any stimuli).

On the contrary, preferences for colors and odors depend on innate alarm level. The choice of blue or green ($\sum f > 0.748$) or peppermint or musk ($\sum f > 0.834$) correlates with high alarm level, while of red, yellow and violet ($\sum f > 0.762$) and floral and ethereal odors ($\sum f > 0.603$) – with low alarm level ($P < 0.001$). Such reactions reflect modes of behavior compensating: alarm vs. passive and avoiding vs. active.

We also studied reactions to fragrances – their rejection or preferences – presented to the right and left hemispheres (RH/ LH) in normal adults, including professional tasters. Results showed that RH personalities prevailed at the cost of a decrease in LH performance (correspondingly 0.55 vs. 0.45; $P < 0.05$), while in the group of non-professional testers we found the opposite pattern of results (0.32 vs. 0.68; $P < 0.01$). This is not surprising, as testers use a Gestalt type of processing as their main tool.

In our experiments subjects with the RH type of reactions (as previously evaluated by special questionnaires) showed a reliable cross-correlation of biopotentials in the RH when stimulated by odors preferable for them. Individuals of the LH type showed a correlation of biopotentials in the LH when stimulated by the odors rejected by them previously. The choice of preferable odors and colors of the Lüscher set was dependent on individual levels of anxiety. Classification and verbalization of colors showed significant differences in the types of strategies used by RH vs. LH subjects.

The data suggest that most RH individuals demonstrate specific memory and verbalization of odors and that most professional testers of odors appear to be RH

Table 2. Changes in choice frequency of colors and odors in subjects with different hemispheric types after preferable or rejected odors presentation.

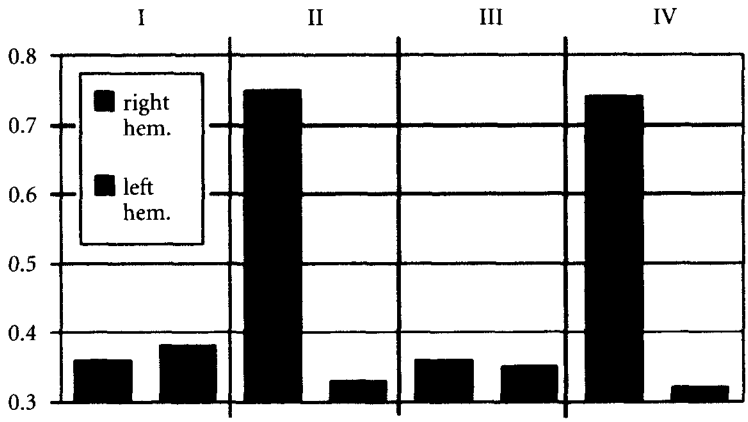
Hemispheric type		Preference Color	f	odor	f	Rejection color	f	odor	f
Baseline									
RH	26	3	0.308	1	0.308				
		4	0.272	2	0.346				
		5	0.269						
		Ø	≤0.115*	Ø	≤0.076*	Ø	≤0.154	Ø	≤0.154
LH	47	1	0.362	3	0.426				
		2	0.404	4	0.426				
		Ø	≤0.064**	Ø	≤0.064**	Ø	≤0.115	Ø	≤0.154
In an hour after previously preferred odor presentation									
RH	26	3	0.346	1	0.308	0	0.269	0	0.231
		4	0.272	2	0.346	6	0.269	6	0.308
		5	0.308			7	0.385	7	0.346
		Ø	≤0.076*	Ø	≤0.076	Ø	≤0.038**	Ø	≤0.038**
LH	47	1	0.340	3	0.426				
		2	0.404	4	0.426				
		Ø	≤0.076**	Ø	≤0.064**	Ø	≤0.115	Ø	≤0.076
In an hour after previously rejected odor presentation									
RH	26	3	0.308	1	0.308				
		4	0.346	2	0.346				
		5	0.269						
		Ø	≤0.076*	Ø	≤0.076**	Ø	≤0.154	Ø	≤0.165
LH	47	1	0.383	3	0.426				
		2	0.447	4	0.468				
		Ø	≤0.064**	Ø	≤0.043**	Ø	≤0.149	Ø	≤0.176

* $P < 0.05$; ** $P < 0.01$

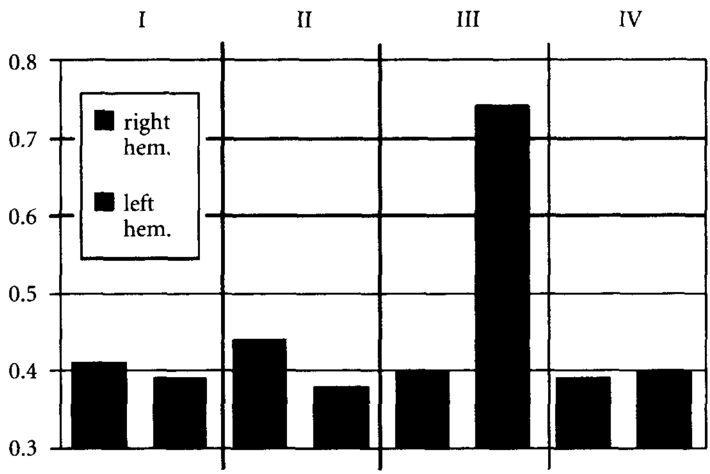
Colors: 0 – grey, 1 – blue, 2 – green, 3 – red, 4 – yellow, 5 – violet, 6 – brown, 7 – black, Ø – others.
Odors: 0 – none, 1 – floral, 2 – etheral, 3 – muscus, 4 –peppermint, 5 – camphora, 6 – acid, 7 – saprogenic, Ø– others.

personalities. They also show the important role of social and cultural, as well as of linguistic, backgrounds. Right hemispheric visual, auditory and olfactory processing seems to correlate with certain behavioral characteristics reflecting successful adaptation and resistance to stress and psychic or somato-psychic diseases, and adaptive behavior in general.

The correlation analysis of the EEG first derivative in RH and LH persons showed different patterns of space synchronization of biopotentials, with preferable vs. rejected odors associated with alarm level (Tables 1 and 2, Figures 1–4).



Right-hemispheric personality, n = 26



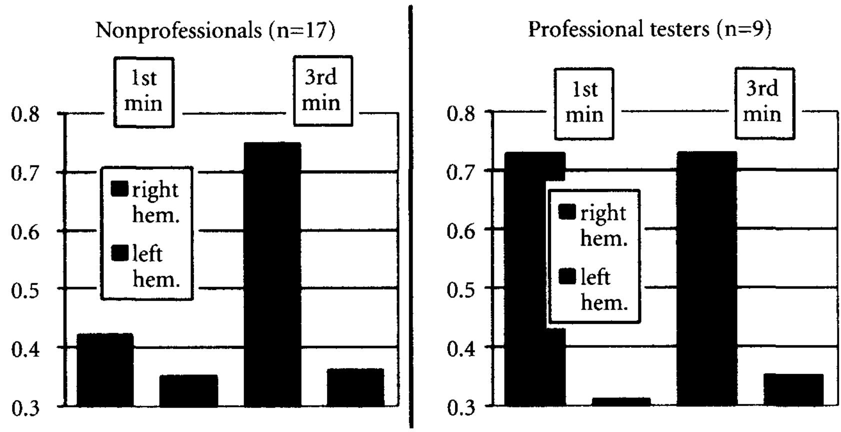
Left-hemispheric personality, n = 47

I – baseline, II – preferable smells, III – rejected smells, IV – post-stimulus

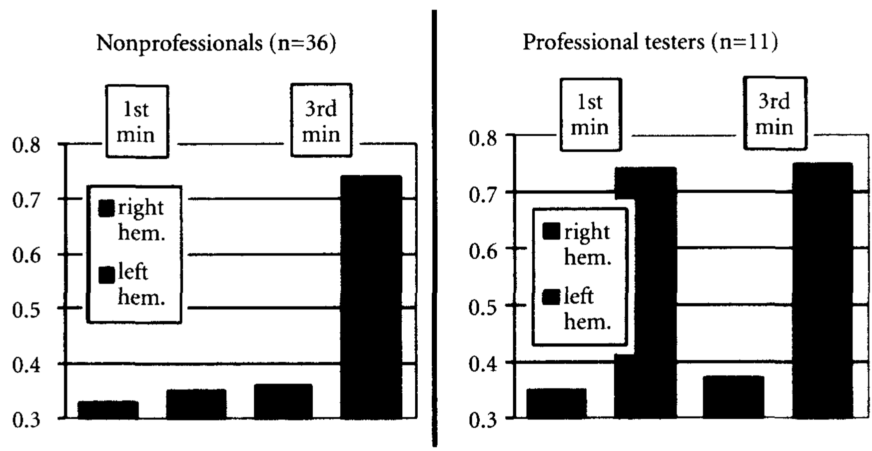
Figures 1 and 2. Coefficient correlation change of the EEG first derivative in individuals of different hemispheric types subjected to preferable or rejected olfactory stimuli.

Individuals of RH type use Gestalt processing of all the items presented with picking up the preferable; the rejected in this case will be the last in the row. LH persons on the contrary use a step by step rejecting strategy, so that the preferred odor is left to be the last in the row. Professional testers have lower latency thresholds of odor recognition and appreciation.

In another test normal adults coming from different languages and cultures and tested for lateralities and cognitive styles were accessed for voluntary free associations concerning individual memory for odors. Associations were later eval-



Right-hemispheric personality, preferable smells



Left-hemispheric personality, rejected smells

Figures 3 and 4. Time thresholds in strong correlation of hemispheric bio-potentials in nonprofessionals and professional testers of different hemispheric types subjected to preferable or rejected olfactory stimuli.

uated by the subjects as neutral, negative or positive and classified according to different semantic fields. Similar to Gilbert and Wysocki (1987), our data suggest a high level of universality in the semantic organization of the olfactory semiosphere: the major classification clusters were similar in different groups. At the same time it is evident that cultural specifics and social constraints play a very important role (Ugolev & Chernigovskaya 1989).

Conclusion

Our data suggest that there is a neurological basis for olfactory preferences governing human behavior, with the right hemisphere playing a very important role. It is also evident that *right-hemispheric populations and individuals* tend to specific type of culture in which olfaction is one of the central parts of the semiosphere. As Wildgen (this volume) discusses it in this volume, perception governed by neural architecture (see also Fahle in this volume) and communication based on social structure form the transition between sensibility and sense.

Language appears to be the vehicle to label cortical representations of input and to normalize subjective experiences, and thus subserves not only communication but reflection as well and thus helps in orientation in the world and in adaptation to it. This means that language, being a cultural phenomenon though based on genetically developed algorithms, relates natural objects to neurophysiological events via conventional semiotic mechanisms. Our perception could be described in vague terms of objectiveness only because we have an agreement in naming, i.e., 'boxes' in which to pack the sensations.

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