

Odors, words and objects

Felice Cimatti¹, Andrea Flumini², Martina Vittuari, Anna M. Borghi³

Abstract The paper focuses on concepts and words referring to odors and to objects that have an odor. We argue that odors are an interesting object of study since they are evanescent, and since odor words do not refer to concrete and manipulable objects, but to scents evoked by objects. A second reason why odors are interesting is that some languages, as the Western ones, lack a specific odor lexicon, comparable in richness and variety to the color lexicon, and that performance on odors naming is typically worse than performance in color naming. In this work we discuss three main issues. First, we illustrate literature showing that, even if odor words do not have concrete referents, many languages encode them quite easily: the case of odors suggests that word meaning cannot be exhausted by the relationship with a referent, and highlights the importance of the social sharing of meaning. Second, we have discussed the peculiar status of odor concepts and words. Given their ambiguous status, their simple existence poses problems both to theories according to which concrete and abstract concepts do not differ, and to theories according to which they represent a dichotomy. Finally, we present an experiment in which we show that names of objects evoke their smell, and that these smells evoke approach and avoidance movements, in line with theories according to which words are grounded in both sensorial and motor systems.

Keywords: language, ‘abstract’ and ‘concrete’ concepts, olfaction, perception, action, approach-avoidance, embodied and grounded cognition.

Received 10 October 2015; received in revised form 28 May 2016; accepted 10 June 2016.

0. Introduction

This paper focuses on odors, and specifically on concepts and words referring to odors and to objects that have an odor. Curiously the cognitive literature on odors is not broad as the literature on color, or on shape. We believe instead that odors represent an

¹ Università della Calabria ; felice.cimatti@gmail.com

² Università di Bologna e Università di Granada, Spagna.

³ Università di Bologna e ISTC-CNR, Roma.

interesting case of study, full of theoretical implications. Odors seem rather evanescent: they are not objects, but are rather scents evoked by objects. Odor concepts cannot be considered as concrete concepts, since they do not possess specific, bounded referent, but at the same time they cannot be considered as completely abstract, since they activate our senses. They can be perceived through olfaction, but apparently they do not evoke actions. The odor case is therefore challenging for embodied and grounded theories of cognition (BARSALOU, 2008) because odors concepts place themselves somewhere between concrete and abstract ones.

Another reason to concentrate on the odor concepts pertains the way in which they are linguistically encoded. Classical behavioral evidence showed marked differences in performance on visual objects naming and smell sources naming. Seminal studies about odor naming demonstrated that if a sample of participants was able to correctly name about the totally of common visual object pictures, in an analogue naming task conducted on smells they were able to indicate less than the 50% of common odor sources (e.g., CAIN, 1979; ENGEN, ROSS, 1973). Odor concepts seem namely to represent a case study for language acquisition (WILSON, STEVENSON, 2006), because of the differences in odor lexicon across different languages. More recent studies have shown that the richness of the odor lexicon greatly differs across cultures. Languages spoken by cultures living in quite a 'natural' habitat have a richer odor lexicon in comparison to languages spoken by cultures living in a more artificial and technological habitat.

In the following pages we will discuss some theoretical issues that odor words raise. First, we will explain that in spite of their apparent evanescence, language can easily encode odor words, as revealed by cross-linguistic evidence. Treating of odors will help us to discuss what linguistic meaning is. Second, we will argue that odors can tell something on the distinction between concrete and abstract concepts. Third, we will show by means of a behavioral experiment that words referring to objects evoke odors, and that these odors, in spite of their apparent evanescence and abstractness, activate actions.

1. Odor words and linguistic meaning

Notwithstanding a very widespread commonplace (MAIJD, BURENHULT, 2014), «human languages can encode odors» (WNUK, MAJID 2014: 136). Recent evidence shows that the often reported difficulties in encoding odors (ENGEN, ENGEN 1997; RICHARDSON, ZUCCO 1989; YESHURUN, SOBEL 2010) are not the results of presumed intrinsic limits of Language (in general) in attributing a name to odors. According to this commonplace, while it is somewhat simple to give a name to a material thing, like a bottle for example, it would be intrinsically difficult to individuate and to name a flavor. The problem would lie in the fact that while a bottle is an entity with precise boundaries, that is an entity delimited in space and time, a flavor cannot be delimited in the same way. The commonplace implicitly holds that Language is at ease when confronted with objects and simple events, whilst it is in trouble when the entity that has to be named has not such characteristics. From this point of view odors seem the worst entities Language can face. Luckily, cross-cultural evidence shows that this is just a

commonplace (MAJID, BURENHULT, 2014). Jahai speakers of the Malay Peninsula, for example, are able to name odors so as colors. In particular, their odor lexicon is abstract and structured, that is, basic Jahai odor names do not derive from a particular object, which emits a similar odor: «whereas English speakers grappled to find words for odors, Jahai speakers could name odors with the same conciseness and level of agreement as colors» (p. 269). Anthropologists have revealed fascinating examples of cultures, as the Berek Negrito of peninsula Malaysia, who use smell to classify things in their environment: for example, the sun would have a bad smell, as “raw meat”, whereas the moon would be characterized by a good smell, like that of flowers (HOWES & CLASSEN, 2013). The Jahai and the Berek Negrito examples apparently show that the difficulties Western people encounter in naming odors are not at all universal (MAJID, BURENHULT, 2014); English speakers difficulties in naming odors are not the sign that Language cannot cope with the smells. Such a difficulty is simply the sign of a peculiar difficulty of Western society (and therefore of Western languages) with smells. The difficulty in naming odors is a problem of *some* languages, not of Language per se (MAJID, LEVINSON 2011). Furthermore, even in Western languages it has been demonstrated that the odor lexicon can be easily acquired. Western smells experts, like professional perfumers or enologists, are able to learn specific odor categories and to use a special language to talk about them, even if these categories and their labels are not shared by all the individuals of their cultures (ZARZO, STANTON, 2009). This evidence has also been confirmed by the finding of differences in the cerebral architecture of such experts, in particular an increase of the orbitofrontal gyrus, a region that seems to be fundamental for odor categorization (a recent review of neuroimaging literature is in OLOFSSON, GOTTFRIED, 2015). Giving the evidence described, and considering that it has been shown that in general the neural architecture of the smell system in Westerners lacks of connections to high-level functions areas (which include all the linguistic areas in the cortex) (see OLOFSSON, GOTTFRIED, 2015), it is possible that these differences are mainly culturally rooted: Western cultures are mainly focused on vision, and Western technology is mainly visually oriented. The extension of Western visual lexicons is impressive, and Western individuals learn this specific way of categorizing the world from the very beginning of their life. Thus, if it is true that differences between languages might directly affect the ways people think and organize their world, as hypothesized by Whorf's Linguistic Determinism, (e.g., WHORF 2000a, 2000b; GENTNER, 1982), it would be no surprise that the way to conceptualize reality of Western individuals is predominantly visual, with vision being the strongest force that scaffolds and structures their cognitive system, leaving the other senses in the background.

The case of odors points to another general question, the very nature of linguistic *meaning*. According to a naïve exclusively referential view of Language, the meaning of a linguistic form is the object it is attached to. This referential view of language has dominated for long in cognitive science in general. For years not only defenders of traditional views of cognition but even proponents of an embodied cognition view, according to which human cognitive processes are influenced by bodily experiences, have assumed this referential view. In this vein, scientists adopting an embodied cognition view have tried to demonstrate that words activate the sensorimotor information associated to their referents (see BORGHI ET AL.,

2013, for an extensive critique of such a view). For example, the embodied indexical theory (GLENBERG, ROBERTSON, 2000) claimed that words activate their referents, their perceptual characteristics and their affordances. While this attempt has been useful to contrast traditional propositional views (FODOR, 1983), according to which words are arbitrarily linked to their referents, at the same time it has sometimes led to neglect the importance of other words for the meaning of a specific word. What this theory misses to note is that *every* linguistic meaning is connected to other *meanings*. It is the uncritical adoption of such an unilateral view of meaning what makes so difficult to imagine how an odor could be named. Although it is true that odors are associated to specific sensations, they do not refer to concrete and manipulable objects, like a bottle. What such an idea of Language misses is that the linguistic meaning of a word cannot be exhausted by the possible referent of such a word. Until some years ago, embodied (and referential) views of language were considered as opposed to distributional views of language, according to which the meaning of a word is given by the co-occurrence of words in large corpora (e.g., LANDAUER, DUMAIS, 1997). Now hybrid approaches (e.g., ANDREWS ET AL., 2014) underline, instead, that both the word referent and the way in which words are used in a social context, along with the presence of other associated words, contribute to word meaning.

This is exactly our position, and the case of odors illustrates it very well. In Jahai culture and life odors occupy a very important position (BURENHULT, MAJID, 2011). Therefore, Jahai speakers need to be able to speak of odors in a competent and shared manner. The fact that odors do not present the characteristics of material objects by no means implies a linguistic obstacle for speakers. The point is exactly that the meaning is different from the referent. Put in another way: a linguistic form has a shared meaning even if it does not refer to a precise *thing* into the world (LUPYAN, WARD 2013; LUPYAN, CASASANTO, 2014). Take the case of this Wittgenstein example:

“The smell is marvellous!” Is there a doubt whether it is the smell that is marvellous? Is it a property of the smell? – Why not? It is a property of ten to be divisible by two and also to be the number of my fingers. There might however be a language in which the people merely shut their eyes and say "Oh, this smell!" and there is no subject-predicate sentence equivalent to it. That is simply a 'specific' reaction (WITTGENSTEIN, 1967, § 551).

According to Wittgenstein, and also to recent distributional views of language, the *meaning* of the sentence “Oh, this smell!” is the shared use – what Wittgenstein calls «a ‘specific’ reaction» – such a sentence evokes within a particular linguistic community. In such a perspective, the difference between meaning and referent is apparent. More precisely, the meaning of “Oh, this smell!” *are* the action and thoughts people entertain when using such a sentence.

Our point is quite common in classical analytic philosophy of language: a word has a meaning even if it does not refer to a spatially bounded object, since the word meaning is different from its referent. To be more specific: the meaning of an odor word is *prima facie* what a human body *does* with such a word. Wittgenstein helps us

to avoid speaking of “ineffability” when confronted with the case of odors. Odors are not ineffable at all. The actual linguistic evidence (MAJID, BURENHULT 2014; MAJID 2015) clearly shows that cultures that rely more on ‘natural’ resources seem not to encounter the same difficulties in encoding odors than languages spoken by more ‘artificial’ and ‘technological’ cultures. Therefore, it seems to us that the importance of culture in linguistically encoding odors should not be underestimated. In our view both the referent of the word – in the case of odors it is not an object, but the scent evoked by a specific object or entity which activates a specific sense, olfaction – and the shared use of the word concur to determine meaning. If we avoid to equating meaning and referent, taking into account that there is more in the meaning than the mere relationship with a specific referent, the presumed ineffability of odors loses much of its theoretical attractiveness (LEVINSON, MAJID 2014).

2. Are odor concepts concrete or abstract ones?

The case of smells can be used to face a more general psychological question: the presumed difference existing between the so-called ‘abstract’ and ‘concrete’ concepts. A smell is a physical and chemical entity that cannot be exactly identified in space and time. Does it belong to concrete or to abstract concepts? According to two influential views, concrete and abstract concepts do not differ (for reviews, PECHER ET AL., 2011; BORGHI, BINKOFSKI, 2014). Classical views of cognition posit that words have an arbitrary relations with their referent, and that are represented through semi-linguistic properties. In this perspective, concrete and abstract concepts do not differ. Neither standard embodied views do intend abstract and concrete concepts as different, since they argue that both concrete and abstract concepts are grounded in the sensorimotor system. The interest of words which refer to smells is that they have an ambiguous status. On one side they allow some specific bodily actions (tasting a wine, for example; LEHRER, 1975), on the other side they refer to thousands of subtle and imperceptible entities (CROCKER, 1935). Could they be considered as concrete, since odor is emanated by a concrete object/entity? Or should they be considered as abstract, since smell cannot be seen, touched, manipulated? Clearly, odor words meanings place themselves somewhat in the middle between ‘concrete’ and ‘abstract’ concepts, so they neutralize such a venerable distinction. In this sense, they cannot be accounted for neither by classical views nor by standard embodied views, according to which no distinction between concrete and abstract concepts exist. It becomes instead necessary to assume that there is no concrete-abstract dichotomy, and that concreteness and abstractness are not all or none exclusive dimensions, but are graded, and that concepts are arranged along a continuum (WIEMER-HASTINGS ET AL., 2001).

If it is true that words which refer to smells somehow neutralize the distinction between ‘abstract’ and ‘concrete’ concepts, we hypothesize that this should have a behavioral effect. On one side, the neural processing of a verb like “grasp” recruits the motor area of the brain (SCOROLLI, BORGHI 2007), while on the other side the processing of an adjective like “divine” (CRUTCH, WARRINGTON 2005) relies

more on linguistic brain areas. In the same vein, it has been shown through fMRI that, even if both concrete and abstract words activate sensorimotor areas, abstract sentences recruit more linguistic areas of the brain than concrete sentences (SAKREIDA ET AL., 2013). At a behavioral level, it has been shown that abstract concepts activate more the mouth (BORGHI ET AL., 2011; GHIO ET AL., 2013; GRANITO ET AL., 2015), while concrete ones activate more the hand. Since odor words have a sort of intermediate status between concrete and abstract words, we expect that, when presented with odor words, participants will react in an intermediate way between the typical reaction to a ‘pure’ concrete word and a ‘pure’ abstract word. The idea is that the processing of olfaction language requires both the activation of nose and hands on one side, and of language, and thus the mouth, on the other. Future research should be conducted to test such hypotheses.

3. Words evoke odors and odors evoke actions

As we previously said, odors do not have concrete referents, even if scents are evoked by specific referents. Obviously odors can be perceived, but it is not at all obvious that they activate the motor system. In the experiment we will report, participants were presented with words referring to objects and were asked to evaluate whether they evoked a pleasant vs. unpleasant smell. Please note that, given the limits of Italian lexicon on odors, we decided to focus on words referring to objects and entities with odor rather than on odor words. Such has strategy has been widely adopted in the literature, since a number of results on odor have been drawn from tasks on sources of odors (that is, objects with smell), see for example CAIN, 1979; ENGEN, ROSS, 1973. In keeping with grounded views of cognition (e.g., BARSALOU, 2008), we hypothesize that in such a task words referring to objects and entities (artifacts and natural objects) will activate their perceptual characteristics, and specifically their smell. More crucially, in keeping with more radical embodied views of cognition (e.g., GALLESE, 2008; for a review see BORGHI, CARUANA, 2015), we hypothesize that words will not only evoke the smell of their referents, but that the different smells words evoke will activate different actions. Specifically, we predict that pleasant smells will evoke an approaching action, while unpleasant smell should activate an avoidance movement. To test this hypothesis we performed a behavioral experiment using the approach avoidance paradigm, originally designed by CHEN and BARGH (1999). In the original study, participants were required to pull a lever toward the body or to push it away from the body while responding to positive and negative words. Results showed that participants tend to attract positive words and to avoid negative ones. In further studies that followed the approach-avoidance paradigm participants were asked to press two keys on a keyboard moving their hands either toward or away from the body (e.g., LUGLI ET AL., 2012), rather than pulling or pushing a lever. In our experiment, we decided to use this kind of response device. Words referring to artifacts or natural objects having a pleasant vs. an unpleasant smell [e.g., “armpit” (ascella), “fumigator” (zampirone) vs. “soap” (sapone), “apricot” (albicocca)] were presented at the center of a screen. Importantly, the valence of the words with pleasant vs.

unpleasant smell was not correspondent to the valence of the smell: for example, “armpit” and “broccoli” do not have a negative valence per se, but their valence becomes negative if one considers their odor, since have an unpleasant smell. Participants were asked to decide whether their odor was pleasant or not by pushing two different keys on the keyboard, so to respond they had to perform a movement toward or away from their body. We predicted that they would tend to attract objects with a pleasant smell and to push away objects with an unpleasant smell. Furthermore, we were interested in the possible differences between natural and artificial word smells, starting from the general hypothesis that natural word smells should be more salient due to their evolutionary role.

3.1. Method

3.1.1. Participants

Twenty-four undergraduate students from the University of Bologna volunteered for participating in the experiment (10 males; age = 18-35; 3 left-handed by self-report). All participants had normal or corrected-to-normal vision and were naive as to the purposes of the experiment.

3.1.2. Materials

A total of 36 Italian words, 18 referring to artifacts and 18 to natural objects, with each set including 9 words referring to items with a pleasant smell and 9 referring to items with an unpleasant smell, were selected for the experiment.

3.1.3. Design and procedure

Participants were explicitly instructed to judge the pleasantness/unpleasantness of the smell associated to each linguistic item.

Participants sat 50 cm from the computer screen. Each trial began with a fixation point (+) lasting for 500 ms, then the stimulus word was displayed centrally, and remained on screen until a response was given. A feedback that informed participants about the response time was then displayed. Participants used a modified QWERTY keyboard to respond, which was placed in front of them in a vertical position (i.e., it was 90 degrees counterclockwise rotated with respect to its habitual position on a desk). The keyboard had no keys with the exception of the space bar and the F1 and F12 keys. In each trial participants had to start by pressing the space bar and to keep it pressed until they were ready to respond. When ready to respond, they had to perform a movement toward their body to press the F1 button, or away from their body to press the F12 button. The F1 and F12 keys were not the standard ones, but had been substituted with two big black buttons in order to increase the easiness of the motor response we requested.

Given this arrangement of the response device, it was possible to have two response mappings. In the pleasant-near response mapping condition, participants had to respond to pleasant smell items by pressing F1 (i.e., going towards their body) and to

unpleasant smell items by pressing F12 (i.e., going away from their body); in the pleasant-far response mapping condition, participants used the reversed mapping. Participants were randomly assigned to 2 groups of 12 participants each in order to counterbalance the mapping they used to respond. In the experiment, the 36 critical trials were preceded by 4 training trials to familiarize participants with the procedure.

3.2. Data Analysis and results

We eliminated errors (19 % of the trials) and trimmed responses by removing those trials which response time (RT) was 2 standard deviations over the participant's mean. The remaining responses were entered in a 2 x 2 x 2 ANOVA with the between-subjects factor Response mapping, and the within-subjects factors Type (artificial/natural) and Odor Valence (pleasant/unpleasant smell). Newman-Keuls *post hoc* tests were conducted on significant interactions.

The ANOVA on RTs showed that the expected main effect of Response mapping approached significance, $F(1, 23) = 3.86, p = .06, \eta_p^2 = .149$, due to pleasant-near mapping responses ($M = 1488$ ms) being slower than the pleasant-far responses ($M = 1082$ ms) (see Figure 1).

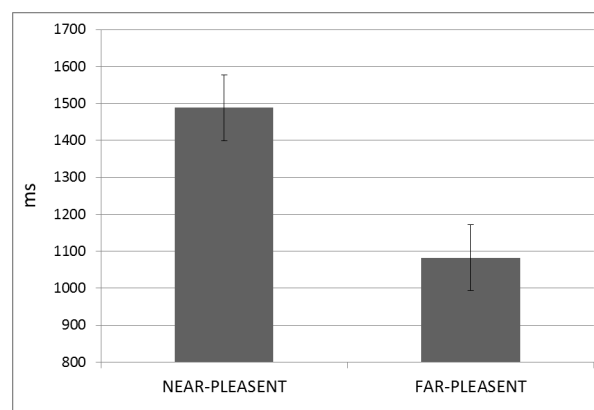


Fig. 1. Block 2 - Main effect of Response mapping

The main effect of Type was significant, $F(1, 23) = 20.29, p < .001, \eta_p^2 = .479$, showing that responses to natural objects ($M = 1379$ ms) were faster than responses to artifacts ($M = 1191$ ms). This result is perfectly in line with a number of previous findings in the literature showing an advantage of natural objects over artifacts in the processing of visual objects (e.g., BORGHI ET AL., 2011; FLUMINI ET AL., 2014).

The interaction Type x Odor Valence was significant as well, $F(2, 46) = 9.65, p < .01, \eta_p^2 = .304$, showing that natural objects characterized by a pleasant smell ($M = 1157$ ms) elicited faster responses compared to natural objects characterized by an unpleasant smell ($M = 1226$ ms - Newman-Keuls $p < .01$), whereas the opposite pattern was observed for artifacts (pleasant smell $M = 1410$ ms, unpleasant smell $M = 1349$ ms - Newman-Keuls $p < .05$). Interestingly, this result revealed that RTs to artifacts with pleasant smell were significantly slower than RTs in any other condition (Newman-Keuls *all ps* < .05).

No other main effects or interactions were significant.

The ANOVA on errors showed a main effect of Odor Valence, $F(1, 23) = 29.31, p < .001, \eta_p^2 = .571$, due to pleasant smell items ($M = .85$) producing less errors than unpleasant ones ($M = 2.62$).

Two interactions were significant as well. First, the Response mapping x Type interaction, $F(2, 46) = 4.34, p < .05, \eta_p^2 = .164$ (pleasant-near mapping: Artifacts $M = 1.83$, Natural objects $M = 1.70$; pleasant-far mapping: Artifacts $M = 1.25$, Natural objects $M = 2.17$ - Newman-Keuls *all ps ns*). Second, and of greater theoretical interest, the interaction Type x Odor Valence was reliable, $F(2, 46) = 23.90, p < .001, \eta_p^2 = .521$ (Artifacts: Pleasant smell $M = 1.38$, Unpleasant smell $M = 1.71$ - Newman-Keuls $p < .05$; Natural objects: Pleasant smell $M = .33$, Unpleasant smell $M = 3.54$ - Newman-Keuls $p < .001$). Interestingly, this result showed that unpleasant smells of natural objects evoked a significantly higher number of errors than all other conditions (Newman-Keuls *all ps < .05*).

3.3. Discussion

The results show that, while comprehending words referring to objects, we not only activate the internal representation of the perception of their odor, but we also prepare a specific action. The motor system is clearly modulated, and this result supports not only grounded but also more radical embodied theories of cognition, according to which the processing of linguistic stimuli activates actions. However, the modulation of the motor system we found deserves some discussion. As anticipated in the introduction, we started from the hypothesis that participants would tend to attract objects with a pleasant smell and reject objects with an unpleasant one. The classical CHEN and BARGH'S (1999) approach-avoidance results consisted in an advantage of the mapping pleasant-near and unpleasant-far over the opposite mapping. However, in the literature there are also results favoring the opposite mapping, as those obtained by FREINA ET AL. (2010), who used the approach-avoidance paradigm with the keyboard, as we did, and manipulated the hand posture. In one condition, in which participants held a small ball in their hands, the main result of Chen and Bargh was replicated. In another condition, in which participants reached the button with an open hand, results showed the opposite pattern, similar to the one we found in the present study. Freina et al. interpreted their results arguing that, when our hands are full, we tend to keep positive objects close and to throw negative objects away. But when our hands are empty the opposite becomes true: we reach for positive objects by moving away from the body, and we defend our own body from negative objects by moving toward it.

Given the exploratory character of our study and the different results present in the literature, our hypothesis was two-tailed. Even if the response mapping effect only approached significance, our results revealed that the pleasant-far, unpleasant-near mapping yielded slightly faster responses compared to pleasant-near, unpleasant-far. The interpretation of our interaction is rather straightforward in light of the previous work by FREINA ET AL. (2009). Our participants, who responded using an open hand, tend to reach for objects with pleasant odor moving away from their body, and to avoid smelly objects by keeping them far from their own body.

The interaction between smell and kind of concept (artifact vs. natural objects) is also of interest. While the fact that artifacts are slower than natural objects is in line with previous literature (BORGHI ET AL., 2007; FLUMINI ET AL., 2014; VAINIO ET AL., 2008), the finding that pleasant artifacts are particularly slow when compared to natural objects is completely new. This result suggests that, likely due to our evolutionary history, we tend to appreciate more natural pleasant odors than artificial ones. The same interaction found in errors shows that we are also more affected and we tend to suffer in a greater manner natural unpleasant odors than artificial ones.

A caveat: In the experiment we did not use an implicit task, but only an explicit one: participants were explicitly required to evaluate the pleasantness of odors. Further research is needed to clarify if odors are automatically evoked upon reading the word, or whether an explicit evaluation of odors is always necessary to activate perception and motor responses.

4. Conclusion

We hope to have convinced readers that odors, and odor words, are interesting for cognitive science (including philosophy). Here we have tried to make three main points. First, we have shown that the debate on the lack of a specific odor lexicon in Western cultures is sometimes misleading. Even if there are data showing that people encounter more difficulties in odor naming than in color naming, cross-cultural studies reveal that many languages encode odor words quite easily and have a rich odor lexicon, even if odors clearly do not have “pure” concrete referents. Furthermore, evidence on Western individuals shows that a specific odor lexicon can be learned with expertise. A note of caution is necessary, however: to date it remains unclear whether visual stimuli are better integrated with linguistic ones than odor stimuli, independently of the culture. As highlighted by OLOFSSON and GOTTFRIED (2015), further research is needed to investigate whether odors, compared to visual stimuli, activate a larger set of semantic concepts, and further cross-cultural studies are necessary to investigate the role played by cultural influences.

The case of odor clearly exemplifies our view on meaning: it suggests that meaning cannot be exhausted by its relationship with a referent, and highlights the importance of the social sharing of meaning. Clearly, the less the referent is concrete and well defined, the more the social and cultural dimension of word use acquires relevance (BORGHI, CIMATTI, 2009; BORGHI, BINKOFSKI, 2014).

Second, we have discussed the peculiar status of odor concepts and words. We have seen that odor concepts and words are peculiar, since they cannot be defined neither as concrete nor as abstract. Their simple existence poses problems both to theories according to which concrete and abstract concepts do not differ, and to theories according to which they represent a dichotomy. We have also outlined some possible research directions aimed at testing the special “status” of odor words.

Finally, by asking participants to evaluate the pleasantness of objects with odors moving their hand toward or away from the body, we have demonstrated that words not only activated a given sense, odor, but that odor was related to a specific

approach-avoidance action too. This suggests that concepts, perception and action are strongly interrelated, as posited by embodied and grounded theories of cognition.

References

ANDREWS, M., FRANK, S., VIGLIOCCO, G. (2014), "Reconciling embodied and distributional accounts of meaning in language", in *Topics in cognitive science*, 6(3), pp. 359-370.

BARSALOU, L. W. (2008), "Grounded cognition", in *Annu. Rev. Psychol.*, 59, pp. 617-645.

BORGHI, A.M., BINKOFSKI, F. (2014), *Words As social Tools: An embodied view on abstract concepts*, Springer, New York.

BORGHI, A.M., BONFIGLIOLI, C., LUGLI, L., RICCIARDELLI, P., RUBICHI, S., NICOLETTI, R. (2007), "Are visual stimuli sufficient to evoke motor information? Studies with hand primes", in *Neuroscience Letters*, 411, pp. 17-21.

BORGHI, A.M., CARUANA, F. (2015), "Embodiment Theory", in James D. Wright (editor-in-chief), *International Encyclopedia of the Social & Behavioral Sciences*, 2nd edition, Vol 7. Elsevier, Oxford, pp. 420-426.

BORGHI, A.M., CIMATTI, F. (2009), "Words as tools and the problem of abstract words meanings", in TAATGEN, N. & VAN RIJN, H. (eds.), *Proceedings of the 31st Annual Conference of the Cognitive Science Society*, Cognitive Science Society, Amsterdam, pp. 2304-2309.

BORGHI, A. M., FLUMINI, A., CIMATTI, F., MAROCCO, D., SCOROLLI, C. (2011), "Manipulating objects and telling words: a study on concrete and abstract words acquisition", in *Embodied and Grounded Cognition*, 173, pp. 1-14.

BORGHI, A. M., FLUMINI, A., NATRAJ, N., WHEATON, L. A. (2012), "One hand, two objects: Emergence of affordance in contexts", in *Brain and cognition*, 80(1), pp. 64-73.

BORGHI, A. M., SCOROLLI, C., CALIGIORE, D., BALDASSARRE, G., TUMMOLINI, L. (2013), "The embodied mind extended: using words as social tools", in *Frontiers in psychology*, 4, pp. 1-10.

BURENHULT, N., MAJID, A. (2011), "Olfaction in Aslian ideology and language", *The Senses and Society*, 6(1), pp. 19-29.

CAIN, W. S. (1979), "To know with the nose: keys to odor identification", in *Science*, 203(4379), pp. 467-470.

CHEN, M., BARGH, J. A. (1999), "Consequences of automatic evaluation: Immediate behavioral predispositions to approach or avoid the stimulus", in *Personality and social psychology bulletin*, 25(2), pp. 215-224.

CROCKER, E. (1935), "Seeking a Working Language for Odors and Flavors", in *Industrial & Engineering Chemistry*, 27(10), pp.1225-1228.

CRUTCH, S., WARRINGTON, E. (2005), "Abstract and concrete concepts have structurally different representational frameworks", in *Brain*, vol. 128(3), pp. 615-627.

DOVE, G. (2014), "Thinking in Words: Language as an Embodied Medium of Thought", in *Topics in Cognitive Science*, vol. 6, pp. 371-389.

ENGEN, E., ENGEN, T. (1997), "Relationship between development of odor perception and language", in *Enfance*, vol. 50(1), pp. 125-140.

ENGEN, T., ROSS, B. M. (1973), "Long-term memory of odors with and without verbal descriptions", in *Journal of Experimental Psychology*, 100(2), 221.

FODOR, J. (1983), *The modularity of mind*, The MIT Press, Cambridge.

FLUMINI, A., BARCA, L., BORGHI, A. M., PEZZULO, G. (2014), "How do you hold your mouse? Tracking the compatibility effect between hand posture and stimulus size", in *Psychological research*, pp. 1-11.

FREINA, L., BARONI, G., BORGHI, A.M., NICOLETTI, R. (2009), "Emotive Concept-Nouns and Motor Responses: Attraction or Repulsion?", in *Memory and Cognition*, 37, pp. 493-499.

GALLESE, V. (2008), "Mirror neurons and the social nature of language: The neural exploitation hypothesis", in *Social neuroscience*, 3(3-4), pp. 317-333.

GENTNER, D. (1982), "Why nouns are learned before verbs: Linguistic relativity versus natural partitioning", in *Center for the Study of Reading Technical Report*, 257.

GHIO, M., VAGHI, M. M. S., TETTAMANTI, M. (2013), "Fine-grained semantic categorization across the abstract and concrete domains", in *PloS one*, 8(6), e67090.

GLENBERG, A.M., ROBERTSON, D. A. (2000), "Symbol grounding and meaning: A comparison of high-dimensional and embodied theories of meaning", in *Journal of memory and language*, 43(3), pp. 379-401.

GRANITO, C., SCOROLLI, C., BORGHI, A. M. (2015), "Naming a Lego World. The Role of Language in the Acquisition of Abstract Concepts", in *PloS one*, 10(1), e0114615.

HOWES, D., CLASSEN, C. (2013). *Ways of sensing: understanding the senses in society*, Routledge.

LANDAUER, T. K., DUMAIS, S. T. (1997), "A solution to Plato's problem: The latent semantic analysis theory of acquisition, induction, and representation of knowledge", in *Psychological review*, 104(2), pp. 211-240.

LEHRER, A. (1975), "Talking about wine", in *Language*, vol. 51(4), pp. 901-923.

LEVINSON, S., MAJID, A. (2014), "Differential ineffability and the senses", in *Mind & Language*, vol. 29, pp. 407-427.

LUPYAN, G., WARD, E. (2013), "Language can boost otherwise unseen objects into visual awareness", in *PNAS*, vol. 110(35), pp. 14196-14201.

LUPYAN, G., CASASANTO, D. (2014), "Meaningless words promote meaningful categorization", in *Language and Cognition / FirstView Article*, pp. 1-27.

MAJID, A. (2015), "Cultural factors shape olfactory language", in *Trends in cognitive sciences*, 19(11), pp. 629-630.

MAJID, A., LEVINSON, S. (2011), "The Senses in Language and Culture", in *Senses & Society*, vol. 6(1), pp. 5-18.

MAJID, A., BURENHULT, N. (2014), "Odors are expressible in language, as long as you speak the right language", in *Cognition*, vol. 130(2), pp. 266-270.

OLOFSSON, J.K., GOTTFRIED, J.A. (2015), "The muted sense: neurocognitive limitations of olfactory language", in *Trends in Cognitive Science*, 19, 314-321.

PECHER, D., BOOT, I., VAN DANTZIG, S. (2011), "Abstract concepts: sensory-motor grounding, metaphors, and beyond", in ROSS, B. (Ed.). *The Psychology of Learning and Motivation*, vol. 54, pp. 217-248, Academic Press, Burlington.

RICHARDSON, J., ZUCCO, G. (1989), "Cognition and olfaction: A review", in *Psychological Bulletin*, vol. 105(3), pp. 352-360.

SAKREIDA, K., SCOROLLI, C., MENZ, M. M., HEIM, S., BORGHI, A. M., BINKOFSKI, F. (2013), "Are abstract action words embodied? An fMRI investigation at the interface between language and motor cognition", in *Frontiers in human neuroscience*, 7, <http://dx.doi.org/10.3389/fnhum.2013.00125>.

SCOROLLI, C., BORGHI, A. (2007), “Sentence comprehension and action: Effector specific modulation of the motor system”, in *Brain Research*, vol. 1130, pp. 119-124.

TETTAMANTI, M., BUCCINO, G., SACCUMAN, M. C., GALLESE, V., DANNA, M., SCIFO, P., FERRUCCIO, F., RIZZOLATTI, G., CAPPA, S., PERANI, D. (2005), “Listening to Action-related Sentences Activates Fronto-parietal Motor Circuits”, in *Journal of Cognitive Neuroscience*, vol. 17(2), pp. 273-281.

YESHURUN, Y., SOBEL, N. (2010), “An odor is not worth a thousand words: from multidimensional odors to unidimensional odor objects”, in *Annual Review of Psychology*, vol. 61, pp. 219-41.

VAINIO, L., SYMES, E., ELLIS, R., TUCKER, M., OTTOBONI, G. (2008), “On the relations between action planning, object identification, and motor representations of observed actions and objects”, in *Cognition*, 108(2), pp. 444-465.

WANG, J., CONDER, J., BLITZER, D., SHINKAREVA, S. (2010), “Neural representation of abstract and concrete concepts: A meta-analysis of neuroimaging studies”, in *Human Brain Mapping*, vol. 31, pp. 1459-1468.

WIEMER-HASTINGS, K., KRUG, J., XU, X. (2001), “Imagery, context availability, contextual constraint, and abstractness/abstractness”, in *Proceedings of the 23rd annual conference of the cognitive science society*, pp. 1134-1139, Erlbaum Mahwah, NJ.

WILSON D., STEVENSON (2006), *Learning to Smell. Olfactory Perception from Neurobiology to Behavior*, The Johns Hopkins University Press, Baltimore.

WITTGENSTEIN, L. (1967), *Zettel*, Blackwell, Oxford.

WHORF, B. L. (2000a). *The relation of habitual thought and behavior to language*, in CARROLL, J. B. (Ed.), *Language, thought and reality: Selected writings of Benjamin Lee Whorf*, MIT Press, Cambridge, pp. 134-159. (Original work published 1939).

WHORF, B. L. (2000b). *Science and linguistics*, in CARROLL, J. B. (Ed.), *Language, thought and reality: Selected writings of Benjamin Lee Whorf*, MIT Press, Cambridge, pp. 207-219. (Original work published 1940).

WNUK, E., MAJID, A. (2014), “Revisiting the limits of language: The odor lexicon of Maniq”, in *Cognition*, vol. 131, pp. 125-138.

ZARZO, M., STANTON, D. T. (2009), “Understanding the underlying dimensions in perfumers’ odor perception space as a basis for developing meaningful odor maps”, in *Attention, Perception, & Psychophysics*, 71(2), pp. 225-247.