A Sense of Smell Institute White Paper

I KNOW WHAT I LIKE:
UNDERSTANDING ODOR PREFERENCES

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"You like tomato, I like tamato… let's call the whole thing off."
Ella Fitzgerald and Louis Armstrong (1959)

Have you ever noticed that your scent preferences are not necessarily matched by others, or that in some cases you ardently disagree with another's scent opinion? Why is this so? Is rose necessarily a good smell and skunk a bad one? Are we born with a template of what smells we will like and what scents we won't, or do our smell preferences develop and change? And why do we not all share the same preferences? The goal of this paper will be to address these questions with the latest scientific evidence and theory and to explain where our odor preferences come from, what influences them, and how they can be changed.

Odor Hedonics

The most immediate and basic response we have to a scent is whether we like it or not. In scientific parlance this is referred to as *odor hedonics*. Hedonic perception is an affective evaluation that centers on liking; that is our preferences. Pleasantness, familiarity and intensity are the three factors most often evaluated when examining odor hedonic perception. Pleasantness and familiarity are usually highly correlated in odor preference perception, whereas intensity has a more complex relationship to pleasantness (Moskowitz et al., 1976; Sulmont et al., 2002). That is, familiar odors tend to be better liked than unfamiliar odors, and pleasant odors are often perceived as familiar. In contrast, how strong a scent is and how it affects our pleasure of it depends on what the scent is. For example, a weak fishy odor may be acceptable, but not a strong one. However, a stronger lilac scent is usually preferred to a weak one (at least up to a point).

A long-standing debate in theories of olfactory perception is whether hedonic responses to odors are innate or learned. The *innate view* of odor preference claims that we are born with a predisposition to like or dislike various smells. Though widely held, this view has not been empirically validated in humans and is largely due to extrapolations from animal pheromonal communication (Rasmussen & Schulte, 1998). In contrast, the *learned view* states that we are born merely with a predisposition to ***learn*** to like or dislike smells, and whether we have a preference for a certain smell or not is

due to our acquired emotional associations to that scent (Bartoshuk, 1991; Engen, 1991; Herz, 2001).

Associative Learning and Odor Hedonic Perception

Associative learning is at the basis of the *learned view* of odor hedonic perception. Associative learning is the process by which one event or item comes to be linked to another because of an individual's past experiences (Wasserman & Miller, 1997). For example, imagine there is a stimulus, call it "A". Your response to A is A+. Now imagine there is another stimulus, call it "B." Your response to B, however, is nothing (0). Now put A and B together and what happens? When you are presented with A again your response to it is still A+. However, when you are presented with B again, your response to it is now A+ as well. That is, through association, B, which was formally meaningless has taken on the properties of A. Associative learning is responsible for a large part of human cognition and behavior and is also the foundation of classical conditioning.[1]

The associative learning view of odor hedonic perception states that an odor is initially meaningless or a *tabula rasa* (blank slate) and that through association with the context in which it is perceived it takes on the associations/meaning of that context (Bartoshuk, 1991; Engen, 1991). Specifically, the theory states that odor hedonic perception is formed from a learned association combining the odor and the emotional valence surrounding one's first encounter with the odor (Herz, 2001; Herz, et al., 2004). For example, a novel odor is first experienced in conjunction with an emotional event that induces anxiety, such as a surgical procedure in a hospital. That odor, through its association with the emotion of anxiety, then acquires the emotional significance of anxiety which imbues the odor with hedonic meaning, and influences its perception (e.g., unpleasant). Thus the reason why "hospital smell" is generally disliked is because of the unpleasant associations we have to hospitals. In contrast, a novel odor experienced in conjunction with someone whom we are passionately attracted to will be imbued with very positive associations and thereby become very pleasant. Thus, the reason why we

[1] Pavlov's dogs inherently salivated to meat, but a bell meant nothing to them. After a bell had been paired with the presentation of meat several times, the bell alone was sufficient to make the dogs salivate.

like or dislike various smells is due to our emotional associative history with the odors in question. Notably, our emotional associations do not always have to come from direct experience; cultural learning provides meaning to many unencountered stimuli. For example, one need not have suffered through a fire to know that smoke signals danger.

When discussing odor preference formation it is important to consider the issue of odor novelty, because if an odor is already familiar, it necessarily has been previously associated to past experiences. It is known that once an association to an odor has been formed it is difficult to re-associate that odor to something different. This was clearly shown in a study by Lawless and Engen (1977) which demonstrated that the first association made to an odor interfered with learning subsequent associations to the same scent (proactive interference), whereas new pairings to the scent did little to over-ride the previous associations made. Therefore, the first associations made to an odor are very powerful. This has important implications for introducing new scents and changing odor preferences once they have been formed (see **Direct Experimental Evidence for Odor Preference Formation** for further discussion).

Developmental Factors in Odor Hedonics

We are born with a fully functional sense of smell. And newborns have very minimal prior experience. Therefore, if one wanted to examine whether our odor preferences were innate the best place to look would be at infants, because if odor preferences are innate then newborns should display them. However, infants do not respond to scents the same way their parents do. Indeed infants often show opposing responses to adult preferences, for instance liking the smell of sweat and feces (Engen, 1982; Stein et al., 1958). Research with toddlers and youngsters up to the age of five (Engen, 1988) also indicates that this age group often does not differentiate between odors that adults find either very unpleasant (e.g., butyric acid = rancid) or pleasant (amyl acetate = banana) and typically display neophobia as a general response; avoidance of unfamiliar foods/flavors (Frank & Kalisewicz, 2000). Only one study has reported that young children (3-year olds) showed adult-like responses to certain odors which would be in keeping with an ‘innate’ framework (Schmidt & Beauchamp, 1988). However, this research has been criticized on methodological grounds (Engen & Engen, 1997). Notably,

by the time a child is approximately eight years old, olfactory responses closely resemble those of the adults in his culture (Engen, 1982).

The developmental literature suggests that olfactory preference learning begins at the very onset of life itself. Indeed our sense of the smell is fully operational by the time we are just three months in the womb (Schaal et al., 1995, 1998; Winberg & Porter, 1998). Mennella and colleagues found that infants of mothers who consumed distinctive smelling volatiles (e.g., garlic, alcohol, cigarette smoke) during pregnancy or lactation showed preferences for these smells compared to infants who had not been exposed to these scents (Mennella & Beauchamp,1991; Mennella & Beauchamp,1993; Mennella, et al., 1995). Additionally, early learned odor preferences go on to influence food and flavor preferences in later childhood (Mennella & Garcia, 2000) and adulthood (Haller, et al., 1999).[2] Notably feeding, in addition to providing nutrition, is an opportunity for close physical contact and emotional bonding. Association through affectionate cuddling alone has been shown to induce preferences for specific (yet arbitrary) scents among infants, such as cherry oil or mother's perfume (Balough & Porter, 1986; Davis & Porter, 1991; Lott et al., 1989; Schleidt & Genzel, 1990; Sullivan et al., 1991). Thus, the developmental literature demonstrates both the lack of *a priori* hedonic responses to odors, as well as the readiness of the olfactory system to learn the meaning of odors/flavors based on associative learning and the emotional significance of the associated experience.

Although the majority of our odor preferences are acquired during childhood, because of the novelty and salience of so many experiences, any time a new odor is encountered associative learning mechanisms can determine our odor preferences. Anecdotes of liking or disliking scents because of their connection to significant others (Herz, 2001) and idiosyncratic cuisine preferences (Rozin, 1996) are just a few examples of how associative learning and emotional-social context influences odor perception throughout life. The forthcoming section **Direct Experimental Evidence for Odor Preference Formation** discusses this issue in detail.

[2] Flavor is produced primarily by odor; taste contributes only the sensations of salt, sour, sweet, bitter and savory (Bartoshuk & Beauchamp, 1994).

Cultural Differences

A supermarket poll reported by the *Times of London* (January, 2004) revealed that Britain's top 10 favorite smells were: fresh bread, frying bacon, coffee, ironing, cut grass, babies, the sea, Christmas tree, perfume, and fish & chips. We may agree with some of this list, but guaranteed someone from the UK won't agree with our top 10. Wintergreen candy and root-beer are two American favorite smells and yet the British find both of these repellent. Why? And why are those particular scents favorites for the British?

No scientific studies to date have found agreement for hedonic responses to common everyday smells, both "good" and "bad" (Ayabe-Kanamura et al., 1998; Schleidt et al., 1981). Many anecdotal and observational examples illustrate the culturally polarized responses we have to specific odors. Asians consider the smell of cheese to be disgusting, yet Westerners consider it anything from comfort food to an extravagant indulgence. In contrast, the Japanese enjoy a meal for breakfast called "nato" (a fermented soy bean dish) which an American couldn't bring near her mouth. The fruit durain (also called "jackfruit), which is found in the middle east and other regions of Africa is a local delicacy, but when Westerners smell it they are repelled. And in case you are thinking that everyday odors aren't really *that* bad, and that there must be consensus on really horrid stenches—this also doesn't seem to be the case. Fecal smells are not high up on most North American's "best smells list," but the Masai like to dress their hair with cow dung as a cosmetic color treatment, and to the US military's great surprise it has been impossible to develop a 'stink bomb' to use for crowd dispersal. In a recent study undertaken by the United States military to create a stink bomb it was impossible to find an odor (including US army issue latrine scent) that was unanimously considered unpleasant across various ethnic groups (Dilks et al., 1999).

So how is that some people find the smell of feces tolerable and others are disgusted by the scent of cheddar cheese or root-beer? The answer is associative learning with emotion as the key variable. The following example illustrates this process. In the mid-1960's in Britain, Moncrieff (1966) asked adult respondents to provide hedonic ratings to a battery of common odors. A similar study was conducted in the United States in the late 1970's (Cain & Johnson, 1978). Included in both studies was the odorant methyl salicylate (wintergreen). Notably, in the British study, wintergreen was given one

of the lowest pleasantness ratings out of the entire set, whereas in the American study it was given the highest pleasantness rating. The reason for this difference can be explained by history. In Britain, the smell of wintergreen is associated with medicine and particularly for the participants in the 1966 study with analgesics that were popular during WWII, a time that these individuals would not remember fondly. Conversely, in the United States, the smell of wintergreen is exclusively a candy mint smell and one that only has sweet, positive connotations. Thus, the key to olfactory associative learning is the experience that occurs when the odor is first encountered and in particular the emotional connotation of that experience (Bartoshuk, 1991; Engen, 1991; Herz, 2001).

Neuroanatomy also supports the proposition that our olfactory system is especially prepared to learn the significance of odors. The orbitofrontal cortex, the area of the brain responsible for processing olfaction, is also the area of the brain critical for assigning affective value (positivity-negativity) to stimuli; in other words, assigning hedonic meaning (Davidson et al., 2000). Furthermore, the amygdala which synapses directly with the olfactory nerve is critical for emotional associative learning (Davis & Whalen, 2001).

Direct Experimental Evidence for Odor Preference Formation

Only a few studies have directly examined the relationship between odor preference formation and emotional learning. Hvastja and Zanuttini (1989) presented children between the ages of 6.5 to 10.5 with odors paired with either positive or negative slides and showed that, for the younger children in the sample, odors paired with positive pictures were evaluated more favorably than odors paired with negative pictures. Baeyens and Wrzesniewski (1996) examined naturalistic manipulations of a familiar odor paired with idiosyncratically perceived pleasant and unpleasant toilet experiences and found that, compared to a control odor, hedonic perception of the paired odor changed in accord with the individual's emotional attribution of going to the bathroom. In another experiment assessing physiological responses to odors, Robin et al. (1998) found that the smell of eugenol ("clove" odor used in dental cement) was evaluated negatively and elicited physiological fear responses among patients who were afraid of dental

procedures, but not unafraid patients. Notably, in each of these studies, changes in olfactory perception were somewhat equivocal.

Most recently, we conducted a study directly aimed at addressing the hypothesis that olfactory hedonic responses are acquired through associative learning with emotion (Herz et al., 2004). We conducted two experiments that varied with regard to whether a novel ("target") odor was pre-experimentally pleasant or unpleasant and the emotional association that was linked to it was positive or negative. In each experiment, participants were randomly assigned to an Experimental Group (odor + emotional association) and various Control Groups. Evaluations of the target odor and several "anchor odors" that were not explicitly part of the association procedures were made several times throughout the study: (i) prior to the manipulation, (ii) post-manipulation, (iii) 24 hrs after the manipulation, and (iv) 1 week from the start date. The results from both experiments showed that evaluation of the target odor by all participants was comparable prior to the manipulations, and responses to the anchor odors were unaffected by time or experimental condition. However, in each experiment, all post-emotional manipulation ratings to the target odor were significantly altered in the Experimental Group and showed that odor perception had changed in accord with the emotional valence of the associated experience. When an "unpleasant" target odor was paired with a positive emotional experience, subsequent evaluations of that odor were more favorable, and when a "pleasant" target odor was paired with a negative emotional experience, subsequent evaluations of that odor were more unpleasant. No such effects were seen in the Control Groups. Moreover, changes in odor preferences in the Experimental Groups remained throughout the week of testing. This implies that changes in odor preferences by emotional associations can endure a long time.

Our findings showed that when a novel odor is paired with an emotional event, hedonic perception of that odor was altered in accord with the associated emotion. Although our study could not rule out the possibility of innate responding to odors, together with past empirical work and developmental and cross-cultural data (Ayabe-Kanamura et al., 1998; Hvastja & Zanuttini, 1989; Baeyens & Wrzesniewski, 1996; Mennella et al., 1995; Robin et al., 1998) it appears that emotion in conjunction with odor exposure is a powerful manipulator of odor preference formation.

The results of Herz et al. (2004) also have important implications for how odor preferences can be altered. For odors that do not yet have specific emotional associations to them, but are nevertheless not perceived as neutral, it appears that their preference evaluations can be easily altered by association to specific emotions. It has not yet been studied how to best alter preferences for odors that have already been linked to explicit emotional associations. However, indirect evidence from the clinical literature on post-traumatic stress disorder suggests that when odors have been linked to emotionally intense events they are very difficult to modify (Vermetten & Bremner, 2003), and the literature on proactive interference in odor memory substantiates this (Lawless & Engen, 1977). My hypothesis is that the effectiveness of changing odor preferences that have already been formed will depend on the strength of the original emotional association, the new emotional association and the frequency with which that odor is encountered. I predict that odors that have very powerful prior emotional associations will be most difficult to change and may require various de-conditioning methods prior to re-association with a very positive new experience. Odors that have mild-moderate prior emotional associations will be changeable with a strong new association. And odors that are encountered frequently and are very familiar (e.g., coffee) will be harder to alter than odors that are only rarely encountered because of multiply reinforced prior learning. It would be very informative for psychological research and the fragrance community to address these issues in future research.

An Evolutionary Theory

In addition to the empirical evidence, the associative learning hypothesis for odor preference learning (in contrast to the innate view) is theoretically supported by an evolutionary analysis contrasting the goals and requirements of animals that are generalists versus those that are specialists.

Specialists are animals that are restricted to specific habitats, and thus can often only eat a few foods and have particular local predators (Rozin, 1976). The eucalyptus exclusive diet of the panda bear is one extreme example. Thus, because the ecological niche of specialists is restricted, having hard-wired responses to particular odors is adaptive. Innate odor responses have been empirically demonstrated for many specialist

species. For example, both lab-born and wild-reared California ground squirrels show a discriminative defensive response to their natural predator, the Pacific rattlesnake, as compared to the Pacific gopher snake (not a natural predator), when first exposed to them. And the discrimination between these two snakes is made on the basis of subtle olfactory cues that differentiate them (Coss et al., 1993; Poran & Coss, 1990). The same type of specificity in responding has also been demonstrated for food sources and in many other specialist species.

In contrast to specialists, generalists (humans, rats, cockroaches) can exploit any habitat and therefore potential prey and predators are myriad. The available resources and potential predators and dangers, however, differ widely across environments. The sea and the savannah, for example, impose very different survival challenges. Therefore, it is not adaptive to have pre-determined olfactory responses to potential prey or predators, but rather to be especially prepared to learn associations on the basis of their significance when they are encountered. The best natural example of the potency of odor learning is the case of taste aversions. Rats and humans can be made to avoid a novel flavor by being made sick after consumption. For example, presenting a rat with a sweet tasting banana scented drink and then injecting it with lithium causes avoidance of the smell of banana thereafter (Garcia & Koelling, 1966). Similarly, children who have experienced chemotherapy after ingesting a novel ice-cream flavor subsequently show avoidance to that flavor (Bernstein, 1978). Bartoshuk (1989) has made it clear that it is the smell, not the taste, of the substance that is responsible for the learned aversion response. These example show how for generalists, such as us, a scent is a blank slate before exposure in an emotional context but after association it takes on the character of that emotion. A *tabula rasa* olfactory system also explains the neophobia that human infants display to most new smells until they have learned their meaning. From an evolutionarily perspective it is therefore adaptive that the olfactory system of generalists not to be predisposed to like or dislike any particular odors, but rather be especially prepared to learn and remember what to approach and what to avoid based on experience.

Mediating Factors: Caveats, Context, Expectation and Verbal Illusions

Caveats: At least two caveats to the assertion that all olfactory hedonic responses are learned must be mentioned. One is the issue of trigeminal stimulation. Trigeminal stimulation is responsible for the tactile (burning, cooling) and irritating component of odor perception. Although the trigeminal system is separate from the olfactory system, subjective experience is not distinct and it is often very difficult to dissociate the olfactory from the trigeminal aspects of a scent (e.g., gasoline). Odors vary greatly in the degree to which they stimulate the trigeminal nerve and in many cases this aspect is negligible (Doty et al., 1978). However, trigeminally irritating odors may elicit immediate avoidance responses on the basis of their trigeminal component and thus odors that cause trigeminal irritation do not require learning to be considered unpleasant. This is adaptive for us as well as many toxic substances are strongly trigeminal.

A second consideration is the individual variability that may exist in specific genes and pseudogenes for olfactory perception across individuals. It is known that of the 1,000 genes coding for olfactory receptors, only a subset of them (between 300-400) are functional (e.g., Malnic et al., 2004). It is quite likely given the variability in the number of functional genes reported, that there is also variability between individuals in what those functional genes are. Thus, it may be the case that a person who likes the smell of skunk does so in part because they are missing receptors for detecting some of the more pungent volatiles, while another who is repulsed by this scent is endowed with a greater number of receptors that are keenly attuned to the mercaptan and sulphide aspects of this bouquet. In particular, it appears that a genetic case can be made for the spice cilantro. Cilantro elicits strong and polarizing hedonic responses. Current research by Chuck Wysocki has shown that identical twins always have the same immediate hedonic response to cilantro (either loving it or hating it) while fraternal twins do not (see the *Monell Connection* newsletter, winter 2003, for more details). It is not yet known what olfactory receptors or genes account for these differences, however it appears that genetic/receptor mechanisms mediate perception of this specific spice. Very recent molecular research also suggests that the timing of the turning on or off of certain genes that govern specific olfactory receptors causes changes to our sense of smell throughout life (Stuart Firestein, personal communication, January 9, 2004). That is, the way a rose

smelled to us at 2 yrs of age, at 20 yrs of age and at 50 yrs of age may not be the same. It would be interesting to examine how genetic effects and aging interact with susceptibility for odor-associative learning. Perhaps someone who is genetically endowed to dislike cilantro will still be able to become fond of it if their first true love is a Mexican chef. Further exploration and understanding of the role of genetics in odor preferences will be very fruitful and future research should investigate individual genetic differences and aging as covariates to susceptibility for odor-associative learning.

Context, Expectation and Verbal Illusions: In addition to the power of emotion and associative learning for odor preference formation, there are several other factors that mediate odor preference perception, in particular: context, expectation and language.

A context is a state or situation (mental or physical) or environment that induces a set of preconceptions and expectations. Context can be a powerful mediator of odor hedonic perception. For example, if you are walking by a garbage dumpster and you smell a particular scent with a few sharp notes, you are likely to perceive the smell as unpleasant, however, that exact same chemical composition hovering above the cheese plate at a French restaurant might inspire salivation. Thus, the preconceptions and expectations elicited by the physical context in which you are exposed to an odor can be a strong determinant of its hedonic meaning. A poignant literary example of the influence of expectation on olfaction was described in Mark Twain's *The Invalid's Tale*. A stowaway on a train car jumps to what becomes the cause of his untimely death, because he convinces himself that the sack beside him contains a dead body, when in fact all it contained was "a lot of innocent cheese." This anecdote describes a visual context (a burlap sack of a particular shape) that created a set of expectations that powerfully influenced odor hedonic perception. No experiments to date have investigated visual context effects on odor perception, however, verbal contexts have been well studied and appear to be very influential for altering odor perception (Herz & von Clef, 2001; Herz, 2003).

My laboratory has found that verbal expectation effects are so great that they can cause olfactory illusions to be induced by words alone (Herz & von Clef, 2001). Using the definition that an illusion is created when a physical stimulus remains invariant but its

context alters perception, we investigated whether verbal context could produce olfactory illusions. We examined five ambiguous odors.[3] The odors were: violet leaf, patchouli, pine oil, menthol, and a 1:1 mixture of isovaleric + butyric acid. Participants sniffed each odor at two different sessions separated by one week. At each session an odor was given a different verbal label, either positive or negative (for example, iso-valeric + butyric acid was alternately called "vomit" or "parmesan cheese," and pine oil was called "disinfectant" or "Christmas tree"). Participants then gave ratings to the odors on several hedonic scales and provided motivational and interpretative responses to them. Results showed that the hedonic perception of all of the odors could be significantly influenced by the label provided for it. When the label was positive each odorant was evaluated as more pleasant and familiar than when that same odorant was given a negative label. Moreover, motivational responses were entirely different as a function of label. For example, when isovaleric + butyric acid was called "parmesan cheese" it inspired participants to say they would like to eat it, while when it was given the negative label ("vomit") it provoked the wish to escape from it. The effect was so strong for certain odors, that participants could not believe that the same odorant had been presented to them at both sessions. This dramatic alteration of the perception of an odor by words alone is the first empirical demonstration of olfactory illusions.

In another study, the concepts of 'synthetic' and 'natural' were examined as mediators of odor preference (Herz, 2003). Eight common positive and negative odors (rose, vanilla, lemon, peppermint, fish, sweat, bad breath and rotten egg) were presented in their natural and synthetic forms and verbal labels designating name and source (natural, synthetic) information were either: explicitly given, self-generated, falsely provided, or not provided. Results showed that when an odor was *believed* to be "synthetic" it was given lower hedonic evaluations than when the same odorant was believed to be "natural," regardless of whether or not the odorant was truly natural or synthetic. It also didn't matter whether an odor was actually present, or whether the scent was positive or negative. That is, using the label "natural vanilla" resulted in higher pleasantness and familiarity ratings than the label "synthetic vanilla" even when there

[3] Ambiguous odors are those with minimally fixed sources and can thus be interpreted with various hedonic connotations.

was no accompanying smell. And "natural" was evaluated as superior for negative odors as much as the positive odors (i.e., "natural" bad breath was preferred to "synthetic bad breath"). Notably, if the participant *believed* the odorant to be comprised of "both natural and synthetic" components (this was actually never the case) it was given equally positive ratings as the same odorant believed to be 100% natural. Furthermore, participants were objectively unable to discriminate between natural and synthetic versions of the same scents, and without any labels truly natural and synthetic odorants were given either equivalent evaluations or in some cases the synthetic versions were actually preferred.

Together these studies show that the connotation of words can have a tremendous impact on how well liked an odor will be, independent of how it was originally learned. For example, parmesan cheese may be associated with the comfort and pleasure of eating pasta, but a chemical that could be parmesan cheese if believed to be something quite different (e.g., vomit) will utterly negate the past positive association. Thus, words provide a context in which an odor is interpreted, and how that interpretation fits with past experiences will determine how it will be evaluated.

Sex Differences?

Women have been shown to be more sensitive to odors than men under some conditions. In particular when an odorant is at sub-threshold concentration, women are more likely to report detecting a scent before a man (Whisman et al., 1978). However, at or above average threshold concentration there are typically no differences between men and women in their odor sensitivity. Menstrual cycle phase also plays an important role in women's odor detection abilities. During ovulation, women are especially sensitive to odors, however during the menses stage of their cycle women are equivalent or may even be less sensitive than the average male to any given scent (Doty et al., 1981).

Given that odor intensity is related to odor hedonic perception, it is worth considering whether there are any preference differences between men and women. No systematic test of this question has been conducted that is not restricted to body-odor, and conclusions from this area of work are confounded by heterosexual attraction mechanisms. Nevertheless, in the many studies I have conducted and the numerous

others that I have read, I have never observed any systematic sex differences in basic odor preference evaluations. To the extent that familiarity plays a role in odor hedonic judgments, Cain (1982) showed that women were more familiar with and better able to name many common odors than men, but at closer inspection this familiarity bias was due to cultural exposure effects. That is, women were more familiar with cooking and cosmetic odors, while men were more familiar with outdoors and mechanical odors.

The personality predisposition of being particularly interested in and attentive to scent is related to odor preferences and may be mediated to some degree by sex. People who pay attention to and care about smell tend to be more favorably predisposed to odors in general, and therefore will like more odors than someone who is uninterested in scent. Wrzesniewski, McCauley and Rozin (1999) developed a questionnaire to assess the degree to which people are interested in and pay attention to odors. The higher the score on this questionnaire the greater the importance of odors to that individual. Wrzesniewski et al. (1999) did not obtain sex differences in their data, however, a non-significant trend for women to score higher on this questionnaire has been observed (Herz, 2004), suggesting that women may like odors more or have more odor preferences than men.

I would like to end the topic of sex differences by discussing a condition where many anecdotal reports of temporarily altered odor preferences among women exist; the state of pregnancy. In addition to surprising food cravings like pickles and ice-cream, sudden food/odor preferences and aversions are also often reported. In many cases, the suddenly repulsive food/odor was very well liked prior to pregnancy; for example fried chicken, or pizza (Pope et al., 1992). Folklore has received much more attention than science in this domain so we tend to believe that something about pregnancy (e.g., hormonal state) alters women's odor preferences. But what is the scientific evidence?

Several recent studies have examined olfactory sensitivity changes during pregnancy, focusing both on the first trimester, where there is much anecdotal report of increased sensitivity to smells, as well as the entire period of pregnancy. A review of this literature shows that no systematic changes in odor sensitivity were found at any point of pregnancy and pregnant women are no more sensitive to odors than their non-pregnant peers (Kobel et al, 1991: Hummel et al., 2002; Lashka et al., 1996). Odor induced nausea

is also seen during pregnancy and has been experimentally investigated in relation to olfactory sensitivity, but the data suggest that feeling sick from smelling fried chicken is due to how the odor is psychologically perceived and not due to any changes in olfactory sensitivity or hormonal changes due to pregnancy (Bayley et al., 2002; Hummel et al., 2002). In other words, the olfactory-food oddities that are reported during pregnancy seem to be idiosyncratic and psychological rather than physiological. It is possible that women who experience pregnancy as a psychologically heightened emotional state, may be more susceptible to developing new emotional associations during this time and hence new cravings and aversions (i.e., hedonic responses) appear. It is also conceivable that because there is so much popular lore about food and odor changes during pregnancy that much of the alterations in preferences reported are a function of and perpetuated by cultural suggestion; that is, culturally induced associative learning (see Carruth & Skinner, 1991 and Pope et al., 1992).

Summary and Significance for the Fragrance Industry

The present scientific review of odor preferences highlights several important factors. First, it appears that our odor preferences are learned and malleable. In particular, when a new odor is presented how it will be perceived depends greatly on the emotional association that accompanies it. Advertising methods that take advantage of this connection are currently used and they could be exploited much further to create positive emotional associations to new odors. Presenting an elegantly dressed, beautiful, successful woman in conjunction with a new perfume creates the link between the concepts of elegance, beauty and success with this new fragrance. However, a more powerful method would be to use direct marketing techniques where a person experiences a very positive experience while being exposed to a new fragrance for the first time.

This report also indicated that odor preferences can be changed, at least if they are not indelibly formed. In our study (Herz et al., 2004) after only two 15 minute pairings with a moderately positive emotional experience, an unpleasant odor was subsequently evaluated as much more acceptable and this improvement was sustained for at least one week (see Herz et al., 2004 for details).

In sum, the commercially significant features concerning associative learning and odor preferences are: (1) Through association with emotional experiences the hedonic perception of odors can be changed accordingly. Olfactory aspects of a product can be made to be perceived as particularly pleasant and unpleasant odors can be changed to be perceived as more acceptable. (2) Emotions and messages can be associated to a product's aroma that will be re-activated when the aroma is experienced in the future.

Another major point revealed by this review is that the context, especially the verbal context in which an odor is encountered can be a powerful mediator of odor preferences, independent of past emotional learning. In particular, odors that are not strongly anchored to a specific source can be manipulated by the words used to describe them. Furthermore, the concepts of natural and synthetic/artificial are powerful mediators of odor preference, yet the average consumer is unable to distinguish between the natural and synthetic version of many common odorants, and often finds synthetic scents more appealing than natural ones.[4] Notably, in my study where "synthetic" and "natural" odors were compared, when participants *believed* an odorant to be a mixture of natural and synthetic components they evaluated it just as positively as they did when they believed it to be 100% natural. This suggests that consumers will be satisfied with a product that contains artificial ingredients as long as an equivalent number of "natural" ingredients are also present.

The labels given for fragrances and perfumed products can also influence how they will be welcomed upon first sniff. For example, by creating a specific expectation, the name "Mr. Clean" has more inherent positive value than "Pinesol." In addition to providing information and delivery promise, product names could also be more emotionally descriptive. For example, something named "Smiling Roses" is more attractive than "Rose" and would set up the expectation for the mood of happiness. Thus, the commercially relevant factors concerning verbal context are: (1) The words used to describe odors will set up an expectation for the consumer. (2) Words can manipulate a consumer's appreciation for a scent (e.g., natural, synthetic). (3) Words invoking emotional suggestions can create a more holistic experience and be emotionally

[4] It is presumed that synthetic versions are preferred because of greater past exposure and familiarity with them in products.

motivating. The bottom line is that the verbal context and emotional associations made during initial odor exposure are the keys to its success.

The findings described in this report have shown that we learn our odor preferences through associative learning with emotion. Our odor preferences can be manipulated and changed through emotional associative learning and the words used to describe odors will be pivotal to how they are perceived. These findings can be capitalized upon by the fragrance industry and should be very valuable.

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