A Sense of Smell Institute White Paper

The Effects of Expectation and Context on Odor Perception

Tyler S. Lorig, Ph.D.

Ruth Parmly Professor

Washington and Lee University

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Summary

While we tend to think of odor perception being about the chemicals we smell, there is far more to this process. The chemicals, receptors in the nose and expectations for what we smell all play a crucial role in our perception. This whitepaper describes this process and reviews some of the studies that illustrate the importance of expectation and context in perceiving odors. This information has importance not just for our basic understanding of the olfactory process but can also be used to create better fragrances. The paper concludes by discussing how the industry might make more effective use of both research and advertising to create better smelling products.

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The effects of expectation, context on odor processing

How does a fragrance remind you of an old friend, make you happy or reflective, or hide the smell of last night's dinner? The answer is, at one level, obvious, but at another level it remains a complex mystery. This paper addresses the most fundamental parts of the olfactory process and, it is hoped, provides the reader with a solid foundation in understanding why olfaction is more than meets the nose.

At various points in the history of our understanding of the sense of smell, we have believed that we had this story of how smell works worked out. Unfortunately, we have always been wrong about that and certainly don't yet have the whole story. Even so, this paper is designed to bring the reader to our current views about how olfaction works as well as to point out some issues that new theories must address.

A whiff of history

Let's start with a quick tour of the last fifty years even though our certainty about how smell works has waxed and waned for centuries. In the 1960's and 70's, John Amoore (1963, 1977) proposed a valuable, interesting, and still widely held view of how olfaction worked. Known as the *stereochemical* theory, Amoore proposed that we smell different things when chemicals of different molecular shapes enter the nose and stimulate the neural receptors that go to our brains. So far, so good. We do smell chemicals. No doubt about it. And many of the readers of this paper are engaged in industrially producing these chemicals that become the foundation of the fragrance in many of the products we buy. It is also quite true that the chemicals that we smell have shapes. These shapes are the result of atoms that bind together in predictable ways and make molecules. Molecules are often complicated three-dimensional shapes with electrical charges that attract or repel other molecules –much like a few small magnets on a table - some forming connections and others pushing different magnets away.

So this much of the stereochemical theory is quite true. The stimuli that we smell are molecules that have shapes and these molecular shapes fit into receptors in our nose. The receptors signal our brains about the nature of the molecule and the rest is *smell*. Amoore held that there were seven basic shapes that combined to give us the rich world of smell. While this may seem a little far-fetched to some readers, it is very similar to how we see! The eye has not seven receptors but four! All that we see, no matter how colorful or complex, is the result of three color receptors and fourth that simply senses how much light is out there so Amoore's theory was plausible. There was much to like about the theory and it seemed on good footing but like all scientific theories, it required testing.

Without digressing too much into the sociology of science, Amoore's theory filled a much-needed void in the science of smell. There were few theories that could be tested at the time he proposed this idea and that led many scientists to jump into the fray. It wasn't long before some olfactory oddities began to challenge Amoore's idea. These strange findings came from testing people who could smell some things, but could not smell others. Think of how strange this really is. A scientist places 10 bottles in front of you. You tell the scientist that 8 of the bottles contain odors and two do not. Your friend then takes the test and they agree that 8 of the ten bottles contain scent. The problem is that their two "non-smelling" bottles are two that you thought smelled the strongest! How could this be? The molecules are the same! There must be something different about your noses and if you just have the molecules and receptors in your nose, then it must be the receptors!

A little biology

And so it is. People do have different receptors and these receptors match the configuration of some molecules but not others. This means that a person with an otherwise great sense of smell can't smell some odors. That is called a specific anosmia because the lack of smelling (anosmia) is specific to one chemical. According to Amoore's theory, these anosmias should be within one of the seven odor categories. So a specific anosmia to a musky odor (one of Amoore's categories) should mean that you are missing the musky receptor and shouldn't be able to smell others in that same category. Sadly, for the theory, it doesn't work that way. Musk, in particular, can be very specific and not smelling one does not mean that you are insensitive to all the various musk molecules that comprise this odor category. Ultimately this sort of finding led to Amoore's theory being mostly dismissed but it also led to far more interest in the nature of receptors.

That interest and the ongoing revolution in an area of science that seeks to understand the molecular nature of biology led two researchers, in particular, to try to understand how receptors come to be and how they are different from each other. Those two researchers, Richard Axel and Linda Buck, won the 2006 Nobel Prize for finding out how odor receptors come to work. Subsequent work has established with stunning detail how genes encode for these receptors. Led by Stuart Firestein, Peter Mombarts, Daniele Reed, and many others, scientists now know our genes come to produce different receptors and how those receptors are interconnected to the first bits of the brain involved in smell. The story is fascinating and full of some amazing puzzles. For instance while there are more than 1000 genes that could code for olfactory receptors, there are only about 350 genes actually producing working olfactory receptors in a person. The other 650 genes are "pseudogenes" – the apparent result of mutations in the human genome that have diminished the number of available receptors in our species. No one (probably) has all the olfactory receptors that these 350 genes encode but the fact that there are so many suggests that Amoore should have had more than his original seven categories! And just for comparison, while we don't know the exact number of genes that code for color vision receptors in the eye. It is clear that the number is far, far fewer than those that code for our olfactory receptors (Deeb, 2004).

The revolution that Axel and Buck started is going strong. We now have been able to remove a fragment of DNA for an olfactory receptor and replace it with another bit of DNA that makes the olfactory receptor sensitive to blue light. Now, when a blue light comes on, mice *smell* it! While this sounds a bit like science fiction, it will give us tremendous insight into how the olfactory system works because it provides the ability to better control these cells that send olfactory information into the brain (Soucy et al, 2009).

So this sounds like it should be the end of our story. We understand the nature of the molecules and now the receptors. There is certainly work to be done to connect those two systems but the fundamentals are in place. The two sides of the odor mystery coin, while not completely understood, are well on their way to being revealed. Making better fragrances would seem to be related to simply doing a better job of putting the right chemical in the right place. The problem is that there are far more than two sides to this olfactory puzzle. We may have the chemicals and the receptors but we've left out another essential part: the brain

It's all in your head

It really is. Most people tend to think of the brain as an organ such as the heart, liver, spleen or gall bladder. Important? To be sure! Can't live without it! But unlike these other organs, the brain is far more than just something we need to keep us going. It ***is*** us. All that we think, sense, imagine, dream, and experience is the result of this organ and its connectors to the outside (and inside) world. Our personality, memories, aspirations and secrets are a product of the tissue in our brains. Change the brain and our experience is changed. Doubt that? Humans have, for centuries, made an art form of creating different versions of alcohol-based liquids to alter brain function. While beer may be quite nutritious and a glass of red wine really may help one's heart, would these beverages be so popular if they didn't change our brains and consequently the way we appreciate the world around us? The world is surely a different place as the bottle of wine nears emptiness. Perception changes because alcohol alters the physical substrate of the cells in our brain. Our sensory processes and the brain's evaluation of those processes are physically (and measurably) altered by being bathed in the "warmth" (and oxidative agents) of alcohol. This is how all "mind altering" drugs exert their effects-by changing the physical substrate of the chemicals that make the cells in our brains work. While they may have different chemical mechanisms operating on different brain regions, all alter the way the brain handles the information that shuttles from one place to another. We may describe our "mental" lives to others but our thoughts, our memories and senses are quite physical in their true nature. They arise from the physical world via, light, molecules, or force (e.g. touch and hearing) and *remain physical* as they alter chemicals in our brain that, in turn, alter the richly interconnected tapestry of our thinking.

Why is this important for our discussion of smell? Because recognizing, enjoying or being offended by a smell is the result of three things: 1) the molecules that are the odor, 2) the genetically encoded receptors that respond with a sequence of coded chemical activity, and 3) the brain – the organ that receives these signals and holds your expectations about what you are smelling and your memories, of similar smells. It is the brain where the evaluation of that odor-induced activity takes place. This is why what you expect to smell makes a difference - a really big difference.

Take, for instance, the now classic study by O'Mahoney (1978) about smelling things that aren't really there. The study involved people watching an English television show late one evening in the 1970s. Toward the conclusion of the show, a voice announced that "through the use of new technologies," the television station was now able to cause smells to be experienced by transmitting different tones. They emphasized their point by showing the apparatus – a cone with various wires connected to an oscilloscope. They told the audience that the tone was the same vibratory frequency as the odor molecules and that through the use of Raman Spectroscopy and Fourier analysis of the signal using the computers at the University of Manchester, they would smell a "country" odor. Many did and reports of the smell of hay, manure and complaints of hay fever soon reached the station. The television station received 179 telephone calls or letters within the first 24 hours. A number that the station reported was large for a program in that time slot. Just for the record, both Fourier analysis and Raman spectroscopy are real things and there have been several vibrational theories of smell. Despite these canards, you can't really (in normal brains) produce a smell via a tone, yet people did smell things. We must wonder how many people went to bed that evening with the smell of a barn in their noses and the words "what will they think of next" on their lips!

Before trying to understand the reasons for these errors, let's look at another example from Pamela Dalton and her collaborators at Monell Chemical Senses Center in Philadelphia (Dalton et al, 1997). They were interested in the relationship between odors and health. A number of researchers had observed that people believe that bad odors are associated with illness. This is a very old idea. Known as *miasma*, it is the idea that foul smelling vapors spread disease and was popular in the middle ages. In fact, the art of perfumery arose to combat this problem in Europe. Even though we have far more sophisticated and scientifically valid theories of illness, many people still feel malodorous environments are dangerous. So, in this study, the investigators gave people several different things to smell. The participants were told that one of the smells was a natural extract used in aromatherapy and another was a chemical used as industrial solvent. In reality, there were two different odors used in the study and the label *solvent* or *aromatherapy agent* was applied to ***both*** odors. At the end of the study, one could see how people rated one odor (the smell of nail polish remover), when it was called a solvent *or* an aromatherapy agent. As you might guess, it smelled much better to people when it was described as an aromatherapy agent. It was also believed to be less irritating. The other real odor, a rose-like smell, showed similar but smaller results depending upon whether it was described as a solvent or aromatherapy agent. The moral of this story is that a rose, by another name really isn't as sweet! The "story" changed what people smelled in Dalton's study or reported smelling in O'Mahoney's study. This is really what we mean by "top-down" processing – context, expectation, and biases alter the real perception. Same odor, same receptors, different label – <u>*different smell*</u>.

Some readers may regard these findings as predictable but others are likely to be shocked. It depends on how you see the external world. If you think of the odors as fixed due to their molecular structure and the fact that you have a particular set of genetically encoded receptors, you should be surprised to find that the olfactory experience is so malleable. This very fact has led many in the fragrance industry to be suspicious of psychological studies because such studies tend to have lots of variable responses. It may surprise readers but this variability isn't limited to olfaction. It can be found in the other senses.

Consider for a moment how human vision works. Like olfaction, we have specialized receptors that gather information about the world. In the case of vision, we are gathering light into the eye. The light alters the activity of receptors in our retinas and those receptors send signals into our brains leading us to respond to things in our world. This is the same story as olfaction but different kinds of signals. Have a look at figure 1 below and say aloud what you see.

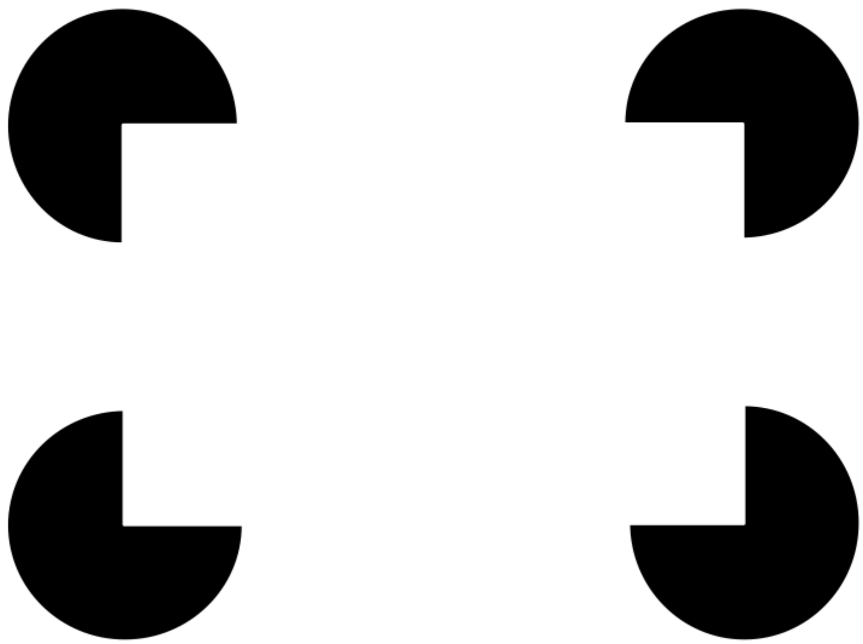

Figure 1. Kanizsa Illusion

Figure 2.

Most readers will say they see four black dots and a large white rectangle. If you haven't already done so, look at figure 2 above and say aloud what you see. I've asked you to say aloud your answer so there is no going back… you heard it just as everyone around you heard it. It's on the record.

Figure one is called the Kanizsa illusion. It is about as simple as such things get. It is just light and dark with a few contours. You saw four black dots and a larger white rectangle that was resting on the tops of all the dots. Now have a look at Figure 3 on the following page. What do you see now?

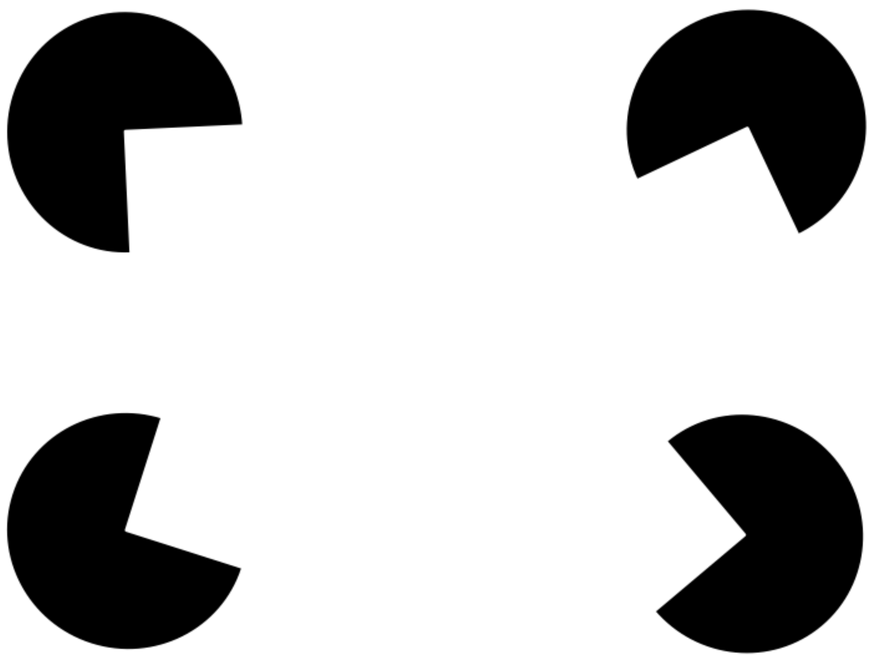

Figure 3. Kanizsa Illusion foiled

Hmmm? The white rectangle sitting on the dots is gone…The image information is identical except that the dots have been rotated slightly. That's all it takes to alter your perception. By now you must realize that the previous experience of a white rectangle was an illusion. You provide the rectangle. It isn't on the paper. The rectangle was "in your head."

The same thing is true of "THE CAT." Figure 2 does not say "THE CAT." It can't. The "letter" in the middle of both words is the same – and not really an English letter at all. The context of the letters around it makes the letter appear to be an "H" in one context and an "A" in the other.

These illusions are the result of expectations, implicit or explicit, that drive our perception. It is a complicated world out there and the nervous system that we are makes guesses. In this case the real sensory signals are processed and elaborated upon to provide a "best guess" about the world out there. In order to process these stimuli, we had to decode them and send them into the brain. That process is called "bottom up" processing by cognitive scientists. Stimuli “force” this on the nervous system. They command our bodies to convert the physical stimuli in the world to activity in our nervous system – a process known as transduction. But as we discussed previously, our personal history and expectations shape what comes up from the bottom and this is called “top down” processing. It is because of top down processing that you made errors on the figures.

Let’s return for a moment to the O’Mahoney study on TV smells and reconsider it with this new information about top down processing. Were those callers really hallucinating smells? Well, perhaps in a technical sense but what was really happening was that their criteria for saying something smelled changed as a result of their expectations that were “induced” by the radio announcer. All of our environments are filled with odors even if we don’t notice. Our clothing, the other people around us, the furniture, carpet, pets, the dish washing detergent and last night’s lasagna all contribute to a rich molecular world that smells-just a little. Our nervous system has been smelling those things for hours and those “unnoticed” smells don’t really give us any important information so we ignore them. But what if you hear a frightening radio report that a train derailment near your home was producing toxic levels of ammonia? Now, your olfactory world becomes crucial to your survival! You begin sniffing for ammonia all over your house. The trouble is that your house is full of all those low level smells and they are confusing – like looking for a tiger in the jungle, the consequences of missing the tiger are grave. Your nervous system is “sniffing through” the odors of your home looking for ammonia among the confusing alternatives. Is it there? Is it really there? Is it enough for you to call emergency services? Does the confluence of molecular signals show through enough for you to say it’s there?...Does it say “THE CAT” to you?

Let’s take a break from this dramatic exercise and change the context a bit. What if, instead of hearing that broadcast about the train, you hear a person at the door. That person is making a delivery and as you sign for the package they say “do you smell ammonia?” You take a sniff and say “no.” They respond with “Oh well, must be me…have a nice day.” You take the package into the other room and, after one more sniff, never give the ammonia a second thought. What’s the difference between these two situations? The low level odors/chemicals in your house are the same. The search is for the same for chemical and it is a chemical you know well. The difference is the importance of the detection of that chemical. In one case, it is potentially life threatening. In the other, it is of no consequence. That “top-down” difference changes your willingness to say, “Yes, I smell it” and to genuinely believe that you have. This is, of course, exactly what happened in the Dalton study mentioned previously. The implicit belief that an “industrial solvent” was dangerous or an “aromatherapy” agent was healthy led people to misinterpret the odors they encountered.

Taking stock

It’s good to take a moment here to review the central themes so far. By now, you should be convinced that fragrances are collections of molecules. Our perception of those molecules is a function of both our receptors and our brains including the expectations and demands our environment places on them. It is also worth noting something a bit odd that has not yet been discussed about our receptors. You might consider this a bit of a sidebar but it is quite interesting and something to which we will return later. Recall that each of us has a unique set of receptors with which we smell the world. This means that even though we might join a friend shopping to select a new perfume, the same perfume produces a different set of receptor activities in each person. Even if our shoppers come at the smell with identical expectations, the perfume *must* smell different to each person (unless they are identical twins with identical expectations) – but we never know this. We presume that when we each take a sniff, we are smelling the same thing even though we are not surprised if our “tastes in perfume” differ. Just as when you look at a painting you love and your friend is unimpressed, we assume this is wholly a matter of some aesthetic sense that we are happy (usually) to be different among people…as in the oft used English phrase the “eye of the beholder.” It just isn’t so. While we all tend to have fairly similar receptors in our retinas (colorblindness affects only about 8% of men and less than 1% of women), we have remarkably dissimilar receptors in our nose. We are decidedly *not* “looking” at same olfactory scene. This is also much of the problem when we are learning what odors are called. If, as a child, your mother held a freshly cut lemon to your nose and said “lemon.” You learned this was the smell of lemon. Your sibling (if you have one), would have learned what a lemon smells like in just the same way. Because you both have a different set of genetically programmed receptors, you have different sorts of activity being generated by the same stimulus. Even so, you both come to label the unique pattern in your nose– “lemon.” Have a look at figure four below. It is a simple, hypothetical diagram of odor receptors that respond to lemon for you and your presumptive sibling. Lemon activates all six types and you and your sibling don’t happen to share any receptors for lemon. Even though you have no receptors in common, you still both smell lemon and describe it as lemon. For you, lemon is when receptors A, B, and C are active and for your sibling it is D, E, and F. It is only because smells like lemon are so complex and activate so many receptors that we can do this. If a simple smell, such as those found in laboratories, activated only a single receptor, it would be easy to see who had that receptor and who didn't.

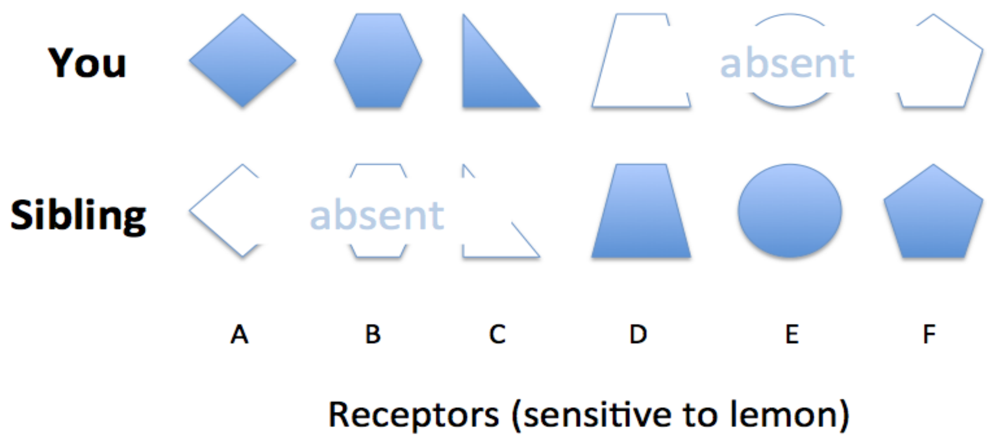

Figure 4.

Realize that it is exactly the same process when food is involved yet parents can't understand why their offspring hate some foods they love. Part of the answer is that they don't share the same complement of olfactory receptors as Mom or Dad.

Taking it from the top…down.

So far, a few examples of top down processing have been provided but there are many others. One of the clearest comes from Debra Zellner in a beautiful and simple experiment, she shows the power of implicit expectancy on smell (Zellner & Kautz, 1990). She asked people to rate how strong four different odors smelled. In every case, the addition of color to the normally colorless vials led subjects to say the odor they smelled was stronger even there was no change in the odor concentration. This is simple and clear evidence that the context of the experience biases judgment. A similar study was conducted by Stevenson and Oaten, (2008) with just the same predictable effects – they found that appropriate colors for the odors led to improved discrimination among them. These sorts of "subjective" findings are one reason some people turn to measuring brain activity as a way to improve objectivity. Unfortunately, these studies don't show objectivity…they just show brain activity involved in human bias.

Take for example a study in which people are asked to smell three odors labeled as A, B and C (Lorig & Roberts, 1990). While they are smelling these odors the electrical activity of their brain is recorded. The pattern that emerges is clearly different for each of the three odors. Now people are told that they are smelling lower concentrations of A, B, or C and their brain responses recorded again. As one might expect, the pattern of brain activity for the low concentration of A, nicely matched the original version of A. The same was true for the matches of the low concentrations of B and C compared to the original versions of B and C. What people didn't know, however, was that the lower concentrations of A, B, and C were actually ***the same odor***! It was a mixture of low concentrations of ALL the odors! So when they were told they were smelling a low concentration of A, it was actually a low concentration of A plus a low concentration of B and a low concentration of C! This same mixture was used no matter what the subject was told they were smelling. This means that the pattern of brain activity was evoked by what they expected to be smelling, rather than what they were actually smelling. The brain changes were just another way of measuring the subject bias in what they believed they were smelling as a result of the different labels.

More recently, Gottfried and colleagues also showed the neural foundations of this "top-down" processing (2003) using functional magnetic resonance imaging, a technique that provides exquisite detail about the activity in the brain. Like the previous paper by Stevenson and Oaten, they "enhanced" olfactory judgments by providing visual information that was congruent with the odor. For example, they provided a pine aroma with a picture of a pine (congruent) or a picture of rose (incongruent). In cases where the congruent pair was presented, people were better at identification showing a sort of mutual enhancement. Furthermore, it appears that much of this enhancement is the result of increased activity in a portion of the brain that mediates the production of new memories and associations – the hippocampus.

Araujo, et al. 2005 conducted a similar study using verbal labels rather than pictures. They also found portions of the limbic system more active during congruent labels but saw the greatest activity in the portion of the brain just above the eyes. All of these cases illustrate the bias introduced by images or labels on altering the perception of odors and the brain processes that underlie those perceptual differences.

These studies are certainly not an exhaustive review of the literature; they are only a few of the many studies that illustrate the power that context and expectancy have on our evaluation of odors. Stephan Jellinek (1997) has also provided an excellent review of this topic. There are certainly many interesting studies that illustrate the "eye (or nose) of the beholder" is crucial in appreciating odors. These studies should also caution us in our zeal or distaste for a particular odor. Between our genes, receptors and expectations, our own experience is just that

– our own. Others may smell exactly the same molecule and have a completely different experience because of their receptors, experience or expectations.

Applying our knowledge

While the foregoing discussion has been interesting, it is far from academic. Not only should we embrace the opinions of others about smells when they differ from our own, but we should use this variability to understand the business of fragrance. Many readers of this paper will be involved in the fragrance industry and must make decisions about the fragrances that are to be placed in products or marketed as fine fragrances. Understanding the importance of how expectations alter perception can have a profound impact on the success of that venture.

It should be clear by now that for reasons of genetics, personal history, and the expectations that are brought to the evaluation of potential products, that one person's opinion is not enough to make a decision about whether a fragrance is good or bad. Indeed, nor is it enough to have the person sitting next to you "really like" the fragrance too. Because responses to fragrances can be so individualized, it is important to see real quantitative and statistical evaluation of the fragrances in comparative studies. It is quite possible and often expected to collect data from large numbers of potential customers to evaluate the fragrance in question. Those data and your "gut feeling" should inform your choice. Your intuition about a great fragrance may be extraordinary but a single molecule may convey a dissonant note that can change everything in a fragrance and your DNA may not have coded your nose for a receptor sensitive to that molecule.

Those quantitative studies must be good studies and should have been conducted by investigators cognizant of top-down effects. Obviously, the people conducting these studies presume them to be good but how do *you* decide if a study is good or not? Certainly the expertise of the investigators matters, but there has been a tendency to conduct studies in olfaction that seem to answer the question and really don't! Consider this hypothetical but typical experiment to find a new fragrance for a deodorant.

The study takes place in a health club. Forty people agree to participate and half are randomly assigned to be in the fragrance condition while the other half are in the placebo control condition. Each person is asked to hang a towel around their neck while they work out. The people in the fragrance condition have the fragrance in question sprayed on their towel while the people in the placebo condition have distilled water sprayed on their towels. After 30 minutes of exercise, people complete a questionnaire to evaluate how they feel after their workout. Not surprisingly, the people who got the scented towels feel more invigorated, confident, and had a better workout than those who got the unscented placebo towels. The question is: Did the fragrance really make these people fell better? While it seems obvious that it did, the study suffers from at least one major problem related to top down odor processing. It is a common mistake in olfactory research but the fact that you are comparing a fragrance condition to a non-fragrance condition produces, in and of itself, a unique context and set of expectations in only half the subjects. These implicit expectations are known as "demand characteristics." Consider what the new scent does to those people with the fragranced towels. First, they notice the odor and sniff the towel. They know the experiment is on. They think about the fragrance as they exercise. They think about what they'll be asked after they exercise – they know they are being evaluated and want to help those nice people doing the experiment. They wonder if they are being watched or if their miles on the treadmill are being relayed to a computer somewhere? Maybe they'll try just a little harder to work out today! Now, contrast that with the people who got the no odor, distilled water towel. They sniff the towel but just smell the regular detergent…maybe they weren't really selected for the experiment? They wonder why. They wonder if there was something wrong with their application to be in the experiment. Maybe it was what they were wearing? Soon they forget about it…since there is no fragrance to remind them and exercise as usual. Is it any wonder that the fragrance group showed enhanced responses to the questions they were asked at the end!

A good experiment has just one attribute that differs between the two groups. If, in the end, you find the groups are dissimilar, you can then attribute the difference in the group's behavior to that one attribute. It would seem the fragrance versus the distilled water is just one attribute but it is actually many. The fragrance condition brings with it attention to the scent, breathing/sniffing differences and those differences in breathing change cardiac output. There is also knowledge that is different ("I'm in the experiment!") and potentially other differences – any or all of which may account for the differences the investigator finds between the two conditions of their experiment because they influence the top-down evaluation of the odor. A recent paper by Elmes and Lorig (2008) describes this problem and various solutions in detail.

Notice as you read the fragrance research literature how often a no odor control is used in olfaction research! It is a surprising but common problem and especially a nagging one since it is so easily fixed! All it would take to make a good experiment of the example above is to change the distilled water to a second fragrance and compare the two!

Using good research to guide decisions about selecting a winning fragrance isn't new but the research on top-down processing also speaks directly to the advertising of fragrance. Since the context of the story matters so much, the advertising and "buying context" should be a crucial part of the perception. Clearly, research has shown that the color of the liquid is very important to the perception of the fragrance, as is what's on the label. The same mechanisms surely govern the effects of the flacon and product packaging. Furthermore, the product advertising in print, television, on-line and at point of sale can also "brand" a fragrance and change it perceptual characteristics. Perception depends not only on the chemicals in the bottle, but what we believe the bottle holds. While we often see elaborate advertising campaigns for new fragrance launches, are they consistently used in a strategic manner to enhance the way the fragrance actually smells?

Even though we see top-down processing in all the senses, it seems to be clearly more pronounced in olfaction than the other senses. This may be because, as some scientists believe, the human sense of smell is becoming less important to our species (Brodal, 1988). As it becomes a vestige of what it once was and a less veridical source of information about the external world, it can be more manipulated by expectation. This may be true but an alternative (and perhaps complementary) explanation is that fine fragrances don't represent any real thing in our environment. They are completely new in the world and have never been experienced before. Like an abstract painting, they are sometimes vaguely familiar and sometimes completely indecipherable. This explanation argues that the brain has no model for what it is receiving from the olfactory bulb and it seeks to find *something* to link to the olfactory experience. Here, all the aspects of the fragrance and its presentation matter: color, feeling on the skin, label, bottle, and advertising – right down to the look on the salesperson's face. It all changes how it smells.

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