ROLE OF SENSORY ANALYSIS IN FLAVOR CHEMISTRY

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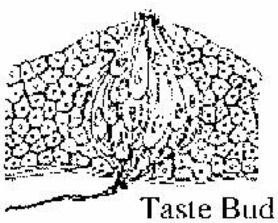
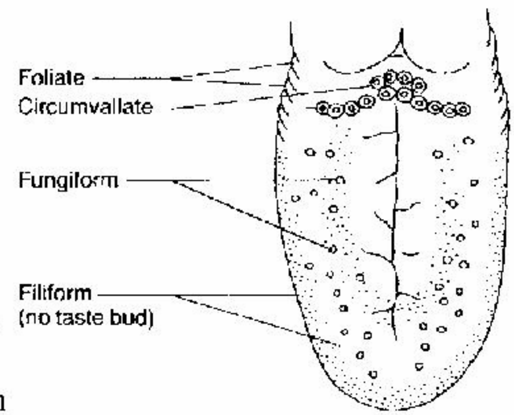
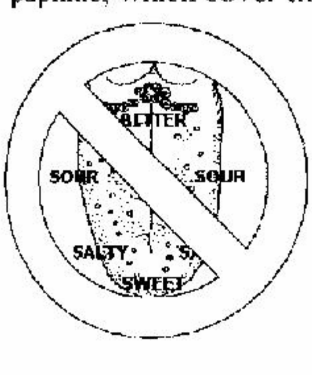
If you double the amount of a fruity-smelling compound in the headspace of a jar, verifying this increase with instrumental analysis, the perceived aroma is rarely, if ever, doubled. In contrast, if you hold the headspace constant, again verifying this by instrumental analysis, but add sweetener, the perceived aroma increases. Why is it while instruments can detect chemical changes with one-to-one correspondence, humans are so poor at this task? The main reasons are the number of physiological systems that detect chemicals and interpretation by the brain.

Turning to the physiological mechanisms first, there are three distinct sensory systems designed to detect chemicals in the environment: taste, smell, and chemesthesis. The taste system detects relatively small, water-soluble chemicals, the smell system detects relatively large, volatile chemicals, and the chemesthetic system responds to chemicals that elicit sensations normally associated with other sensory systems, like burning (thermal and pain), cooling (thermal), and prickling (tactile). All three of these systems convert one form of energy to another, a process called transduction, whereby they convert chemicals in the environment into chemo-electrical signals that can be interpreted by the nervous system.


Taste Bud

The smallest functional unit of the taste system is the taste bud. Taste buds are located throughout the oral cavity on the back of the throat (epiglottis), the soft palate, and especially on the tongue. On the tongue, taste buds are found in specialized structures known as papillae. There are four kinds of papillae, three of which contain taste buds. The circumvallate papillae are a series of ring-like trenches found in an inverted V-shape at the back of the tongue. Taste buds line both sides of these trenches. The foliate papillae are a series of folds located on the back sides of the tongue. As with the circumvallate papillae, taste buds line both sides of the trenches formed by these folds. The fungiform papillae are scattered across the top front two-thirds of the tongue. They appear like darker red bumps against the paler pink of the rest of the tongue. Taste buds are located at the tops of these structures. The filiform papillae, which cover the rest of the tongue, do not contain any papillae and contribute to the detection of taste compounds only by holding chemicals on the tongue so they can stimulate the taste buds located in other papillae. Finally, it is important to mention that the tongue taste map, which indicates that sweetness is detected at the tip of the tongue, bitterness at the back, etc. is a myth. Every taste sensation can be perceived everywhere on the tongue, despite the pervasiveness of this myth. A simple home experiment with cotton swabs, sugar, salt, lemon juice and instant coffee will quickly demonstrate this to any doubters.

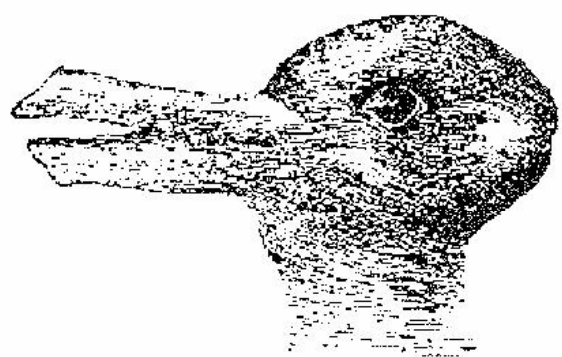




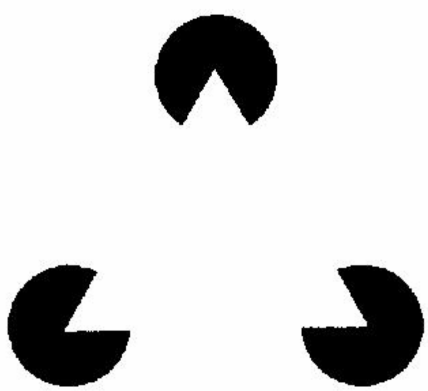
The smell system is located at the top of the nasal cavity and the base of the brain. In fact, the olfactory bulb is a specialized outgrowth of brain tissue. Olfactory neurons penetrate a porous piece of bone, known as the cribiform plate, and hair-like extensions, known as cilia, interact with volatile chemicals and subsequently send odor signal to the brain. Odor compounds tend to be hydrophobic, or oil-soluble, because they need to dissolve in air, which is nonpolar (or hydrophobic).

The chemesthetic system is located throughout the body in the skin. It is the system that responds to the burn of chili peppers and the cooling of mouthwash. It is also the system that causes your eyes to sting when they are exposed to ammonia, your nose to tickle when you sniff a carbonated beverage, or your skin to burn after using capsaicin ointment.

All three of these systems work in concert to tell us about the chemicals in our environment. Instrumental systems, in contrast, can typically only accurately measure the presence of one type of chemical at a time. This is part of the reason that while instruments can more successfully detect one-to-one correspondence changes in chemistry than can humans. Another reason that humans are particularly poor at making such judgments is that final perception depends upon interpretation by the brain, and this perception can be influenced by a multitude of factors.



One can readily demonstrate the importance of interpretation. Consider the image to the right. An example of an ambiguous figure, it is a single physical stimulus that can be interpreted two different ways, either as a duck or a rabbit. The rabbit is facing to the right and the duck is facing to the left. It is impossible to see this figure as both a duck and a rabbit simultaneously. It is interpretation by the brain that results in your final perception of the image as being one or the other. The physical stimulus remains unchanged. It does not morph on the page from one form to another. It is your interpretation of the stimulus that changes.



If the brain has to make decisions on the final perception, then it can, and does, make a mistake. These "mistakes" are responsible for illusions in all the senses, and are most readily demonstrated visually. Consider the image to the left. It appears to be a white triangle set on top of three black circles. The center of the white triangle appears to be a brighter white than that outside the triangle. However, this appearance is false. The same background paper and same illumination of whiteness can be found throughout the figure. The brain interprets this image as a difficult-to-see triangle and tries to aid in your ability to interpret the figure by making the triangle stand out more   it touches the picture up. However, in doing so, when asked about the whiteness in the center of the triangle, the observer makes a mistake.

Further, interpretation of any sensation(s) can be influenced by a variety of factors, including background, presentation, attentional focus, perceptual interactions, and individual differences. For example, changing the background by adding coloring to a white wine so it looks like a rose or a red can alter its ratings. One study (Delwiche 2003) showed that whether the wine looked like a red wine, a white wine or a rose significantly altered ratings for fruitiness, fullness/body, complexity, maturity. The pink-colored wine was rated highest in fruitiness and the red-colored wine was rated the highest in maturity, complexity, and fullness/body, despite the fact that the same base wine was presented every time -- the only difference being the amount of added food color.

Other studies have show that presenting a wine in different glass shapes can alter ratings of the wines (Delwiche 2002). Hummel et al (in press) had 181 expert wine drinkers assessed wine in 3 glasses of different shape, but similar height and opening diameter. 89 subjects assessed red wines while 92 subjects assessed white wines. They found that odor complexity and intensities were rated higher when the wines were presented in bulbous glass shapes. However, when subjects were kept unaware of the fact that glass shape was changing and restricted to assessing wine by aroma alone, glass shape did not have an impact (Delwiche and Pelchat 2002). This indicates that the presentation of a wine can impact upon wine assessment, but has a much stronger impact if judges are aware of the different presentations.

How you detect a person's attention can also impact perception. If you keep people focused on the whole, they will assess products differently than if you ask them to analyze its components (Stevenson and Prescott 1995). There are also many lines of evidence that indicate that the sensations of taste and smell interact. A recent study showed that if you presented a subject with a subthreshold concentration of a sweet-tasting compound at the same time as a subthreshold concentration of a cherry-almond odor resulted in detection of the combination (Dalton et al 2000), demonstrating cross-modal summation of taste and smell - a true interaction between sensory systems.

There are also huge individual differences in the perception of taste and smell compounds. Individuals differ in the number of papillae they have and their perception of certain taste compounds, and papillae number alone does not account for this difference (Delwiche et al 2001). There are also large differences in sensitivity to odors across individuals.

Sensory Analysis can reconcile the differences between instrumental measures and perception. Even if chemical analysis indicates products differ, it still is not necessary clear whether two products differ perceptually. When perceptual differences are small, they can be examined using difference tests, such as the paired comparison or triangle tests. When perceptual differences are large, it is more productive to determine the ways in which they differ, which can be done by a highly-trained, expert panel. Descriptive analysis performed by such a panel can be used to quantify how perceived attributes differ, and these ratings can then sometimes be correlated to instrumental measures. However, for reliable information, such panels must be both highly trained and maintained.

Questions about how many people like or prefer a product or about how much a product is preferred over another cannot be answered via instrumental measures. A gas chromatogram does not like one kind of wine more than another. Consumers view foods holistically, and base their judgments on a synthesis of attributes. Carefully constructed experiments using a combination of consumer ratings and descriptive analysis ratings can indicate often reveal what attributes are influencing consumer responses, which sometimes in turn can be linked to instrumental measures.

Thus, while at times chemical analysis and sensory analysis may appear to give conflicting results, when they are used in combination successfully, not only can product viability be enhanced, but also the underlying mechanisms that determine this viability can be better understood. Ultimately, these types of measures can benefit grape-growers, wine-makers, and consumers alike.

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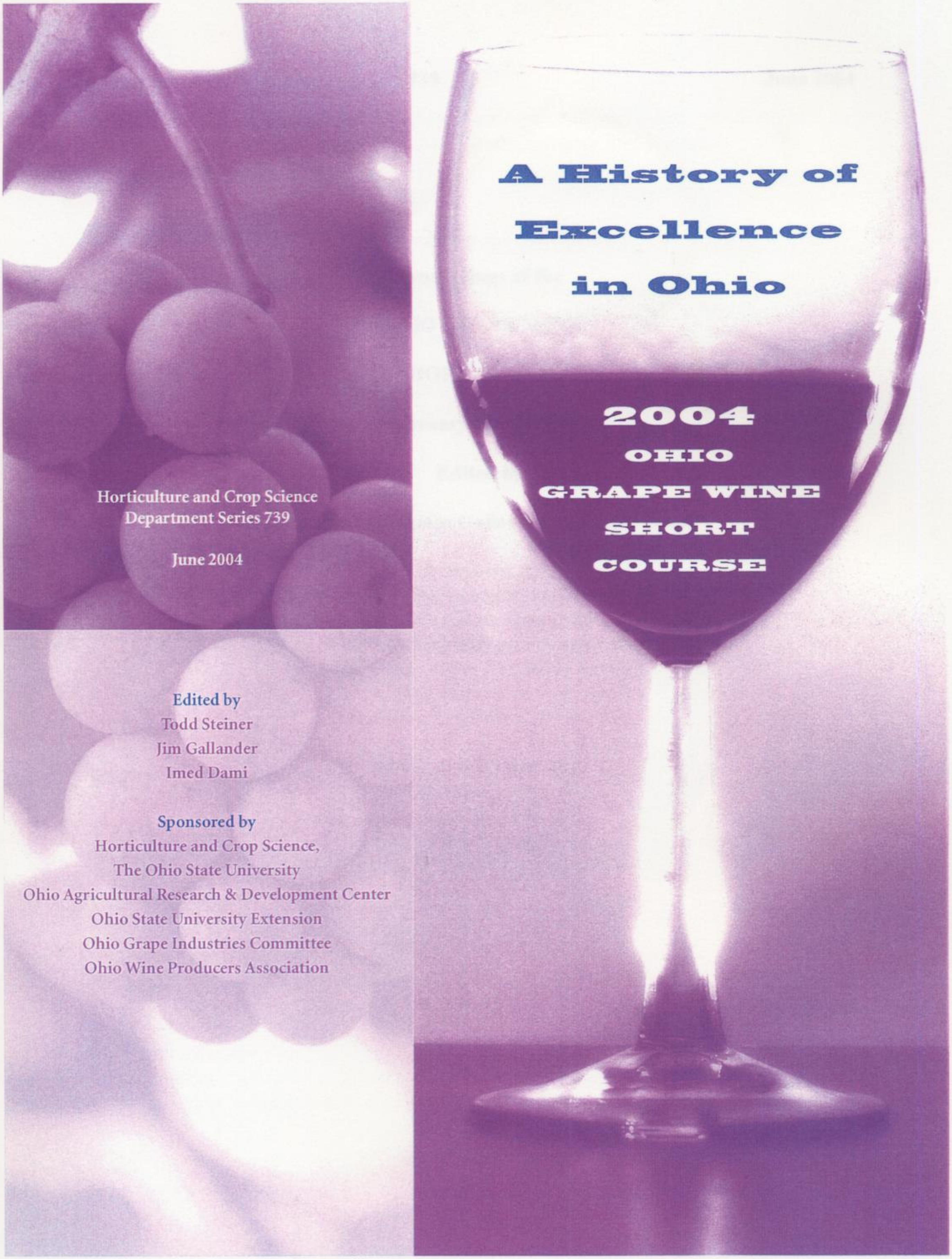

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