The maximum age that can be measured in the larger counter at the Quaternary Isotope Laboratory is about 61,000 years. Because a 56,000-year-old sample has retained only 0.1 percent of its original ^{14}C activity, this age has to be considered minimal until further experiments have been carried out. Although the new age is a lower limit only, it is clear that Mercer and Laugenie's conclusions based on the 36,000-year date are invalid. However, they interpreted the wood and the underlying interbedded peat, ash, and clay as interstadial, not interglacial, on account of the stratigraphic position as well as the apparent age of this nonglacial sequence. Reexamination of the site in September 1974 by Mercer and Moreno supports this interpretation, the strongest evidence being the slight weathering of the diamicton, thought to be till, immediately below the nonglacial sequence, compared to the intense weathering of all known examples of till of the penultimate glaciation, even where buried by younger glacial deposits. The new radiometric age determination would require that the interstadial occurred early in the last glaciation. However, the evidence for this chronostratigraphic interpretation is not conclusive, and the nonglacial sequence may date from the last interglacial.

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Dimensions of Olfactory Quality

Schiffman (*1*) has recently applied nonmetric multidimensional scaling techniques to the problem of the dimensions of olfactory quality. Her reanalysis of data collected by Wright and Michels (*2*) and Woskow (*3*) yields similar two-dimensional solutions, one dimension clearly having to do with pleasantness and the other being more opaque but apparently relating to spiciness or sharpness. Showing that new techniques allow an approximate replication of this configural space using weighted physiochemical properties, Schiffman (*1*) argues that such methods hold promise for discovery of underlying olfactory receptor mechanisms. In so doing, she fails to take into account central processes that mediate judgments concerning the pleasantness dimension. Research workers in olfaction have had to labor under the hardship of not beginning with a fairly good idea of what the relevant dimensions were. By analogy, let us imagine that psychophysics had begun without any notions of the relevant dimensions of vision and audition. Some sort of multidimensional approach wherein subjects were asked to rate or classify a miscellany of objects and events—such as girls, chairs, whispers, rainbows—might seem to give promise of yielding relevant dimensions. But would we emerge from our analysis with dimensions such as hue, brightness, size, shape, and pitch? Osgood, Suci, and Tannenbaum (*4*) in asking subjects to rate words were essentially asking them to rate mental images varying along the basic visual, auditory, and other dimensions. They, of course, obtained factors of evaluation, activity, and potency. Now the first two are the same dimensions that Schiffman obtained. But for the fact that it was known in advance that concentration or strength was a relevant dimension and must be controlled, a potency factor as well would probably have emerged. Even if we could replicate Osgood's semantic space, using some set of physical properties of the rated objects, we would not search for pleasantness receptors in the retina or cochlea since we know that connotative meaning is a central and not a peripheral phenomenon.

Pleasure would seem to be a central process based upon the arousal potential or impact value of stimuli. As such, it can be induced by variations along a number of stimulus dimensions. Wundt (*5*) first presented the hypothesis that hedonic tone is an inverted-U function of stimulus intensity, with stimuli of medium intensity being felt as pleasant, those of greater intensity as unpleasant, and those of low intensity as neutral. Subsequent research has confirmed this notion as well as suggesting that pleasantness is related in a similar inverted-U fashion to variables such as meaningfulness, complexity, and novelty.

If such pleasure dimensions as the one obtained by Schiffman are based upon central processes, then they cannot be connected in any direct way with receptor mechanisms. There are two reasons for this. First, since compounds may gain their arousal potential by simultaneous variation along any of a number of fairly independent dimensions, compounds that are similar in their pleasantness are not necessarily similar in their positions on the basic dimensions. The more diverse or "representative" the stimuli being judged, the less likely it is that similar pleasantness derives from similar positions on the underlying dimensions. The method, then, actually confounds the basic olfactory dimensions rather than disentangling them to the extent that it is applied to judgments of heterogeneous sets of stimuli. Moreover, only some of these stimulus dimensions, such as molecular weight and Raman intensity, may be of relevance to olfaction. Others, such as familiarity and stimulation of trigeminal nerve endings, may not be. These dimensions are not equally represented or controlled in the stimuli used by Schiffman. Some of her stimuli are believed to stimulate not only olfactory but also trigeminal receptors (*6*). Optical antipodes, such as *d*- and *l*-carvone, which have the same molecular weights and vibrational spectra but different odors (*7*), are not included.

Second, because of the curvilinear relation between arousal potential and pleasure, the method systematically obscures the relevant dimensions. For example, in Schiffman's dimensional space the light carboxylic acids are unpleasant while a heavy, less volatile one is pleasant. If we assume that arousal potential varies directly with volatility, then we can predict that an even heavier one would fall between these groups in the neutral area because of its even lower arousal potential. The three groups as ordered on the pleasure dimension would be out of order on the more basic volatility dimension, and it is the latter which would be expected to relate in a straightforward fashion to receptor mechanisms.

For statistical reasons, Schiffman (*1*) presents separate reanalyses of pleasant and of unpleasant compounds. This does not remove the pleasantness dimension, as it reemerges clearly in both reanalyses. Interestingly, the reanalysis of the unpleasant compounds [figure 3 in (*1*)] yields a cluster of compounds, most of which are important for primate sexual attraction defining the second dimension. It seems altogether possible that arousal potential, mediated by ecological meaningfulness, is the relevant variable. Again, this would be a central process. Such clusters pointing to central rather than peripheral mechanisms would be expected to gain further prominence were biologically active compounds such as the macrocyclic musks, which have caused difficulties for molecular theories of olfaction (*8*), included in the range of stimuli. Thus, multidimensional methods applied to diverse sets of stimuli would seem to hold more promise of elucidating central than peripheral processes.

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In olfaction we are starting from a lack of understanding of (i) how individual odorant stimuli are related to one another and (ii) what physicochemical properties account for the quality of the odorants. For this reason, one of us (*1*) determined that arranging odorants in a multidimensional space on the basis of the similarities in their smells might give a handle on the dimensions underlying the sensation of odor. The stimuli arranged are only a sample for a first attempt, however, and it would be good to include more stimuli, such as biologically active substances and optical antipodes.

In their evaluation, Martindale and Hines consider that "pleasantness" is a "central" rather than "peripheral" event for the nervous system. In the article by Schiffman (*1*), "pleasantness" was used as a descriptor after the multidimensional arrangement of the stimuli. "Arousal" or even a physicochemical dimension might have worked just as well as a description. The "pleasantness" dimension should not be assumed to be anything more than a description, but was not intended without "physical" basis. Multidimensional arrangements and their ensuing dimensions can only derive from peripheral events; the central nervous system cannot add information not in the original stimulus. Central mechanisms may select, repress, or otherwise reorganize peripheral processes; *however, additional information (such as pleasantness) cannot be made up centrally and added to peripheral processes.* In this sense, central processes cannot be categorically different from peripheral processes, and the present descriptors are considered of interest at either level.

The usefulness of multidimensional scaling in elaborating peripheral processes gains support from empirical evidence in three separate sensory systems (olfaction, vision, and taste). Multidimensional spaces based on psychophysical data closely parallel arrangements for neural data at the periphery. In olfaction, analysis (*2*) of single unit data in the frog revealed an arrangement which bears a resemblance to the human psychophysical results (*1*). For both psychophysical data in human and neural data in frog (*3*), there was one quality grouping of benzaldehyde, nitrobenzene, and geraniol and another grouping of propanol, butanol, and benzene. Two substances fell between these groupings: decanol and menthol.

In vision, application of Shepard's multidimensional scaling procedure (*4*) to Ekman's psychophysical similarity data for 14 monochromatic colors (*5*) yields a color circle; a color circle also results from analysis of spectral absorption data in goldfish cones (*6*).

In the taste system, arrangements of human psychophysical data compare favorably with neural data in rat at both the first- and second-synaptic levels (*7*). For both psychophysical and neural data, the taste stimuli fall roughly into a tetrahedral arrangement, with stimuli having sweet, sour, salty, and bitter sensations located at the four corners and alkaline stimuli falling outside the tetrahedral structure.

Finally, the basic data for Schiffman (*1*) are the similarities among stimuli. The subsequent arrangement of these stimuli in a multidimensional space simply follows from these similarities. The psychological and physicochemical descriptors are expected to be modified as more stimuli are included in the arrangement. The introduction of a "pleasantness" dimension was a method of describing the data; it was useful in reducing the data to a simple, manageable form. It is in this sense that this dimension derives its validity, as is true of any other dimension in the physical or biological sciences.

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