Direct psychophysical scaling of the olfactory pleasantness of diluted n-amyl acetate*

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A category and two magnitude scales were constructed from observations of 12 Os who judged the pleasantness of a geometric dilution series of n-amyl acetate. Pleasantness varied inversely with concentration and had a short subjective range for a fairly typical range of stimulus concentrations. Scales resembled power functions with negative exponents of .110 to .126. A concave upward relationship between the two types of scales, which was also found in previous experiments involving hedonic and oiliness attributes, suggests a nonprothetic continuum, although evidence was mixed.

The subjective ranges of different attributes of smell differ considerably. There is, e.g., a striking difference between the range of intensity and that of pleasantness. Results of scaling by magnitude estimation have indicated that the subjective range of intensity is quite small for a given diluted odorant over commonly studied stimulus concentration intervals (Engen & Lindström, 1963; Engen, 1964). But the hedonic range for a set of diverse undiluted odorants is quite large (Engen & McBurney, 1964). The hedonic characteristic of an odorant may substantially influence variation in olfactory response, and this is one reason that more information about the attribute of pleasantness is needed.

Results based on direct methods of the scaling of pleasantness for odorants within a relatively narrow range of stimuli, such as that provided by a single diluted odorant, have not been reported. It is a common experience that pleasantness for some odorants varies with their concentration (Geldard, 1953; Moncrieff, 1944). In the present investigation, magnitude scales were constructed and it was predicted that the range of pleasantness for diluted amyl acetate over a typical stimulus range would probably fall somewhere close to its intensive range over a similar stimulus range, perhaps above it by a small amount. But in any event it was expected to fall far below the hedonic range reported for a diverse set of undiluted odorants.

A category scale also was constructed and was compared with

the magnitude scales in order to determine if the continuum of pleasantness for a diluted odorant had metathetic, which was expected, or prothetic properties.

METHOD

Observers

Twelve undergraduates, including two women, volunteered to serve without pay as Os; none had participated in olfactory experiments before.

Odorants and Apparatus

The O sniffed cotton saturated with a given concentration solution of amyl acetate diluted in odorless diethyl phthalate, both chemicals being of chromatographic-grade purity. The cotton used was that wrapped on one end of a Q-Tip. The other end was cut off, and this bare end was inserted into the bottom of a small aluminum-foil-wrapped cork, big enough to be taken up conveniently with the fingers. After each sniff, O returned the cork with the attached Q-Tip to a 10 x 75 mm Pyrex test tube containing 1.5 cc of the solution. The cotton was positioned just above the surface of the solution when not in use.

The seven different solutions used consisted of the following concentration series, prepared by means of a pipette: 1.5625%, 3.125%, 6.25%, 12.5%, 25%, 50%, and 100% amyl acetate. The E presented the test tubes containing these concentrations singly to O on a plastic holder.

Procedure

The experiments were performed in a ventilated and air-conditioned room where the temperature was maintained at 25°C. There were three experimental conditions: Two of these required Os to make magnitude estimations with different standards and one to make category ratings. The

O was exposed to all conditions, each of which he received in a single 1-h session, one condition per day, in most cases every other day, and in a counterbalanced order.

The O was instructed to judge only the pleasantness of the stimulus and to ignore all other attributes, such as intensity, to judge each comparison stimulus independently of another, to sniff consistently, and to place the cotton at the same distance from his nose each time.

The standard for a magnitude-estimation condition was either the 6.25% or the 50% concentration. The O was instructed to let 10 represent the pleasantness of the standard, with which he was asked to become familiar. The E presented the seven comparison stimuli, including one with the same concentration as the standard, singly and in random sequence with five trials per stimulus. The O's task was to judge the pleasantness of each by assigning a number to it proportionate on a ratio scale to the 10 of the standard. He could refer to the standard as often as desired, provided that between sniffs there was at least a pause of 1 min, which was the minimal time interval between any two sniffs. Duplicate sets of comparison stimuli were used to reduce the possibility of recognition of previously presented stimuli from accidental markings on corks or test tubes.

There were two standards in the category-estimation condition. The O was instructed to denote the pleasantness of the 100% concentration as 2 and that of the 1.5625% concentration as 9. His task was to assign to a given comparison stimulus an integer from 2 to 9 inclusive, reflecting the pleasantness of the stimulus in relation to that of the two standards on an equal interval scale. If O judged the pleasantness of a comparison stimulus to be outside this range, he could assign a number 1 or 10 to it, which was permitted in order to deal with possible end effects. There were 35 presentations of the seven comparison stimuli, as in each of the magnitude-estimation conditions, consisting of five trials of each, presented singly and in random sequence.

RESULTS

For each magnitude-estimation condition, geometric means were computed from the 60 numbers assigned by Os to each stimulus concentration. The means were combined to obtain data for a more generalized function (Stevens, 1956) based on a computational procedure described by Engen and Lindström (1963). The results are presented in

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Table 1
Scale Values of the Pleasantness of Diluted n-Amyl Acetate by Two Direct Methods

Percentage of Concentration	Method	
	Magnitude Estimation*	Category Rating**
1.5625	10.20	6.65
3.125	10.09	6.37
6.25	10.06	6.07
12.5	9.85	5.80
25	8.70	5.15
50	8.30	4.60
100	5.88	3.97

*Adjusted and combined

**Arithmetic means

the first column of Table 1. The range of olfactory pleasantness for diluted amyl acetate is relatively short. For the particular largest and smallest concentration stimuli selected, the largest average sensation was just about twice that of the smallest average sensation based on the combined magnitude-estimation scale.

This scale forms a function that is strictly decreasing throughout the concentration interval studied. Similar results were obtained from the separate magnitude scales. Functions derived from them were decreasing over the same interval, save for somewhat minor inversions: one lower than expected at the 3.125% concentration, in the case of the 50% standard, and two also lower at the 1.5625% and 3.125% concentrations, in the case of the 6.25% standard. Average standard errors for the scalar data based on these two respective standards were 1.43 and 1.75, with 1.59 as an overall average.

The separate magnitude scales based on the 50% and 6.25% standards, the combined scale, and the category scales generally resemble power functions with exponents of $-.110$, $-.116$, $-.113$, and $-.126$, respectively. In a log-log plot of the combined magnitude scale as a function of concentration, a least-squares fit of a straight line produced an r^2 of .72. In a similar plot of the category scale constructed from the arithmetic mean category ratings displayed in the last column of Table 1, the corresponding r^2 was .94; each of these means has a quartile deviation of about 1.57, with variability being somewhat less for stimuli in the middle range than stimuli at either end.

DISCUSSION

As expected, the subjective range of pleasantness for diluted amyl acetate falls far below, by about 1/70, that found by Engen and McBurney (1964) for a representative sample of undiluted pleasant and unpleasant odorants. The hedonic range of their

sample might be considered a kind of rough working upper bound of the set of reported ranges, since the sample was so heterogeneous. Somewhat unexpectedly, the range in the present investigation also falls below, by about one-third to one-half, that of the intensive range found by Engen and Lindström (1963) for diluted amyl acetate over the same stimulus concentration range, with the subjective range they found constituting perhaps a useful working lower bound. Since the stimulus ranges are the same in each study, the comparison is justified (Henion, 1969, p. 518), which is one reason amyl acetate was selected for the present experiment.¹ Comparisons are obviously affected by the choice of primary odorants and standards, as Engen and McBurney (1964) have pointed out. Still, theirs is a useful and valid proposition, namely, that much more variation in response arises from hedonic, rather than from intensive, characteristics of olfactory stimuli (Engen & McBurney, 1964, p. 437), notwithstanding that the result was the other way round, as it now appears, in the case of diluted amyl acetate.

The fact that the present hedonic range did not fall between the two rough bounds previously mentioned probably should not be considered unusual. Introspectively, amyl acetate is quite pleasing throughout a variety of concentrations, maintaining its quality when diluted to barely perceptible concentrations such as .003% (Engen, 1964). Had an odorant like triethyl phosphine been selected instead, its hedonic range probably would have fallen between these bounds, for it has a pleasing floral fragrance in dilution but is rather suffocating in concentration (Moncrieff, 1944).

It was predicted that the pleasantness of a diluted odorant would constitute a metathetic continuum, for the task of discriminating pleasantness was thought to involve more of a substitutive process than an additive one at the physiological level. The relationship between the category and combined magnitude scales is examined in Fig. 1, where the plot of the first against the second produces a nonlinear function. Nonlinearity does not rule out metatheticity, since the guideline for this classification of continuum is not a strong one, namely, "the category scale may be linear when so plotted [Stevens & Galanter, 1957, p. 377]."² As for the prothetic classification, the general rule requires a concave downward relationship, not the concave upward one of Fig. 1, thus seeming, in the

Fig. 1. Category scale as function of combined magnitude-estimation scale (fitted by eye).

present case, to disqualify pleasantness as being prothetic.

These scalar relationships resemble those found in scaling experiments of pleasantness for a sample of odorants (Engen & McBurney, 1964) and of oiliness for diluted heptanol (Henion, 1969). However, in the latter case the evidence was more in favor of ruling out protheticity than in the present. In plots of pleasantness and oiliness scales as functions of stimulus concentrations in linear coordinates, instead of the category scale's being more concave downward than the magnitude scale, which is another criterion for a prothetic continuum, it was just the other way round. But in the present case, the inverted category scale is actually more concave downward than the inverted³ magnitude scale in the same kind of plot, as is shown in Fig. 2. Hence, the evidence against protheticity is not conclusive. Moreover, a bunching of the responses at the weak end of a prothetic continuum tends to increase the slope of the category scale, leaving the magnitude scale's slope unchanged (Stevens & Galanter, 1957). Apparently, such a bunching effect also may be occurring for diluted amyl acetate, as indicated in Fig. 2.

The importance of size of subjective

Fig. 2. Category and combined magnitude-estimation scales as functions of concentrations of n-amyl acetate (fitted by eye).

range has been suggested as possibly influencing the curvature of the category scale plotted as a function of the magnitude scale (Engen & McBurney, 1964). There now exists evidence that this curvature is concave upward for two different cases involving the same hedonic attribute, one with a very small subjective range and the other, extremely large. Although it would be interesting to know something of the scalar curvature based on an experiment involving a diluted odorant whose hedonic range has a more middle-sized value, more than subjective range is apparently involved.

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NOTES

1. A difference in the kinds of diluent used in the two experiments was judged to be minor and not to invalidate comparisons between them.
2. Their emphasis.
3. Inverting the y-axis changes it to a dimension of unpleasantness, permitting more easily discussed comparisons of curvatures.

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