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Perceived fragrance complexity and its relation to familiarity and pleasantness

J. STEPHAN JELLINEK *Dragoco, D-3450 Holzminden, West Germany* and EGON P. KÖSTER *Psychological Laboratory, Utrecht University, Varkenmarkt 2, Utrecht, The Netherlands.*

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Synopsis

Fifty-nine subjects (23 male, 36 female) rated the FAMILIARITY of nine odors varying in chemical complexity from single odorous compounds to complex perfumes. The results of these ratings were compared with the results of two experiments in which the same subjects were asked to judge the perceived complexity of the odors and their PLEASANTNESS with a paired comparison method.

There was no RELATIONSHIP between the CHEMICAL COMPLEXITY of the stimuli and their PERCEIVED COMPLEXITY. Familiarity and perceived complexity were unrelated both in men and in women. In men there was a significant negative correlation between perceived complexity and preference indicating that men prefer less complex odors over complex ones. There was no correlation between familiarity and preference in men. In women preference was positively correlated with familiarity, whereas there was no relationship between preference and perceived complexity.

INTRODUCTION

Complexity as a dimension of human perceptual experience has been studied occasionally in the fields of vision, audition, taste and food science. Often, complexity is thought to be linked with other perceptual dimensions such as pleasantness and familiarity.

Apart from a recent small-scale study by Moskowitz and Barbe (1) and occasional reports that the pleasantness of an odor mixture increases with increasing complexity (2), very little attention has been given to complexity as a feature of odor perception. Perhaps this is due in part to the poor definition of the concept.

When we speak of a complex odor at least four different meanings may be involved. In the first place we may refer to the *chemical complexity* of the stimulus which is related

to the number of different chemical compounds actually present. Secondly we may mean the *physiological complexity* of an odor, indicating that in the perception of a particular odor only a few or many different receptor sites may be involved. A single substance may stimulate a number of different receptor sites and therefore be physiologically more complex than another single substance that stimulates only one type of receptor sites. Physiological complexity should be measured by direct electrophysiological methods.

In the third place we may mean *perceived or psychological complexity* referring to the notion the observer obtains about the number of separate impressions that make up the total impression he has of the stimulus. The odors of some pure substances might make the impression of being composed of many different odors, whereas chemically complex odor mixtures might seem psychologically simple because all odors in them blend into one single odor impression.

Finally, the notion of *perfumer's complexity* has a different meaning still. The perfumer considers a fragrance the more complex, the greater the variety of "notes" on which it is based. A floral bouquet containing, for example, elements of gardenia, lilac and jasmin is to him more complex than a "straight" lilac composition, but less complex than a fragrance which in addition to floral notes also contains woody, fruity, and musky ones. The perfumer tends to associate complexity with sophistication. He considers simple fragrances generally more appropriate for basic functional products such as a skin treatment product, a family soap, an air freshener; and complex fragrances more appropriate for products associated with the presentation of the product user to the outside world such as colognes or make-up products. Within the realm of colognes, he considers complex fragrances to be more appropriate for the mature woman, simple fragrances more for young girls or elderly ladies. Also, fragrances worn at social occasions are generally more complex than refreshment colognes for daytime or after-bath use.

This use of fragrance complexity on the part of the perfumer assumes that the typical consumer responds to differences in perfumer's complexity, albeit perhaps unconsciously.

The study by Moskowitz and Barbe (1) used methyl salicylate, caproic acid, isobutyl isobutyrate, methyl disulphide and camphor, as well as all possible 2 to 5 component mixtures of these, as the stimuli. These were rated on a range of attributes including complexity, familiarity and pleasantness by fourteen female subjects. Moskowitz and Barbe found only moderate differences in complexity among these stimuli. There was some correlation between perceived complexity and chemical complexity: the three least complex stimuli were single chemicals, and perceived complexity usually increased with the number of components of the mixture. However, there were contradictions; thus one of the single chemicals (isobutyl isobutyrate) was among the highest rated in complexity of the entire set of stimuli. There was no significant correlation between the perceived complexity of the stimuli and their pleasantness or their familiarity, although there was some trend for stimuli rated as more familiar to be rated as less complex ($r = -0.49$).

It was the purpose of the present study to obtain a clearer picture of the significance and meaning of perceived complexity of perfumes to untrained subjects, using an array of stimuli more relevant to practical perfumery, and a larger group of test

subjects including both men and women. Specifically, we wanted to explore the following questions:

- does the untrained subject perceive differences in complexity among stimuli ranging from single chemicals to a typical luxury perfume, and is there sufficient communality in judged complexity among a culturally homogeneous group of subjects to lead to significant differences between the group ratings for the various stimuli?
- What is the relationship between perceived complexity and chemical complexity?
- What is the relationship between perceived complexity by untrained subjects and perfumer's complexity?
- What are the relationships between perceived complexity and familiarity of the stimuli?
- What are the relationships between perceived complexity and judged pleasantness of the stimuli?

METHOD

ODOROUS SUBSTANCES

Nine different odorous materials varying in chemical complexity from solutions of single chemicals to perfume compounds were used in this study. Table I lists these

Table I
Stimuli

Material	Concentration % in DMP	Nature
A. Musk (DRAGOCO O/213650)	10	perfume base
B. Lemon Oil Messina	10	essential oil
C. Linalyl acetate	10	single substance
D. Perfume, type "Rive Gauche" (DRAGOCO O/513490)	10	perfume composition
E. Goldrose (DRAGOCO O/062680)	10	perfume base
F. Isoeugenol	10	single substance
G. alpha Hexyl cinnamic aldehyde	10	single substance
H. Lavender bouquet (DRAGOCO O/062440)	10	perfume composition
I. Ylang-Ylang Oil extra	5	essential oil

substances with an indication of their concentration and nature. All solutions were made in dimethyl phthalate (DMP).

All substances were presented in 20-ml straight bottles containing 0.5 ml of substance, closed with an ordinary cork.

SUBJECTS

Fifty nine subjects (23 male, 36 female) took part in the first session of the experiment. During the second session one female subject was absent because of illness. All subjects were students ranging in age from 16 to 29 years. The subjects were paid the amount of hfl. 25,—for attending both sessions.

EXPERIMENTAL PROCEDURE

In order to determine the familiarity of the subjects with the odor previous to the experiment, we asked them to rate the number of times they had encountered these odors on a 7-cm-long continuous scale ranging from "seldom" to "frequently." The odors were numbered 1 to 9 and presented in random order at 75-sec intervals in order to avoid the influence of adaptation. In the first session of the experiment the familiarity rating was immediately followed by the determination of the psychological complexity of the odors. In order to do this the subjects received all possible 36 pairs of the stimuli, with 75-sec intervals, in a random order. The subjects were told that all bottles contained mixtures of varying numbers of odorants. Subsequently they were instructed to smell the members of a pair in a distinct order (half of them from left to right, the other half the other way round) and to indicate which of the two bottles contained the mixture in which most different substances were present. All stimuli were coded with a three-digit code for which a random selection had been made from the numbers between 101 and 999 with the exception of multiples of 100 and 111. The subjects were told that the numbers were chosen at random.

During the second session, two days later, the subjects rated the familiarity of the odors, again in random order, to see whether the added experience of the first session changed the rating. After the familiarity rating the 36 pairs of stimuli were presented again, but in this session the subjects were asked to indicate which of the pair members they liked best.

In a separate test, eight trained perfumers, all on the staff of Dragoco, Holzminden, West Germany, were asked to rate the same nine odors for their complexity, using a scale from 1 (lowest complexity) to 10 (highest complexity). In this test, the odors were identified by name.

SCORING AND DATA TREATMENT

The responses on the 7-cm familiarity rating scale were classified into seven classes. The mean and the standard deviation for each sample were calculated for men and women separately and for the whole group (see Table II).

For the paired comparison data the frequencies with which each of the pair members was judged to be more complex (Table III) or more preferred (Table IV) were counted for all pairs and recorded in a matrix. For each of the separate pairs the level of significance of the difference between the frequencies for the two pair members was determined on the basis of their direct comparisons and on the basis of the total number of times they were judged in all comparisons.

The frequency values of Tables III and IV may be transformed into scalar values by expressing, for each substance, the difference between its frequency of being judged

Table II
Familiarity Rating

Substance	First session			Second session		
	M	F	T	M	F	T
Musk base	3.00	3.05	3.03	3.70	3.41	3.59
	(1.85)	(1.92)	(1.91)	(2.03)	(1.82)	(2.10)
Lemon oil	4.78	5.13	4.99	5.33	5.08	5.18
	(1.90)	(1.67)	(1.97)	(1.55)	(1.87)	(1.84)
Linalyl acetate	2.91	3.27	3.13	3.79	3.26	3.47
	(1.64)	(1.98)	(2.03)	(1.74)	(1.76)	(1.84)
Rive Gauche	4.60	5.33	5.04	5.08	5.29	5.21
	(1.72)	(1.63)	(1.91)	(1.28)	(1.64)	(1.43)
Goldrose	4.30	4.94	4.69	4.95	4.94	4.94
	(1.71)	(1.89)	(1.96)	(1.45)	(1.70)	(1.51)
Isoeugenol	2.60	2.80	2.72	3.25	3.00	3.10
	(1.77)	(1.47)	(1.83)	(1.72)	(1.59)	(1.73)
Hexyl cinnamic aldehyde	2.43	2.97	2.76	3.25	3.64	3.49
	(1.70)	(1.91)	(1.99)	(1.96)	(1.70)	(2.01)
Lavender bouquet	4.69	4.38	4.50	4.83	4.91	4.88
	(1.76)	(2.07)	(1.97)	(1.46)	(1.62)	(1.57)
Ylang oil	3.39	2.77	3.01	4.29	3.50	3.81
	(1.58)	(1.80)	(2.01)	(1.70)	(1.86)	(2.08)

Mean scores and standard deviations (in parentheses) of male (M) and female (F) subjects and of the total group (T). (1 = low familiarity, 7 = high familiarity).

Table III
Complexity: Number of Times the Substances in the Rows (A) were Judged to be More Complex than the Substances in the columns (B). Example: Lemon Oil was Judged to be more Complex than Musk by 40 Respondents; Musk was Judged to be more Complex than Lemon Oil by 19 Respondents. N = 59.

A \ B	Musk Base	Lemon Oil	Linalyl Acetate	Rive Gauche	Gold-rose	Iso-eugenol	Hexyl Cinnamic Aldehyde	Lav-ender Bouquet	Ylang Oil	Total More Complex
Musk base		19	17	10	21	16	25	15	6	129
Lemon oil	40[1]		35	32	36	27	43[1]	21	16	250
Linalyl acetate	42[1]	24		23	27	26	45[1]	15	18	220
Rive Gauche	49[1]	27	36		40[1]	29	37	28	8	254
Goldrose	38[2]	23	32	19		26	42[1]	23	17	220
Isoeugenol	43[1]	32	33	30	33		45[1]	25	16	257
Hex. cinn. ald.	34	16	14	22	17	14		10	4	131
Lavender bqt.	44[1]	38[2]	44[1]	31	36	34	49[1]		19	295
Ylang oil	53[1]	43[1]	41[1]	51[1]	42[1]	43[1]	55[1]	40[1]		368

[1] $p < 0.01$ (two-tailed).
[2] $p < 0.05$ (two-tailed).
Differences >26 in the "total more complex" column are significant at the 5% level.

Table IV

Preference: Number of Times the Substances in the Rows (A) were Preferred over the Substances in the Columns (B).
(Example: Lemon Oil was Preferred over Musk by 25 Respondents, Musk over Lemon Oil by 33 Respondents.)

A \ B	Musk Base	Lemon Oil	Linalyl Acetate	Rive Gauche	Gold-rose	Iso-eugenol	Hexyl Cinnamic Aldehyde	Lav-ender Bouquet	Ylang Oil	Total Preferred
Musk base		33	43[1]	25	32	51	37[2]	36	47[1]	304
Lemon oil	25		37[2]	19	25	48[1]	26	33	39[1]	252
Linalyl acetate	15	21		12	15	42[1]	13	23	38[2]	179
Rive Gauche	33	39[1]	46[1]		39[1]	52[1]	36	44[1]	51[1]	340
Goldrose	26	33	43[1]	19		53[1]	36	37[2]	38[2]	285
Isoeugenol	7	10	16	6	5		11	18	27	100
Hex. cinn. ald.	21	32	45[1]	22	22	47[1]		31	40[1]	260
Lavender bqt.	22	25	35	14	21	40[1]	27		38[2]	222
Ylang oil	11	19	20	7	20	31	18	20		146

N = 58.
[1]$p < .01$.
[2]$p < .05$.
Differences >27 in the "total preferred" column are significant at the 5% level.

Table V.

Complexity and Preference, Expressed as Unit Normal Deviates Using the Least Complex and the Least Pleasant Stimulus as Reference Points; for Male Respondents (M), Female Respondents (F) and Total Population (T).

Complexity				Preference		
M	F	T		M	F	T
0.00	0.21	0.012	Musk base	1.65	1.00	1.145
0.47	0.97	0.644	Lemon oil	1.06	0.84	0.868
0.27	0.85	0.500	Linalyl acetate	0.76	0.38	0.479
0.34	1.06	0.656	Rive Gauche	1.54	1.34	1.349
0.26	0.85	0.499	Goldrose	1.27	1.02	1.024
0.65	0.91	0.682	Isoeugenol	0.00	0.00	0.000
0.09	0.00	0.000	Hex. cinn. aldehyde	1.20	0.81	0.911
0.71	0.207	0.879	Lavender bouquet	0.96	0.63	0.711
1.01	1.873	1.312	Ylang oil	0.73	0.08	0.300

more complex (or more pleasant, respectively) and the frequency of the least complex (or the least preferred) substance as unit normal deviates. This treatment of the data yields Table V. The total population data from Table V are presented graphically in Figure 1 a and 1 b.

The rank order correlations (Spearman Rho) among judged complexity, familiarity and preference were calculated for the total population and for the male and female subgroups separately (Table VI).

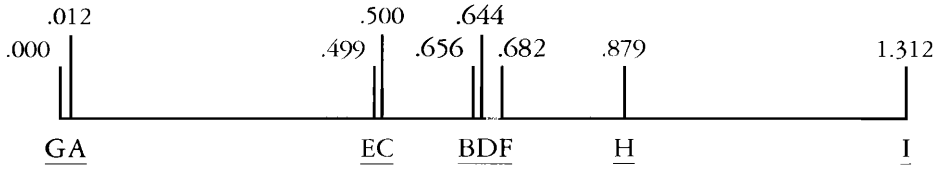

Figure 1 a. Perceived complexity, expressed in normal unit deviates. Substances connected by a horizontal underlining are not significantly different; all others are, at least at the 5% level.

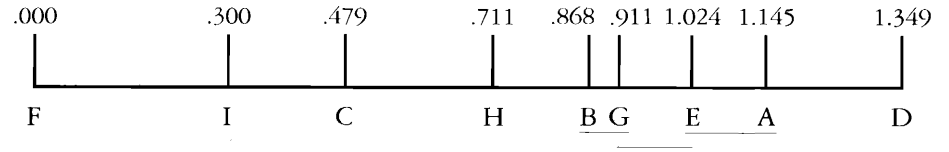

Figure 1 b. Preference, expressed in normal unit deviates. Substances connected by a horizontal underlining are not significantly different; all others are, at least at the 5% level.

Table VI
Correlations Between the Dimensions Investigated, Calculated for Male (M) and Female (F) Subjects Separately and for the Total Group (T)

	Familiarity – Complexity	Familiarity – Preference	Complexity – Preference
M	+.383	+.276	−.667[1]
F	+.117	+.717[1]	−.217
T	+.021	+.583	−.563

[1] = $p < .05$.

The results of the perfumers' complexity rating of the nine substances are summarized in Table VII.

Gas chromatograms were prepared of the nine substances, using a capillary column and conditions of high resolution. The number of peaks obtained for each odorous material may serve as a rough indicator of chemical complexity and are listed in Table VII.

Table VII
Perfumers' Ratings of Complexity [Scale from 1 (Low) to 10 (High)], and Number of Peaks in Gas Chromatogram (Capillary Column)

	Average Complexity Rating— 8 Perfumers	Number of Peaks
Musk base	5.75	12
Lemon Oil	2.63	20
Linalyl acetate	2.00	6
Rive Gauche type	7.88	49
Goldrose	5.75	20
Isoeugenol	3.50	9
Hexyl Cinnamic Aldehyde	3.25	3
Lavender bouquet	5.13	26
Ylang-Ylang Oil	6.00	32

DISCUSSION

COMPLEXITY

The key finding, a precondition for any meaningful discussion about perceived or psychological complexity, was that there were sufficient differences in perceived complexity among the stimuli presented, and sufficient communality among the respondents to result in significant differences in perceived complexity of the stimuli (compare Table III and Figure 1a). Although the untrained respondent rarely if ever spontaneously mentions simplicity or complexity as a feature of a fragrance, when asked to compare an array of fragrance stimuli in terms of the number of components they appear to contain, the answers are fairly clear and consistent.

The low degree of correspondence between chemical and perceived complexity is noteworthy. The single substance Isoeugenol, for example, is perceived as equally complex as the chemically vastly more complex compound "Rive Gauche type" and as more complex than the multicomponent Musk Base. Ylang-Ylang Oil is judged by 51 out of 59 respondents to be more complex than the "Rive Gauche type" perfume which contains this very Ylang-Ylang Oil along with scores of other components.

The perfumers' intuitions regarding complexity turned out to be equally unreliable as predictors of the untrained subjects' responses. The untrained subjects perceived the musk and rose bases, as well as the Rive Gauche type perfume, as simpler than did the perfumers, and the essential oils as more complex. The tendency of perfumers to think of essential oils such as Lemon Oil and of classical bouquets such as the Lavender Bouquet as relatively simple is also the main source of divergence between perfumers' complexity and chemical complexity.

The similarities and disparities between the three types of complexity are summarized in Table VIII. In this table, the three types of complexity measures have all been transformed to rankings; where differences between substances were nonsignificant, they were assigned the same rank. The rank correlation between perceived complexity and chemical complexity was 0.71, between perfumer's and chemical complexity 0.69.

Table VIII
Comparison of Complexity Rankings[1]

	Complexity		
	Perceived	Perfumer's	Chemical
Musk base	1,5	7	4
Lemon Oil	6	2	5,5
Linalyl Acetate	3,5	1	2
Rive Gauche types	6	9	9
Goldrose	3,5	7	5,5
Isoeugenol	6	3,5	3
Alpha-Hexyl cinnamic aldehyde	1,5	3,5	1
Lavender bouquet	8	5	7
Ylang-Ylang Oil	9	7	8

[1]1 = least complex, 9 = most complex. The "Perceived" column is derived from Table III, the "Perfumer's" and "Chemical" columns from Table VII. Substances for which ratings did not differ significantly ($p > 0.05$) were assigned the same ranking.

RELATIONSHIP BETWEEN COMPLEXITY, FAMILIARITY AND PREFERENCE

The finding for the female respondents and for the total population parallel those found by Moskowitz and Barbe (1) for their all-female group of respondents: no significant correlations between perceived complexity and familiarity, nor between perceived complexity and preference. A negative correlation between familiarity and complexity would not have been surprising; one might have expected familiar notes such as Lemon, Rose, or Lavender to be considered easy to pin down and, therefore, non-complex—but this was not the case.

The remarkable feature here was a pronounced sex-related difference: although the preference rankings for the male and female respondents were nearly identical ($r = +0.983$), they apparently came about through different mechanisms. The male respondents gave a significant negative correlation ($p = 0.05$) between complexity and preference, while the female respondents did not. On the other hand, there was a significant positive correlation between familiarity and preference for the female respondents ($p = 0.05$) which had also been found be Moskowitz and Barbe with their all-female panel and which was not present with our male respondents. Simply expressed: our male respondents liked simple fragrances, our female respondents liked familiar fragrances.

OTHER SEX-RELATED RESPONSE DIFFERENCES

At their first exposure to the test stimuli, the female respondents assigned higher familiarity ratings than did the men in seven out of nine cases (Table II). That this was a true difference in familiarity rather than a different use of the scales is made likely by the observation that the pattern disappeared in the second session. The most likely interpretation is that the female respondents were more fragrance-aware coming into the test, but that the male respondents caught up quickly through their fragrance-exposure in the test.

The finding that the female respondents showed more discrimination in their complexity ratings while the male respondents discriminated more on preference (Table V) also supports the notion of the females among the respondents as a more fragrance-sophisticated group, the males as a more fragrance-naive group.

Although it is tempting to state these findings in a general form, we must keep in mind that we are dealing in this study with a rather special group of respondents: Dutch students between the ages 16 and 29. The finding: men like simple fragrances, women like familiar ones, may also, thus far, be stated only as hypothesis based on our special test population.

PREFERENCE RANKINGS

The findings regarding preference (Table IV, Figure 1 b) conform, by and large, to an experienced perfumer's expectations. There were two surprises:

- the fairly high rating for alpha-hexyl cinnamic aldehyde, a synthetic perfume chemical which is widely used but never by itself and rarely as a dominant note. The low familiarity rating (Table II) is in accordance with expectations, but it makes the high preference the more remarkable.

- the high preference rating for the musk base. Actually, this is in line with the popularity of musk fragrances among young adults. The low familiarity ratings suggest that this is not a learned response (recognition of strongly promoted products) but a spontaneous one. It is also of interest that both the musk base and alpha-hexyl cinnamic aldehyde rank very low on perceived complexity (Table III, Figure 1 a).

CONCLUSION

In conclusion, we may summarize that fragrance complexity, as perceived by untrained respondents, is a meaningful and measurable concept. For the male respondents there was a significant inverse relationship between perceived complexity and preference. Neither chemical complexity nor trained perfumers' notions about complexity are good predictors of untrained respondents' complexity perceptions.

In addition, this study yielded indications that the positive correlation between familiarity and preference is stronger for female respondents than for males, and it furnished a few unexpected findings regarding fragrance preferences.

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