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Progress Report

Prediction of consumer choice. Reprint 3.

Methodology of Preference Measurement

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QUARTERMASTER FOOD AND CONTAINER INSTITUTE FOR THE ARMED FORCES
Research and Development Command
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CONTRACT RESEARCH PROJECT REPORT

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Title of the Contract: Methodology of Preference Measurement

SUMMARY

One phase of work is reported: Differences in the preferences for selected foods of regional and urban-rural groups of respondents to Quartermaster Food Preference Survey 006 are studied by a method proposed in Report No. 1 of this project.

Measuring Food Preferences When Tastes[1] are Heterogeneous

I. Introduction

In a previous paper (1) a statistical test was proposed to determine whether the tastes of a limited number of individuals for given objects could be considered homogeneous. It was pointed out that a similar test could be used for determining the statistical significance of differences in tastes between groups of individuals. It was also suggested that when tastes are not found to be homogeneous, preference measurement would still be possible using a mulitvariate model of preferential choice.

This paper reports an application of this statistical test and multivariate model to the preferences of certain groups of respondents to the Quartermaster Food Preference Survey 006. Perferences for fourteen selected menu items were studied.

II. Models of Preferential Choice

Much of preference testing practice is now based upon the following simple Thurstonian model: The preferences of the i-th individual for the j-th object are assumed to reflect an underlying preference score g_{ij} of composition

$$g_{ij} = \mu_j + e_{ij} \qquad (1)$$

where μ_j is a value for the j-th object and e_{ij} is an error term

[1] The term "taste" refers to the subjective basis of preference and not necessarily to phisiological taste.

distributed as $N(0, \sigma_j)$. According to this model, all of the individuals *i* perceive the same value μ_j in the j-th food, but in expressing their preferences they err by amount e_{ij}, and the distribution of this error is assumed normal.

Thurstone's solutions for the method of paired comparisons and successive categories can be regarded as tests of the goodness-of-fit of this model. These solutions generally show that the model peforms well when 1) the objects vary in only one attribute pertinent to tastes, and/or 2) all of the individuals have similar tastes. If these conditions are not met, however, the frequency distributions for given objects in the table of data from the method of successive categories are platykurtic or even bi-model, and the fit is poor. When this is the case, it may be desirable to divide the population of respondents into subgroups and examine the distributions of preferences within each subgroup. If tastes are more homogeneous within the subgroups than in the complete sample, the distributions will become less platykurtic and more normal. The statistical tests described in (1) will then contradict the assumption that tastes are homogeneous between subgroups.

If tastes are heterogeneous and the univariate model cannot be applied, it may be desirable to fit a multivariate model to the data. The simplest such model would be

$$g_{ij} = \alpha_{i1}\mu_{1j} + \alpha_{i2}\mu_{2j} + \dots + \alpha_{im}\mu_{mj} + e_{ij} \quad (2)$$

where g_{ij} is the preference score of the i-th individual for the j-th object, μ_{kj} are the values of *m* attributes of the object, and

α_{ik} are weights which reflect the importance of these attributes in the tastes of the i-th individual. The term "individual" is used generally and, as in this study, may designate a group of individuals with presumably similar tastes.

III. Method

The method proposed in (1) for the statistical test of homogeneity and the fitting of the multivariate model may be described in general terms as follows:

1. The preferences for each group of individuals are scaled by the least-error method described in (1). The quantities resulting from the scaling are:

    a) The mean preference scores of each group for each food.

    b) The average discriminal variances (discriminal dispersion)^2 for each group.

2. By the statistical method of analysis of dispersion, a series of orthogonal linear discriminant functions are constructed which indicate how the mean preference scores of the various groups should be combined to discriminate optimally among foods. The quantities of chief interest from this analysis are:

    a) The coefficients of the k discriminant functions which successively best discriminate among the foods. These are the α_{ik} in (2).

    b) The variance between foods accounted for by each of these functions.

3. After the variance attributable to each discriminant function is removed, the residual variance between foods is tested against the variance of the error term in (2). When the residual is not significantly greater than would be expected from error, no further discriminant functions are computed.

4. The mean preference scores for the foods are substituted into the discriminant function. The resulting quantities may be called "component scores" for the foods and may be interpreted in terms of other information about the foods. These quantities are the (hypothetical) attribute values μ_{kj} in (2).

IV. The Study

1. The composition of the sample of respondents used in this study is shown in Table 1. Respondents within each of the subgroups were selected randomly from those available in the complete sample from Quartermaster Food Preference Survey 006. The breakdown shown in Table 1 was chosen because it was thought that location of home would be the background variable most relevant to differences in taste.

The foods selected for this study from those included in Survey 006 are listed in Table 2. Foods were selected which were thought most subject to regional differences in taste.

2. Preferences were measured in Survey 006 by the standard nine-category hedonic scale (2). Since certain of the categories were little used for these foods, it was found that categories 5, 6, 7, and 8, 9 could be combined with no appreciable loss of information.

Reducing the number of categories shortened the computations necessary for scaling the categories. The discriminal variances over all foods for each group were obtained incidental to the least-error scaling method (1) and are shown in Table 2. Since this method makes use of a scale factor which brings the total variance for each group to unity, the discriminal variances indicate the degree of individual differences in taste within the group. Note, in Table 2, that the discriminal variances are a uniformally large fraction of the total variance for all groups. This means that individual differences in tastes were not well accounted for by the division of the sample into regional and urban-rural groups. This fact will appear again in the formal analysis of differences in tastes between groups.

3. The mean preferences score of each group for each food was obtained by multiplying the scale values for the categories by the number of responses for the food in each category and dividing by the number of responses. These values are shown in Table 2.

4. An analysis of the dispersion between foods computed from the mean-preference scores for the foods and the discriminal variances (Table 2) was performed according to the method previously reported (1). The coefficients of the resulting discriminant functions and the variances between foods attributable to each are shown in Table 3.

5. The numerical value of the variances between foods attributable to each discriminant function and their degrees of freedom were as follows:

Discriminant Function	Variance	d.f.
First	1715	22
Second	154	20
Third	121	18
Residual	179	70
Total	2169	130

The large sample test of significance of the residual variance between foods after the variance attributable to each discriminant function was removed was given by the following χ^2 test:

Source of χ^2	χ^2	d.f.	P
Total, eliminating 1st variance	454	118	P .01
" " 1st & 2nd "	300	98	P .01
" " 1st, 2nd & 3rd "	179	70	P .01

6. This test indicated that the components variance removed by the three discriminant functions were significant and that significance variance remained which was still unaccounted for. Because the test was based upon a very large sample, however, it was sensitive to differences among the foods too small to be of practical importance. For this reason, it was considered not worth while to extract a further discriminant function and the analysis was stopped at this point.

7. Substitution of the mean preference scores in Table 2 into the three discriminant functions yielded the "component scores" for each food as shown in Table 4.

8. For purposes of interpretation, the coefficients of

discriminant functions and the component scores for the foods were plotted in Figures 1, 2, and 3.

V. Interpretation

1. <u>The First Component</u>. It seems apparent that the first component in the preceding analysis should be labeled "common taste." This component gives scores of each food which measure the all-over preference of the respondents regardless to which subgroup they belong. This measure would be quite similar to the measures of preference already used to report the findings of the Quartermaster survey--for example, mean preference score, per cent dislike, etc.

The important feature of the first component scores is that they account for nearly 80% of the variance between foods. This means that although the foods used in this study were chosen because regional differences in preference were expected, these differences were minor compared to the all-over agreement of the subgroups for these foods. The differences in preferences observed for these foods were statistically significant, but were numerically small. Perhaps with other classification of respondents in the original sample, more of the individual differences in preference could have been accounted for.

2. <u>The Second and Third Components</u>. Components 2 and 3 represent variance between foods which was not attributable to common taste. In order that the coefficients of the second and third discriminant functions could be interpreted in practical terms, the

coefficients were plotted in Figure 1. Examination of the relative positions of the subgroups indicated that the two components could be described somewhat as follows: The positive arm of component 2 reflected urban and northern tastes. The negative arm reflected southeastern and rural tastes. In this connection, it is of interest that the tastes of the urban-southeast were more rural-like than those of the rural-midwest ahd northeast.

The positive arm of the third component appeared to be attributable to southwestern taste, and the negative arm could be described as eastern taste.

With these labels in mind, a similar plot of component scores for the foods on components 2 and 3 was examined. This plot is shown in Figure 3. The position of the foods in Figure 3 followed closely the regional differences which were expected. Foods which are grown in given regions or traditional to these regions tended to be preferred there. The variance attributable to southwestern tastes, for example, was largely due to greater preference for black olives. Those in the southeast and southwest showed greater preference for fried summer squash. Fried sweet potatoes appealed to southeastern and rural tastes; iced coffee and sauerkraut to northern and eastern tastes. In the urban-north, green olives tended to be preferred to black olives, while in the southwest the converse was true. It should be noted that all of these statements are made with respect only to that variance in the preference scores which is independent of common tastes.

VI. Conclusion

The findings of this study appeared to support the following conclusions:

1. The preferences of the groups of respondents for the 14 selected foods significantly contradicted a unidimensional model for preferential choices; i.e., tastes differed significantly from one group to another.

2. The actual magnitudes of the differences in tastes between groups was small and accounted for only about 20% of the variance between foods. The remaining 80% was attributable to common tastes and reflected a considerable degree of concordance of preferences among the ten groups.

3. A considerable amount of dispersion of preferences remained within the ten regional, urban-rural groups used in this study. Hence, while there were substantial individual differences in the preferences of the respondents, the regional and urban-rural grouping accounted for little of these differences.

4. Such heterogeneity of taste as existed between the groups was largely accounted for by a three-dimensional multivariate model for preferential choice. The hypothetical attribute values of the foods represented by the component scores were interpretable in terms of national regions in which certain of the foods are especially preferred.

References

1. "The selection of judges for preference testing." Report No. 1, Project No. 7-84-15-007, Contract No. DA-19-129-QM-272, File No. P-1101.

2. Jones, L. V., Peryam, D. R. and Thurstone, L. L. "Development of a scale for measuring soldiers' food preferences. Food Research, 1955, 20, 512-520.

Figure 1. Plot of Discriminant Function Coefficients for Second and Third Components of Taste

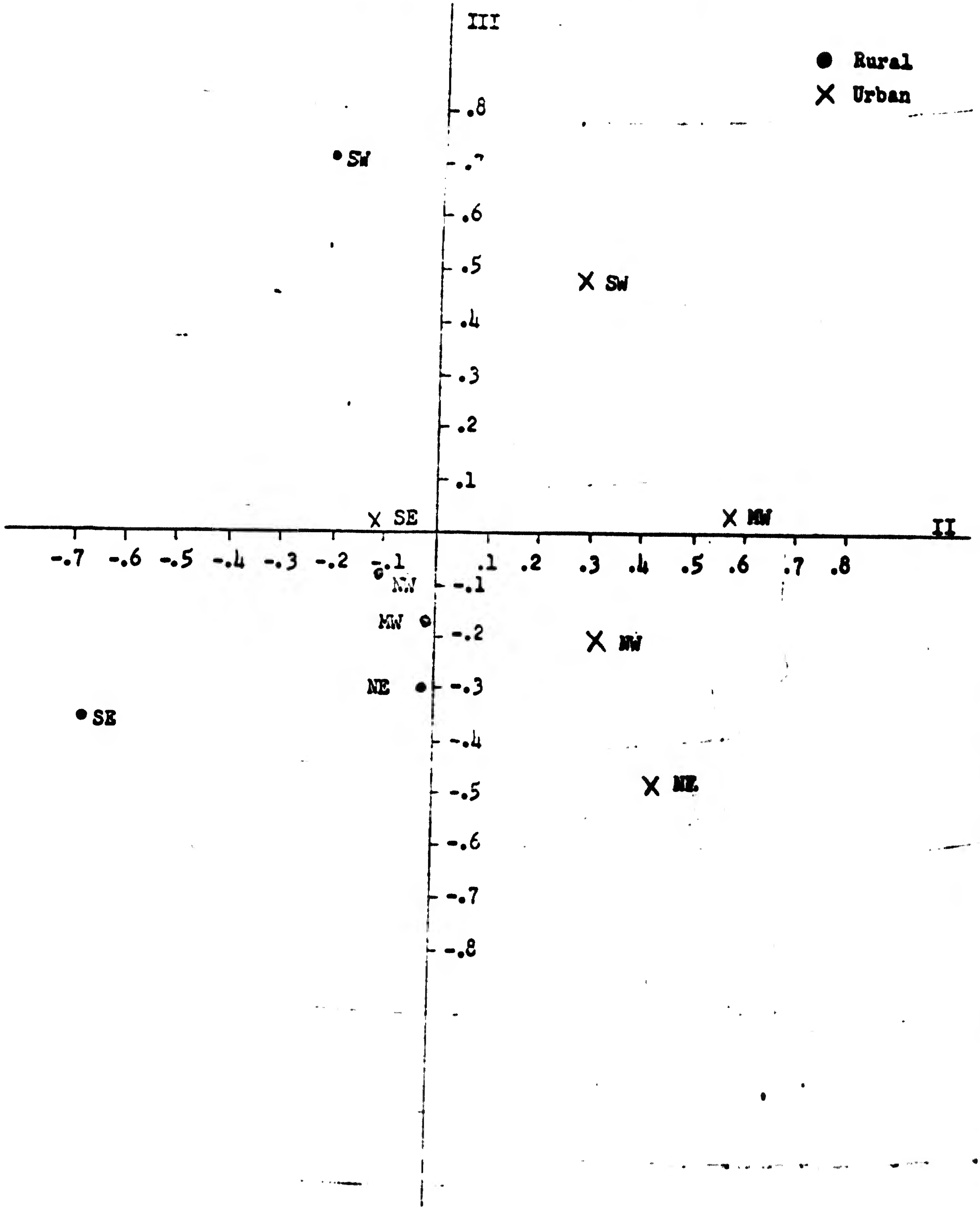

Figure 2. Scores for First Component of Taste of Selected Foods from Survey 006

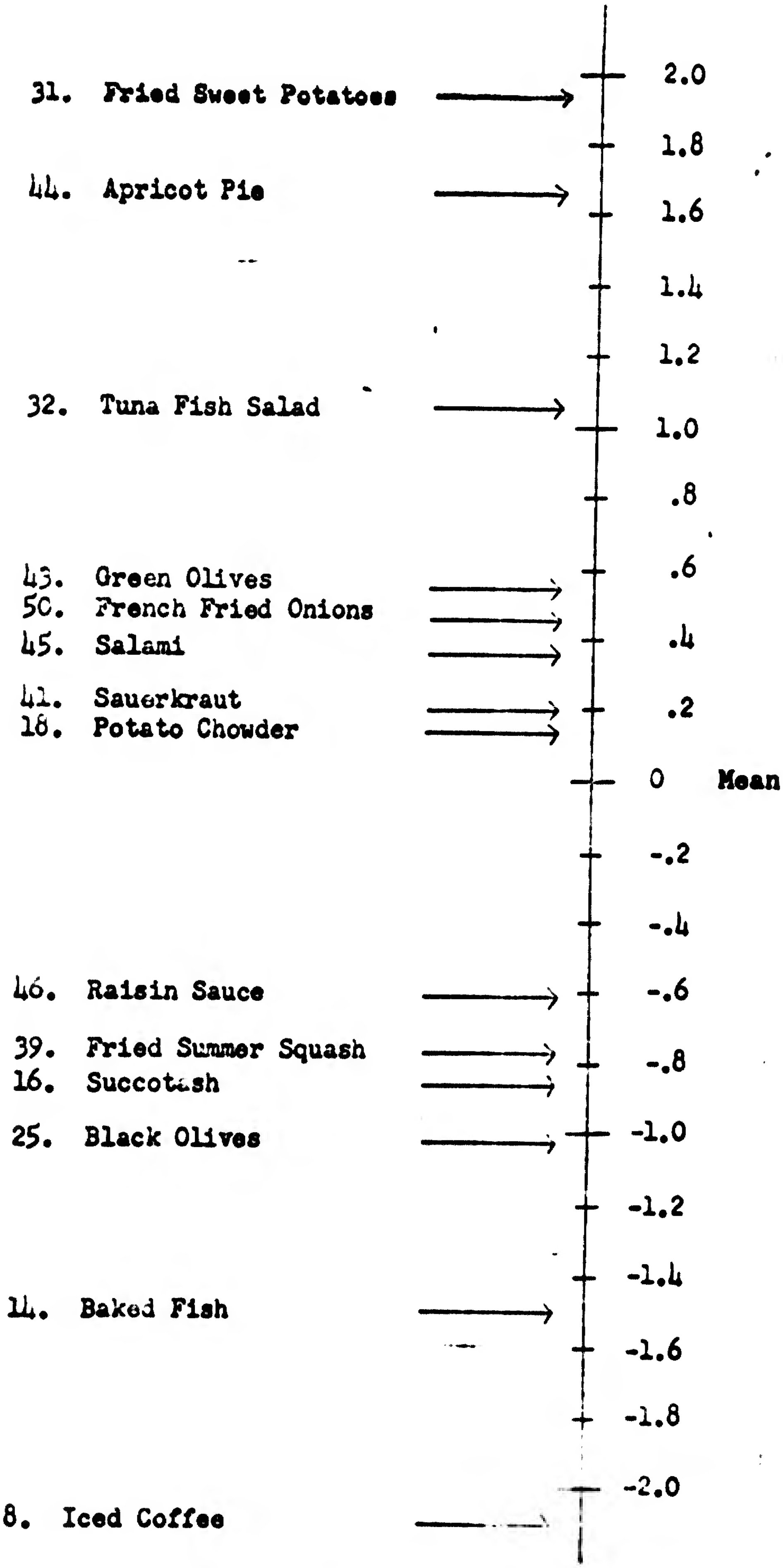

Figure 3. Scores for Second and Third Component of Taste of Selected Foods from Survey 006

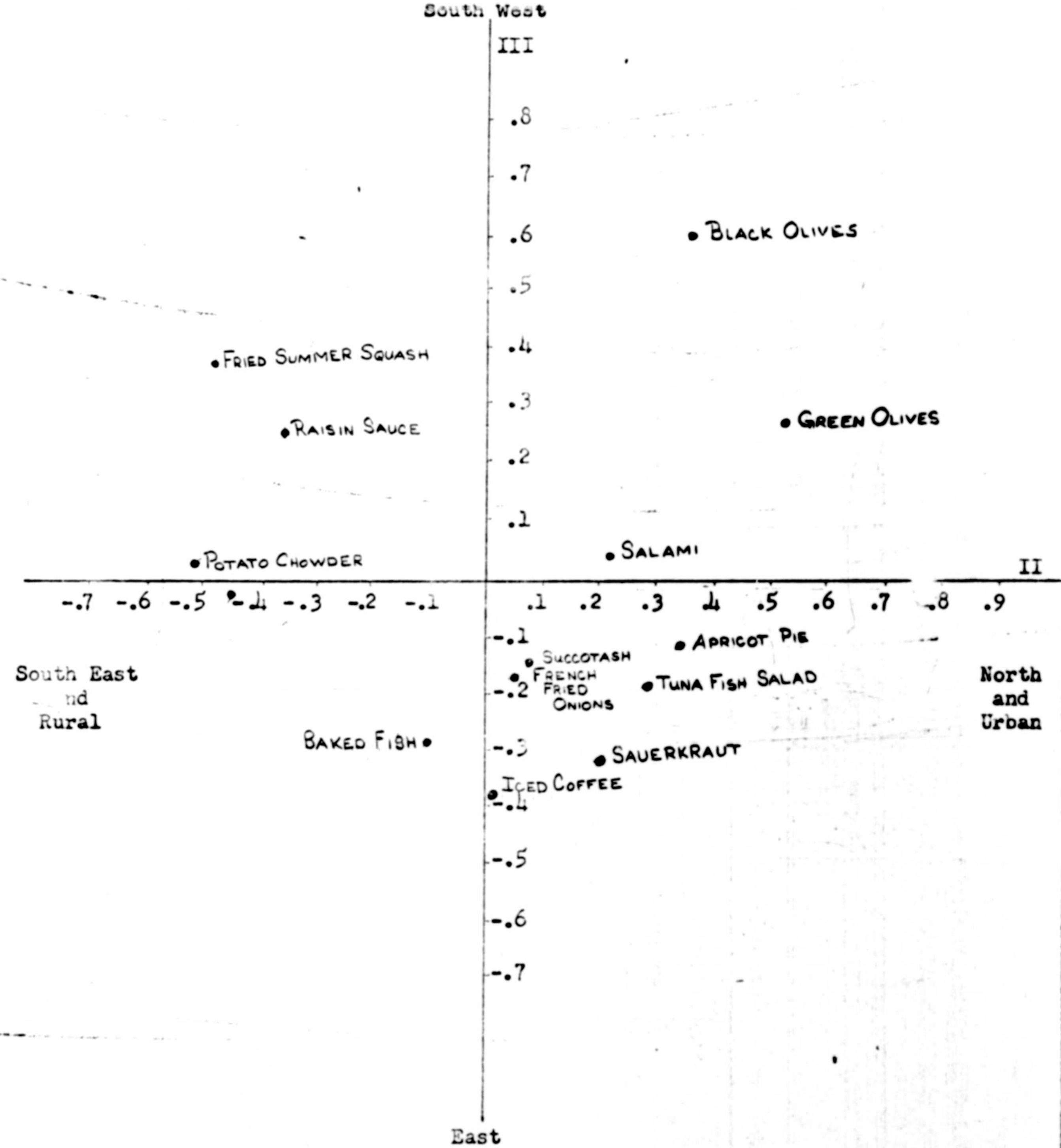

Table 1

Composition of the Sample According to Home of Respondent

	Groups		States	N
1	*Rural-Northwest		Nev. Colo. Wyo. Utah, Mont. Ore. Wash. Idaho	120
2	"	Southwest	Calif. N.M. Ariz. Tex. La. Okla. Ark.	120
3	"	Midwest	N.D. S.D. Min. Ill. Ind. Wis. Mich. Mo. Ia. Kans. Neb.	120
4	"	Southeast	Miss. Ala. Tenn. Fla. N.C. S.C. Va. Ga. Ky.	120
5	"	Northeast	O. Pa. N.Y. N.J. Del. W.Va. M.D. Me. Mass. N.H. V. R.I. Conn.	120
6	**Urban-Northwest			120
7	"	Southwest		120
8	"	Midwest		120
9	"	Southeast		120
10	"	Northeast		120
			Total	1200

* Rural = Farm, Non-farm country, Village (less than 2500 Pop.)

** Urban = City (more than 2500 Pop.)

Table 2

Mean Preference Scores for Selected Foods from Survey 006 ($x10^3$)

	Foods	Group 1 R-NW	2 R-SW	3 R-MW	4 R-SE	5 R-NE	6 U-NW	7 U-SW	8 U-MW	9 U-SE	10 U-NE
8	Iced Coffee	-752	-921	-612	-517	-354	-506	-713	-516	-631	-186
14	Baked Fish	-359	-844	-339	-281	-381	-[illegible]03	-448	-345	-363	-445
16	Succotash	-140	-399	-228	-490	-015	-212	-340	-266	-080	-113
18	Potato Chowder	231	240	165	180	081	001	-199	-305	055	-202
25	Black Olives	-333	-113	-559	-700	-469	-128	059	-089	-358	-360
31	Fried Sweet Potatoes	435	706	194	1033	495	408	547	227	729	318
32	Tuna Fish Salad	263	091	110	293	260	433	370	407	495	344
39	Fried Summer Squash	-311	-002	-213	-119	-225	-420	-111	-431	-044	-484
41	Sauerkraut	151	-061	152	-080	178	191	-229	134	-033	198
43	Green Olives	-132	227	162	-196	130	164	417	403	215	170
44	Apricot Pie	638	483	610	478	438	385	512	417	239	438
45	Salami	225	209	197	-050	-038	083	069	214	-107	201
46	Raisin Sauce	-018	037	-024	-094	-228	-388	-230	-167	-281	-420
50	French Fried Onions	-059	130	240	229	020	038	110	046	054	373
	Discriminal Variance for Groups	875	810	893	813	915	909	865	901	879	891

Table 3

Coefficients of Discriminant Functions,
and Per Cent of Variance Accounted for by Each

	Group	Discriminant Function I	II	III
	Rural			
1	NW	.3674	-.1151	-.0760
2	SW	.4642	-.2128	.6850
3	MW	.3268	-.0077	-.1617
4	SE	.4454	-.6583	-.3398
5	NE	.3036	-.0257	-.2815
	Urban			
6	NW	.3036	.2966	-.1849
7	SW	.3737	.2657	.4781
8	MW	.2982	.5579	.0432
9	SE	.3629	-.1109	.0096
10	NE	.3056	.4205	-.4562
		79%	7%	6%
			Total	92%

Table 4

Component Scores for Selected Food from Survey 006

	Food	Component I	Component II	Component III
8	Iced Coffee	-2.101	.001	-.390
14	Baked Fish	-1.505	-.100	-.285
16	Succotash	-.868	.085	-.139
18	Potato Chowder	.148	-.513	.021
25	Black Olives	-1.095	.356	.617
31	Fried Sweet Potatoes	1.919	-.449	-.020
32	Tuna Fish Salad	1.060	.293	-.186
39	Fried Summer Squash	-.768	-.471	.387
41	Sauerkraut	.189	.201	-.330
43	Green Olives	.518	.523	.280
44	Apricot Pie	1.657	.134	-.108
45	Salami	.348	.220	.056
46	Rasin Sauce	-.592	-.353	.269
50	French Fried Onions	.425	.043	-.151