Reprinted from *J. Food Sci.*
47(5): 1738-1740 & 1742

R83-04

A Research Note

The Standard Scales of Texture: Rescaling by Magnitude Estimation

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ABSTRACT

Food items comprising the six "standard scales" of texture [Szczesniak et al., J. Food Sci. 28: 397 (1963)] were rescaled using the psychophysical method of modulus-free magnitude estimation. The category scale position of each food item on the standard scales was plotted against the geometric mean magnitude estimate for that item. The category (interval) scale data were concave downward relative to the magnitude (ratio) scale data. These results underscore the differences that can be obtained by using either interval or ratio procedures and suggest that the attributes of "hardness," "chewiness," "fracturability," "viscosity," "gumminess," and "adhesiveness" can be classified as "prothetic" continua.

INTRODUCTION

IN THE GERMINAL STUDIES by Szczesniak and her co-workers (Szczesniak, 1963; Szczesniak et al., 1963; Brandt et al., 1963) in developing a standardized methodology for evaluating the sensory texture of foods, a series of six "standard scales" were published. These scales consist of a variety of commercial food items that represent an ordered intensity series for the mechanical attributes of hardness, brittleness (fracturability), chewiness, gumminess, adhesiveness, and viscosity. The development of the scales was conducted so as to insure that the distances between points on the scales were perceptually equivalent (Szczesniak et al., 1963). Only in the case of the chewiness scale was it impossible to identify food items with equivalent perceptual distances. Thus, five of the six standard scales represent equal-interval scales of texture.

Since the development of the "standard scales," they have been used effectively for training panelists in the texture profile method. As pointed out by Civille and Liska (1974) and Civille and Szczesniak (1973), the scales allow establishment of a common frame of reference for panelists. In addition, good correlations have been obtained with instrumental measures (General Foods Texturometer) of the food items comprising the scales (Szczesniak et al., 1963).

With the advent of ratio scaling techniques for direct estimation of apparent magnitude and their subsequent application in the food industry, focus has been placed on integrating ratio scale methods of measuring intensity with the basic texture profile method (Moskowitz and Kapsalis, 1975).

Previous research on a wide variety of perceptual continua have shown category (interval) scale data to be nonlinearly related to ratio scale data (Stevens and Galanter, 1957). Specifically, interval scales produce data that are concave downward relative to ratio scales on continua such as brightness, loudness, and sweetness; whereas on other continua, such as tonal pitch and hue, interval scales produce data that are linearly related to ratio scales. This difference has led to the distinction between two types of sensory continua – prothetic and metathetic. Prothetic continua, such as brightness, loudness, and sweetness are defined as those "for which discrimination appears to be based on an additive mechanism by which excitation is added to excitation at the physiological level," while metathetic continua, such as tonal pitch and hue, are defined as those "for which discrimination behaves as though based on a substitutive mechanism at the physiological level," (Stevens and Galanter, 1957). Interval scales are nonlinearly related to ratio scales on prothetic continua, because the former scales require judgments of equal sensory intervals or differences. Since sensitivity to differences varies over the stimulus range on prothetic continua (being poorer at higher intensities), the interval scale data are concave downward relative to ratio scale data. In contrast, sensitivity to differences is constant along methathetic continua, resulting in linearity of the two scales.

In order to establish ratio scale analogues to the "standard scales" and to compare them with one another, food items comprising the six standard scales were scaled using the method of magnitude estimation.

MATERIALS & METHODS

COMPLETE DETAILS of the materials and methods can be found in Cardello et al., (1982). The major aspects are summarized here.

Subjects

The panel consisted of 20 employees of the U.S. Army Natick Laboratories. All panelists had had extensive experience in the use of the psychophysical method of magnitude estimation. Eight of the panelists had served previously on a texture profile panel, twelve had not.

Test items

Test items consisted of the food items comprising the standard scales of hardness, chewiness, gumminess, viscosity, adhesiveness, and fracturability (Szczesniak et al., 1963). Due to the nonavailability of some of the food items on these scales, some substitutions of items were made. Although the complete list, with substitutions, can be found in Cardello et al., (1982), only those items that were identical, or nearly so, to those on the standard scales (Szczesniak et al., 1963) were used inthe present analysis. These items and their numerical category positions on the standard scales are presented in Table 1.

Procedure

Six sessions were conducted, one for each of the six standard scales. At the start of each session panelists were given written instructions. The instructions included both an operational definition of the attribute to be judged as well as instructions on the use of magnitude estimation. Attribute definitions paralleled those described by Szczesniak et al. (1963).

All samples were presented individually to panelists and in random order. Panelists rated each sample using the method of modulus-free magnitude estimation. Each sample was judged once. Panelists rinsed with distilled water between samples and a 90-second interstimulus interval was maintained.

Data analysis

The data were analyzed by normalizing the magnitude estimates to account for panelist to panelist variability in the range of num-

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Table 1—Food items for the "Standard Scales" used to rescale by magnitude estimation

Scale attribute and category position	Product	Brand, type or preparation	Manufacturer	Sample size	Temp
HARDNESS:					
1	Cream Cheese	Philadelphia	Kraft Foods	½" cube	45–55°F
2	Egg White	hard-cooked 5-min.		½" cube	room
3	Frankfurters	large, uncooked	Hebrew Nat'l	½" slice	50–65°F
4	Cheese	yellow, American, pasteurized process	Kraft Foods	½" cube	50–65°F
5	Olives	Spanish, stuffed	Durkee Famous Foods	1 olive, cut placed back to back	room
6	Peanuts	cocktail type in vacuum tin	Planters Peanuts	1 nut	room
8	Peanut Brittle	candy part	Kraft Foods	½" square	room
VISCOSITY:					
1	Water	distilled		½ tsp	45–55°F
2	Light cream	Sealtest	Sealtest Foods	½ tsp	45–55°F
3	Heavy cream	Sealtest	Sealtest Foods	½ tsp	45–55°F
4	Evaporated milk		Carnation Co.	½ tsp	45–55°F
5	Maple Syrup	Vermont Maid	R.J. Reynolds Foods	½ tsp	45–55°F
6	Chocolate Syrup		Hershey Chocolate Corp.	½ tsp	45–55°F
7*	Mixture: 1½ cup condensed milk & 1 tbl heavy cream		Borden Foods	½ tsp	45–55°F
8	Condensed milk		Borden Foods	½ tsp	45–55°F
ADHESIVENESS:					
1	Hydrogenated vegetable oil	Crisco	Proctor & Gamble Co.	½ tsp	45–55°F
3	Cream Cheese	Philadelphia	Kraft Foods	½" cube	45–55°F
4	Marshmallow topping	Fluff	Durkee-Mower	½ tsp	45–55°F
5	Peanut Butter	Skipp, smooth	Best Foods	½ tsp	45–55°F
CHEWINESS:					
1	Rye bread	fresh, center cut	Arnold's Baking Co.	½" cube	room
2	Frankfurter	large, uncooked skinless	Hebrew National	½" slice	50–70°F
3*	Cherry Red candy	Switzer Licorice	Beatrice Foods Co.	1 piece	room
5	Black Crows candy		Mason Candy Co.	1 piece	room
7	Tootsie rolls	midget size	Sweets Co. of America	1 piece	room
GUMMINESS:					
1	40% flour paste	Gold Medal	General Mills	1 tbs.	room
2	45% flour paste	Gold Medal	General Mills	1 tbs.	room
3	50% flour paste	Gold Medal	General Mills	1 tbs.	room
4	55% flour paste	Gold Medal	General Mills	1 tbs.	room
5	60% flour paste	Gold Medal	General Mills	1 tbs.	room
FRACTURABILITY:					
1	Corn muffin	Finast	First Nat'l Stores	½" cube	room
3	Graham crackers	Nabisco	National Biscuit Co.	½" square	room
4	Melba Toast		Devonsheer Melba Corp.	½" square	room
6	Ginger snaps	Nabisco	National Biscuit Co.	½" square	room
7	Peanut brittle	candy part	Kraft Foods	½" square	room

* Substitute item. **Reference:** G. V. Civille, Course material, **Texture Profiling**, Center for Professional Advancement, East Brunswick, NJ, November 1977.

bers that were used. The method of normalization was that outlined in Stevens (1971). The geometric mean of the normalized magnitude estimates was calculated across subjects for each food item. The geometric mean was used, because magnitude estimates have been shown to be log-normally distributed (see Stevens, 1971).

RESULTS

FIG. 1 shows the obtained data plotted separately for each of the six standard scales. The geometric means of the magnitude estimates for the food items are plotted on the abscissa. The category scale positions associated with these food items (taken from the standard scales) are plotted on the ordinates.

In each graph the interval scale ratings are concave downward relative to the ratio scale ratings. These results are consistent with previous research showing nonlinearity between category and ratio scale data on prothetic continua (Stevens and Galanter, 1957).

DISCUSSION

ONE OF THE CLASSICAL CONTROVERSIES in psychophysics for the past quarter of a century has concerned the relative validity and usefulness of interval versus ratio scales of intensity. Both the questions of validity and usefullness have been addressed numerous times without final resolution (Stevens, 1957; Moskowitz et al., 1972; Moskowitz and Sidel, 1971; Pangborn, 1979). It seems clear at this juncture that both scale types can be used effectively to address problems of concern to the food scientist. However, the data presented here reinforce the concern that the two scale types do not provide identical information.

As concerns the "standard scales" of texture, these data do not detract from their usefullness for training texture profile panels and for establishing a common frame of reference among members of the panel. However, they do suggest that exclusive application of interval scales to prob-

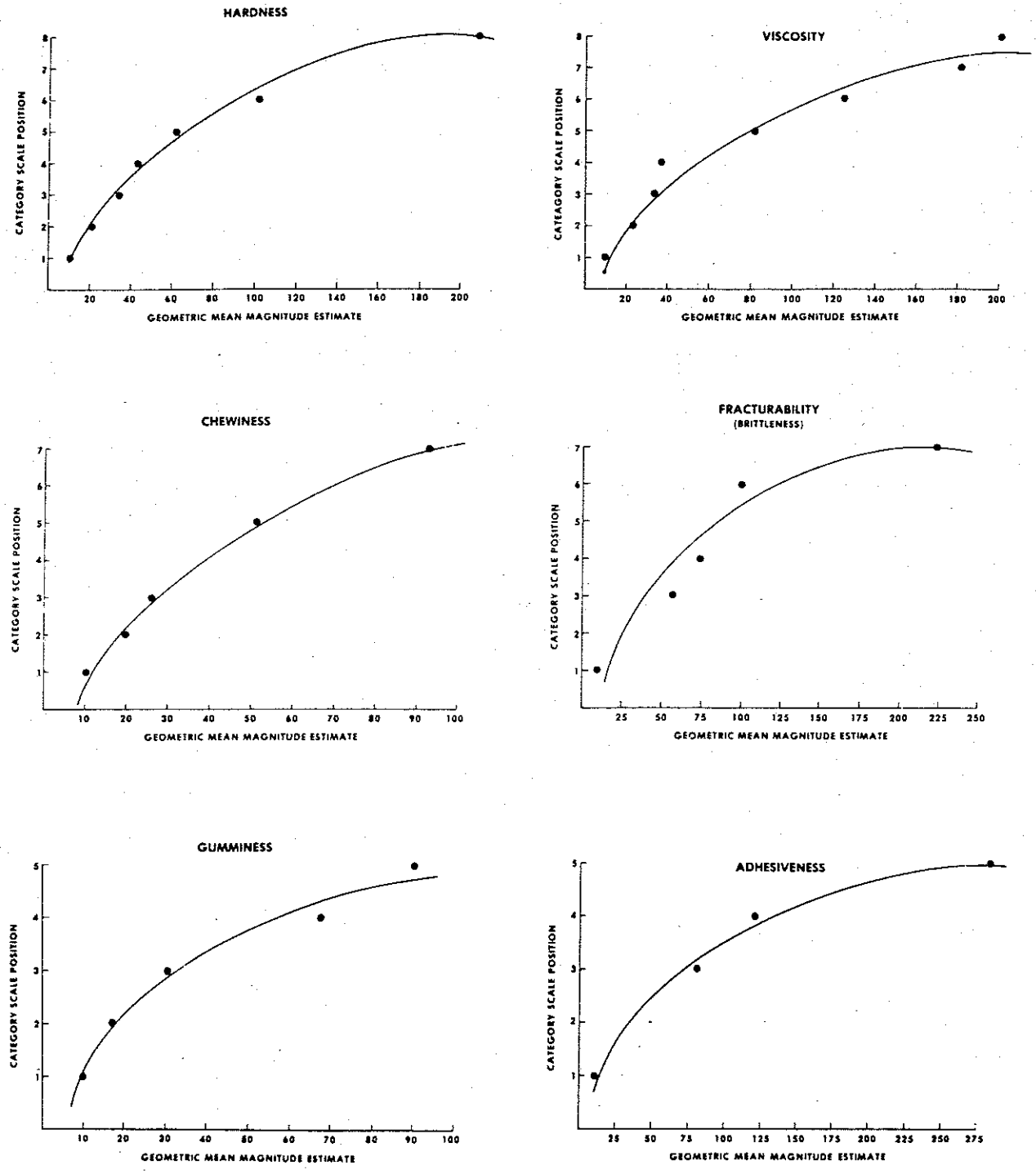

Fig. 1—Plots of the category scale position for each of the food items on the "standard scales" of texture (Szczesniak et al., 1963) as a function of the geometric mean magnitude estimates for the same food items and attributes.

lems of food texture will lead to conclusions that are at odds with conclusions drawn from data collected via ratio scaling procedures.

On the issue of prothetic vs metathetic continua, these data support the notion that "hardness," "chewiness," "fracturability," "viscosity," "gumminess," and "adhesiveness" are all prothetic continua, and therefore, that discrimination among levels of intensity of these attributes is greater at the lower end of the scale (Stevens and Galanter, 1957). It should, of course, be kept in mind, that the food items that were tested possessed other sensory attributes than the one that was judged, and these other attributes may have had some effect on the perception of the attribute in question. However, the striking curvilinearities in Fig. 1 suggest that the relationships are robust. Whether the geometrical textural attributes, e.g., coarseness, fibrousness, etc., would exhibit the same relationship remains to be established.

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Ms received 5/21/82; accepted 5/24/82.