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TO OBJECTIVE FREQUENCY COUNTS

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SUMMARY

A sample of 50 words taken from an American frequency count was used in obtaining subjective estimates of the following attributes: subjective frequency (SF), familiarity (F), associability (A), pronunciability (P), and comprehensibility (C). The last mentioned attribute had hitherto not been reported as scaleable with words presented in singelitem form. The results showed among other things that all attributes, except A, were reliable and highly intercorrelated and an ANOVA also separated A from the other. Correlations with objective frequency counts, one American and two Swedish, were highest for SF, F, and P. Comprehensibility was judged to be a scaleable attribute according to the method used (magnitude estimation). This attribute seems, however, to measure something slightly different from what the other attributes do. Some hypotheses for this are finally formulated.

INTRODUCTION

Some later studies have shown that subjective estimations with success can be used to scale word frequency. Carroll (1971) and Shapiro (1969) found a correlation exceeding .90 between subjective and objective frequency when both variables were expressed in logarithmic form. They also found, as did earlier Underwood (1969), that the relation between subjective estimates of word frequency and objective frequency counts could be described with a power function when the method of magnitude estimation was used.

A large number of experiments in verbal learning, however, have shown that verbal items can be characterized by several different attributes. Some of these attributes seem in some cases to be nearly identical (for a general overview see e.g. Hall 1971). One purpose of this report is to study the relationship between subjective word frequency and some of the most common word attributes namely, familiarity, associability and pronunciability, all measured with the method of magnitude estimation.

Another purpose is to study how individuals

scale words in terms of comprehensibility and at the same time how this dimension is related to the other attributes and objective frequency. Comprehension is one of the most common dependent variables in reading research and also seems to be related to objective frequency. Lorge (1949) reported the correlation .51 between word frequency and comprehension while Bormuth (1966) found curvilinearity between them. His coefficient was .66 after correction. Schwartz, Sparkman & Deese (1970) report positive correlations between ratings (seven point scale) of comprehensibility of sentences and the Flesch Count Index. Recently Marks, Doctorow & Wittrock (1974) have shown a significant rise in comprehension when 15 % of the words in a text were exchanged for high frequency words. A closely related attribute, defineability, is thought to be directly related to "... knowledge of what the word refers to." and has been studied by O'Neill (1972). This attribute was found to be scaleable (seven point rating-scale). Comprehensibility has, however, not yet been reported as a scaleable dimension.

PROCEDURE

Verbal material

Stimuli consisted of 50 different words taken from Shapiro's (1969) material. These words were also used as stimuli in Carroll's (1971) study. Shapiro's original choice, which consisted of 60 words, was taken from Thorndike-Lorge's (1944) and K^Vucera-Francis' (1967) frequency counts. Ten of the original words were not used here due to problems of translation. The words were chosen so that they represented a wide range of frequencies and the values are given in Table I. Three different word frequency counts, one American and two Swedish were chosen for objective data. The American frequency count done by Thorndike-Lorge and K^Vucera-Francis were, however, transformed to a standard measure proposed by Carroll (1970). This index is termed the Standard Frequency Index (SFI) and is computed according to the formula $SFI = 10 (\log_{10} f + 4)$ where f indicates frequencies/million. The median value in SFI in the Thorndike-Lorge frequency count is around 68. The first and the third quartile lie at 50 and 80 respectively and the variation width is from 35 to 90 , each unit increment corresponding to an increase of about 25.9 % in frequency. The SFI values for the

different words are given in the second column of Table I. The Swedish frequency criteria were done by Allén (1970 , 1971.) and by Hassler-Göransson (1966). Corresponding logarithmic transformations were done for these as well as for the American frequency count. The transformations followed according to the formula for Allén: $(\underline{AL}) = 10(\log_{10} f_{AL} + 4)$ and for Hassler-Göransson: $(\underline{HG}) = 10(\log_{10} f_{HG} + 4)$. In the last mentioned case data from Hassler-Göransson's five separate studies were put together in order to give a broader representativeness.

Subjects

One hundred subjects consisting of students at Umeå Teachers College were randomly distributed in 5 groups, 20 students in each group; one group for each attribute.

Method

The estimations of the different attributes were made by Stevens' (1951) method of magnitude estimation. The same word was standard in every attribute, and was given the numerical value of 100. The words which were to be estimated were given in the same order to all groups. This procedure was used because Carroll (1971) has shown that differences in the first variable stimulus in a magnitude estimation task with verbal material did

not have any significant effects on subsequent judgments. The instructions were read out loud for every group and were followed by some examples. Below the specific instructions are given.

Frequency: *"You are now taking part in an experiment where you are asked to estimate degree of occurrence of different words in the written language, that is to say how often different words occur in written form."*

Familiarity: *"... estimate different degrees of word familiarity that is to say how often you have come in contact with the different words."*

Pronunciability: *"... estimate the degree of pronunciability of different words that is to say how easy or difficult the different words are to pronounce."*

Associability: *"... estimate the degree of associability of different words that is to say how few or how many associations the different words give."*

Comprehensibility: *"... estimate degree of comprehensibility of different words, that is to say how easy or difficult it is to comprehend*

different words."

In the remaining sections the following abbreviations for the different dimensions are used: Objective Frequency (OF), Subjective Frequency (SF), Familiarity (F), Pronunciability (P), Associability (A), and Comprehensibility (C).

All the words were presented on a A4 page. The subjects noted their estimations for every word in the indicated space to the right of the word. They were not allowed to correct responses already given.

RESULTS

Logarithmic estimation values for the different words in the five judgement dimensions are given in Table I. The words are arranged according to their

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Insert Table I about here

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ascending SFI-values. Table II gives reliabilities according to different criteria for the attributes when individual estimates were transformed to z-values. The reliability values have been computed with the help of Ebel's method (1951), and it appears that the dimensions SF, F, and P show the highest coefficients and have pronounced deviation from C

and A. A difference test between the reliability coefficients (Fisher's test) gives significance between A and the other dimensions, except C. The smallest difference (P-A) gives $t(94) = 2,35$, $p < .05$. The mean square errors for the different attributes give, in all cases, significant differences and the smallest

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Insert Table II about here

---

difference was found again between SF and F, ($931, 931) = 1,25$, $p < .01$). Standard errors of measurement have been computed as the root mean square errors, which are then transformed to SFI standards to make comparisons possible with Carrolls (1971) American data. This transformation was made with the assumption that the correlation between the z-values and the SFI-values is perfect. Carroll reports the approximate value of 6 ± 1 (depending on the sample) and SF together with F show good comparability with Carroll's data.

Reliabilities based on the means of the z-values are given in Table III. The expressions in the topmost row has been computed according to Ebel (1951). The standard error of measurement has been calculated in the conventional way from the formula $SE = \sigma_z \sqrt{1 - \underline{r}}$.

where $\sigma_{\underline{z}} = \underline{s}$ for obtained means in $\underline{z}$ for different

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Insert Table III about here

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words. The highest degree of precision can in these different cases be noted again for the attributes SF and F. These dimensions in addition to $\underline{P}$ do not deviate markedly from Carroll's data.

The interrelations between the different dimensions have been expressed in correlation coefficients (product-moment) in Table IV. Very high values were obtained for $\underline{SF}$ and $\underline{F}$ (.95), which also show high correlations with $\underline{P}$ (.82 and .85 respectively) and $\underline{C}$ (.65 and .76 respectively). Associability does not seem to be related to any of the other dimensions.

Insert Table IV about here

To test the difference between the attributes an ANOVA was tried. The difference was significant $F(4, 240) = 11.32, p < .001$. Contrast tests with Newman-Keul's method proved that $\underline{A}$ was separate from the other dimensions ($p < .01$). The other dimensions were not significantly different.

Table V shows log-log correlations between the subjective attributes and the three types of objective frequency counts. The way of computing the SFI values has been showed above and corresponding logarithmic transformations were done according to the Swedish counts. Some of the words used are not found in the Swedish counts, therefor the calculations in Table V are based on $N = 37$ for HG and $N = 39$ for AL. Corresponding calculations have been made for SFI in order to permit adequate comparisons. As can be seen from Table V, SF correlates high with OF irrespective of whether the objective count is Swedish or American. None of the pairwise differences among the coefficients .943, .925, .924, .921 and .917 is significant ($t < 1$ with Fisher transformations). F and P also show a high correlation with objective measures, though lower than SF. C seems to be moderately related to SFT based on 49 words, and not at all to HG or AL.

Insert Table V about here

To test the linearity in the correlations an ANOVA was made for every attribute and frequency count. Curvilinearity could be proved for the attribute A and HG's frequency count, where $F(29,6) = 7,32$, $p < .01$. C is

completely unsystematically related to HG and even to AL, but significantly linear to SFI. The other correlations between subjective attributes and objective frequency counts are significantly linear.

The received data permits the computation of psychophysical functions between subjective and objective measures. Provided that the power function is applicable the exponent n in the function $SF = k \cdot OF^n$ can be computed. This function in logarithmic form gives $\log SF = \log k + n \log OF$, where SF = subjective judgement of frequency, k = constant of measurement and OF = objective frequency. The exponent n states as known how subjective estimations grow as a function of objective

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Insert Table VI about here

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frequencies. The exponents for SF are 0.43, 0.44, and 0.35 where objective data are represented by SFI, HG and AL respectively. The fitting of a straight line to

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Insert Figure 1 about here

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the data appears in Figure 1 for SFI. This figure fairly well demonstrates the linear trend also found in the

Swedish counts. Deviations from a straight line are most marked at the lowest frequencies which is expected. Objective frequency counts are here particularly subject to bias in sampling. The differences between the three counts in different dimensions are low. None of the differences exceeds the value 0.12, as can be seen in Table VI.

DISCUSSION

The reliability data for the attribute subjective frequency which are here reported are in good correspondance with Carroll's (1971). Of the two groups Carroll uses as subjects - lexicographers and "other adults" - the least mentioned is more adequate comparison to the subjects used here. This comparison results in higher precision values throughout for the present group. Subjective frequency thus again appears as a reliable attribute and is also highly correlated with objective counts ($>.92$).

The attribute familiarity shows on the whole similar reliabilities as the attribute subjective frequency, and they seem to be closely related ($\underline{r} = .95$). Even if objective frequency is partialled out the correlation is considerable: $\underline{r} = .76$. This relation has been known for a long time ago and Noble

(1954) has even stated that rated familiarity is almost uniquely determined by frequency.

The interdimensional analysis shows what other experiments with different techniques, verbal stimuli and subjects have shown, namely that various verbal attributes are highly correlated. The ANOVA does not separate the dimensions frequency, familiarity, pronounceability and comprehensibility. The same psychological correlate seems to lie behind comprehensibility too. Reliability data for the latter one are, however, somewhat lower than for the other attributes, except associability, but still acceptable at group level (.91). Comprehensibility differs from the other attributes with respect to the relation to objective frequency. It does not covary with any of the three frequency counts ($r \approx 0$, except for the SFI count based on 49 words). This is contrary to the general conception that more frequent words are easier to comprehend. Klare (1968) formulates an opposite point of view: high frequency words have larger number of meanings and therefore might cause interferences and thus render them less comprehensible. Klare thus predicts an inverse relation between comprehensibility and objective frequency. The present result supports none of these predictions. If one

however, makes a distinction between content words (nouns, verbs, adjectives and adverbs) and function words (pronouns, conjunctions, prepositions and the like) a correlation of $r = .51$, $t(32) = 3.75$, $p < .001$, can be calculated between content words and objective frequency. This positive relation has earlier been demonstrated by Coleman (1971) working on sentence level. The results do not support Elley (1969) who reports a readability index which is based upon counting only the number of nouns in a written discourse. The nouns are considered to be the least redundant elements in a text. The present data gives a correlation of .25 between the nouns in SFI and comprehensibility. This is not significant: $t(16) = 1.03$, $p > .10$.

If a grouping of the coefficients is done according to size one can discern a cluster consisting of subjective frequency, familiarity and pronunciability. These three attributes are also highly correlated with objective frequency. Together they form a cluster which can be predicted from Paivio's (1971) theoretical distinction between higher order and lower order meaning. This cluster reflects the lower representational meaning, and has to do with the availability of verbal processes. Comprehensibility on the other hand can be assumed to be

linked to higher-order referential meaning, which evokes reactions, implicit or explicit, that are referential or denotative in nature. Comprehensibility does not enter into the cluster but ought, according to Paivio, to be positively correlated with the other attributes, because knowledge of what a word denotes may be a mediating process for the other attributes. This predicted correlational pattern shows up here (Associability is ignored owing to irreliability).

In conclusion, comprehension seems to be a scaleable attribute of words with an acceptable reliability. The scaling should, however, be restricted to content words, in which case the attribute seems to be related to higher-order referential meaning.

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Some Common

Footnote

The author is indebted to Sture Allén for commenting on an earlier version of this paper.

Table I

SFI values and log values for the different subjective attributes.

Word	<u>SFI</u>	<u>SF</u>	<u>F</u>	<u>P</u>	<u>A</u>	<u>C</u>
AV	85.8	3.1128	2.5100	2.5574	1.4785	1.9325
OCH	84.5	3.4430	2.9781	2.4465	1.1137	2.3296
DET	80.2	3.4217	2.8590	2.5541	1.5009	2.0237
SOM	78.5	3.2082	2.8717	2.4661	1.3143	1.9892
GENOM	77.2	2.6790	2.3417	2.0722	1.6556	2.0104
DU	75.1	3.0225	2.9415	2.5751	1.9257	2.4515
NÄR	73.6	2.9348	2.6488	2.4734	1.5763	2.0564
ANDRA	72.2	2.6270	2.2516	2.0636	1.7073	2.0923
EFTER	70.2	2.9018	2.3572	2.0953	1.5530	2.1664
VARJE	69.4	2.6638	2.3438	2.0872	1.4879	2.2043
NÄGRA	67.7	2.9214	2.3706	1.9757	1.5504	2.1186
IGEN	67.6	2.6498	2.4555	2.0853	1.4673	2.2079
NATT	66.1	2.4496	2.2870	2.2909	2.0994	2.4850
NÄSTA	65.9	2.5270	2.2485	2.1037	1.6810	2.1374
TIDIGT	65.6	2.4624	2.3011	2.0097	1.6891	2.1376
HALV	64.3	2.4462	2.4074	2.1762	1.6810	2.2419
RESULTAT	63.8	2.3153	2.1242	1.9466	1.9493	2.1131
SLUT	61.9	2.5542	2.3850	2.2519	1.7906	2.4091
LISTA	61.2	2.0995	2.0353	1.9730	1.7004	2.2082
PAR	60.8	2.3796	2.0975	2.4477	1.6643	2.2001

Table I

cont.

Word	<u>SFI</u>	<u>SF</u>	<u>F</u>	<u>P</u>	<u>A</u>	<u>C</u>
PRIS	60.3	2.4896	2.3254	2.2044	1.9821	2.0601
VERKLIG	60.0	2.3649	2.0640	1.9121	1.8450	2.0976
ADRESS	58.8	2.4577	2.3303	2.0255	1.9696	2.3211
SKALA	57.7	1.9669	1.9299	2.0286	1.7772	1.9738
HUMOR	56.6	2.1157	2.0924	2.0174	2.0365	2.1464
SNABB	56.3	2.4566	2.1747	2.0900	1.8796	2.2246
OFFER	55.6	2.1864	1.7350	2.0068	1.9332	2.0169
ANKARE	54.1	1.7880	1.7874	1.9118	1.7687	2.1974
FÖRVANDLA	54.0	2.1694	1.9234	1.8871	1.8889	2.0937
KONTRAKT	53.0	1.8402	1.8659	1.8822	1.6888	1.8459
KLIVA	52.6	1.9927	1.9626	2.0954	1.7072	2.0861
VÄXLA	51.8	2.1987	2.1299	1.9477	1.7643	2.1209
VULKAN	51.5	1.6638	1.7582	1.9875	1.8980	2.2231
ARV	49.0	2.0256	1.7883	2.1956	1.8289	2.0304
SUPP	49.0	1.5104	1.4285	1.6879	1.6058	1.4754
SKRÄMYTS- LING	48.5	1.1788	0.8350	1.4602	1.3831	1.5196
KLOSTER	47.8	1.5249	1.7127	1.8892	1.7798	2.2416
SKILJAKTIG	46.0	1.8679	1.6561	1.7025	1.5268	1.8758
DUNS	46.0	1.9020	1.7709	2.1690	1.6719	2.0514
KYRKOHERDE	44.8	1.7212	1.8657	1.8690	1.6658	2.2394
SKÄNKEL	43.0	1.0042	1.4394	1.7638	1.2472	1.6130
UPPIETTA	43.0	1.9055	1.7876	1.9263	1.6909	2.2384
KRYPTISK	40.0	1.1595	1.1119	1.6115	1.1856	1.0685
VETERINÄR	40.0	1.8564	1.8359	1.7832	1.7489	2.2657

Table I

cont.

Word	<u>SFI</u>	<u>SF</u>	<u>F</u>	<u>P</u>	<u>A</u>	<u>C</u>
MODULERA	39.8	1.4803	1.4048	1.8232	1.4791	1.7580
DREGLA	39.8	1.5599	1.7122	1.8666	1.5874	2.0227
ENLEVERA	38.9	1,3843	0.9444	1.5610	1.2787	1.4498
DVALA	38.9	1.6042	1.6419	1.8776	1.6788	1.9471
OKULÄR	37.9	1.0565	0.8477	1.7951	1.1168	1.0056

Table II

Reliabilities, mean square errors and standard errors of measurement for individual estimates.

Individual					
<u>z</u> -scores for	<u>SF</u>	<u>F</u>	<u>P</u>	<u>A</u>	<u>C</u>
words					

Reliability	.770	.714	.616	.252	.370
Mean square error	.235	.293	.392	.764	.643
Standard error of					
measurement (<u>z</u>)	.484	.541	.626	.878	.802
Standard error of					
measurement (<u>SFI</u>)	6.24	6.97	8.07	11.26	10.33

Table III

Reliabilities, standard deviations and standard errors
of measurement for averaged estimates.

Averaged <u>z</u> -scores	<u>SF</u>	<u>F</u>	<u>P</u>	<u>A</u>	<u>C</u>
Reliability	.985	.980	.970	.858	.909
σ_z	.884	.853	.800	.542	.638
Standard error of measurement (<u>SFI</u> -units)	1.56	1.81	2.24	4.85	3.88

Table IV

Correlations (product-moment) between the different dimensions of judgment.

	<u>SF</u>	<u>F</u>	<u>P</u>	<u>A</u>	<u>C</u>
<u>SF</u>		.953	.818	.095	.654
<u>F</u>			.848	.117	.759
<u>P</u>				.207	.061
<u>A</u>					.158

Table V

Correlations (product moment) between subjective judgments and objective frequency counts. (Number of words in brackets).

<u>OF</u>	<u>SFI</u> (49)	<u>SFI</u> (39)	<u>AL</u> (39)	<u>SFI</u> (37)	<u>HG</u> (37)
<u>SF</u>	.925	.921	.917	.924	.943
<u>F</u>	.870	.882	.825	.876	.903
<u>P</u>	.781	.726	.687	.743	.786
<u>A</u>	.045	-.480	-.559	-.507	-.615
<u>C</u>	.458	.038	.093	.027	-.075

Table VI

Exponents for the psychophysical relations between
subjective judgments and objective frequency.

<u>OF</u>	<u>SFI</u>	<u>AL</u>	<u>HG</u>
<u>SF</u>	0.43	0.35	0.44
<u>E</u>	0.34	0.23	0.27
<u>P</u>	0.16	0.12	0.15
<u>A</u>	0.01	-0.09	-0.11
<u>C</u>	0.11	-0.01	0.01

Some Common

Figure

Figure 1. Subjective frequency as a function of objective frequency in logarithmic SFI-units.

LOG SUBJECTIVE FREQUENCY

2

3

LOG OBJECTIVE FREQUENCY
(SF 1 / 10)

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