WORD COMPREHENSION AS FUNCTION OF SYNTACTIC CATEGORY OF CONTENT WORDS

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ABSTRACT

One hundred subjects rated words of the category content words (nouns, verbs, adjectives and adverbs). One half of the group rated comprehensibility, the other half subjective frequency. The rating technique was Thurstone's paired comparisons. The results were in good agreement with a previous investigation as regards the relation comprehension - objective frequency. The comprehension ratings did not co-vary with subjective frequency and underlines their status as a higher-order variable. A linguistic prediction about the unclear position of adjectives and adverbs as syntactic categories was supported. An interactive relation between nouns and verbs and relations to objective frequency were explained by the difference in context dependency and accessibility of entries in semantic memory.

*) This research has been supported by The Swedish Council for Social Research.
Recent research on word comprehension and semantic memory shows an increasing interest in the use of modern scaling techniques. Subjective estimates, in many cases a proximity measure, have been the starting-point for setting up semantic structures or semantic spaces. Knowledge of individual, subjective lexicons regarding, for example, distances between words have then also been used successfully to predict various kinds of language behavior (see e.g. Smith, Shoben & Rips, 1974; Rumelhart & Abrahamson, 1973; Caramazza, Hersh & Torgerson, 1976).

A new variable was recently tested as regards scaling techniques in order to elucidate the organization of the internal lexicon of individuals (Backman, 1976 a). Test subjects were instructed to directly rate the comprehension of words with the aid of the method of magnitude estimation. The variable was found scaleable and probably related to the "referential meaning" of a higher order as understood by Paivio (1971). The ratings of comprehension, restricted to the so-called content words, could also be shown to be positively correlated with objective frequency. The aim of this report is to differentiate the syntactic categories in the group content words and analyse their effects on comprehension with the aid of scaling techniques.

The syntactic categories nouns, verbs, adjectives, and adverbs belong to the content words. Other categories are regarded as function words (prepositions, conjunctions, etc). According to earlier reports word comprehension (as an indicator of the readability of a text) co-varies with "content word ratio" (Gray & Leary, 1935). Perfetti (1969) points out the effects of lexical density (the quotient content words/ the total number of words) on the retention of sentences, but the generalizability of this study has, however, been questioned
More limited studies regarding syntactic categories have shown that the proportion of verbs in a body of text predicts comprehension (Coleman, 1965), that the number of adjectives is inversely related to comprehension, or that adverbs are O-correlated with reading comprehension (Coleman, 1971). Coleman often bases his observations on a fairly unconventional definition of content words and measures the dependent variable via the Cloze Technique - a dubious method (see e.g., Backman 1976 b). Elley (1969) has shown that the noun is the least redundant element in a clause and bases a readability index wholly on calculations of nouns. As for research carried out in Sweden it seems that, in conformity with Elley (1969), the noun occupies a place apart (Danielsson, 1975; Westman 1975). There is, however, no report on a concurrent differentiation and comparison between various syntactic categories of content words as regards comprehension.

There is, in modern linguistics, often doubtfulness in connection with the categories adjectives and adverbs. It is for example considered that adjectives should be classified as verbs (Jacobs & Rosenbaum, 1968 or Lyons, 1971). The adverbs are regarded as a very heterogeneous class and it is questioned whether they ought to make up a separate syntactic category at all (Lyons, 1971). Nouns and verbs seem, however, more syntactically unambiguous, even if both these classes sometimes get a large number of subgroups. It was, however, in a first exploratory experiment decided that all four categories in the group content words should be tested as regards comprehension for a possible verification of objections to prevalent syntax classifications.
METHOD

Subjects

Fifty secondary school students in grade 2 (the theoretical lines) served as subjects. They had never before taken part in experiments of this kind and they were not paid for their participation. The experiment was carried out during regular lessons. Another fifty subjects, also secondary school students, estimated the same words as the first group, but as regards subjective frequency. This was done as a check-up on a possible contamination in the ratings of the individuals.

Material and Procedure

Words were chosen from Allén's Nusvensk frekvensordbok (Frequency Dictionary of Present-Day Swedish, 1970; 1971) according to the following criteria: 1) every syntactic category should be represented on three different frequency levels and be approximately the same on every level. 2) the categories should on every level also be approximately the same as regards modified frequency. 3) the categories should be approximately the same regarding the number of letters. The modified frequency (F-mod) referred to in the second criterion has been included since it takes the variability of different words over the sources into consideration. This is not usual for so-called objective frequency calculations but it is probably a more correct measure. F-mod is based on an index which was originally introduced by Juillard & Chang-Rodriquez (1964) and is here determined according to the following formula:

\[ F_{\text{mod}} = F \left(1 - \frac{\text{SD}}{\sqrt{\frac{M}{N-1}}} \right) \]

F-mod indicates the theoretically corrected frequency, F stands for unmodified frequency, M for mean and N for the number of texts. SD signifies standard deviation.
calculated in the usual way.

Twenty-four words finally made up the test material. They are distributed on three different frequency levels where F reaches approximately 37(I), 82-83 (II) and 450-750 (III). Corresponding means for F-mod were calculated at 28.6, 70.1 and 555.5. The various categories are represented by two words on each frequency level and the total test material with the statistical characteristics belonging to it is presented in Table I.

The task of the subjects was to rate the words as regards comprehension. Thurstone's paired comparisons were used for this purpose and the various words were thus presented in all paired combinations in a randomized order. The task was to put a mark against that of the two words which was easiest to understand. The obtained proportions were transformed into angular deviates instead of normal ones, since the former require simpler mathematical calculations and since the prerequisite of constant sample size for all the pairs is satisfied. An observed proportion $P_{ij}$ is transformed into angular deviates according to the following function:

$$y_{ij} = 2 \sin^{-1} \left( P_{ij} - \frac{\pi}{2} \right)$$

The angular function does not deviate much from the normal one and very large samples are required to show a better goodness of fit for any of the models (see also Bock & Jones, 1968).
Table 1. Stimulus words in the experiment arranged according to part of speech, frequency (F), and modified frequency (F-mod)

<table>
<thead>
<tr>
<th>Word</th>
<th>Synt categ</th>
<th>F</th>
<th>F-mod</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grundval/Foundation</td>
<td>noun</td>
<td>37</td>
<td>29.69</td>
</tr>
<tr>
<td>Svaghet/Weakness</td>
<td>noun</td>
<td>37</td>
<td>31.76</td>
</tr>
<tr>
<td>Skända/Give</td>
<td>vb</td>
<td>37</td>
<td>28.11</td>
</tr>
<tr>
<td>Dirigera/Conduct</td>
<td>vb</td>
<td>37</td>
<td>28.75</td>
</tr>
<tr>
<td>Härlig/Glorious</td>
<td>adj</td>
<td>37</td>
<td>25.31</td>
</tr>
<tr>
<td>Abstrakt/Abstract</td>
<td>adj</td>
<td>37</td>
<td>25.31</td>
</tr>
<tr>
<td>Söderut/Southward</td>
<td>adv</td>
<td>37</td>
<td>27.22</td>
</tr>
<tr>
<td>Sönder/Broken</td>
<td>adv</td>
<td>35</td>
<td>30.43</td>
</tr>
<tr>
<td>Period/Period</td>
<td>noun</td>
<td>82</td>
<td>63.87</td>
</tr>
<tr>
<td>Tillvaro/Existence</td>
<td>noun</td>
<td>82</td>
<td>69.46</td>
</tr>
<tr>
<td>Upprepa/Repeat</td>
<td>vb</td>
<td>82</td>
<td>67.76</td>
</tr>
<tr>
<td>Rymma/Hold</td>
<td>vb</td>
<td>83</td>
<td>72.23</td>
</tr>
<tr>
<td>Sjuk/Ill</td>
<td>adj</td>
<td>82</td>
<td>71.48</td>
</tr>
<tr>
<td>Tillräcklig/Suficient</td>
<td>adj</td>
<td>82</td>
<td>73.57</td>
</tr>
<tr>
<td>Troligen/Probably</td>
<td>adv</td>
<td>82</td>
<td>67.78</td>
</tr>
<tr>
<td>Förut/Berore</td>
<td>adv</td>
<td>83</td>
<td>74.39</td>
</tr>
<tr>
<td>Hand/Hand</td>
<td>noun</td>
<td>482</td>
<td>473.4</td>
</tr>
<tr>
<td>Arbete/Word</td>
<td>noun</td>
<td>512</td>
<td>475.3</td>
</tr>
<tr>
<td>Behöva/Need</td>
<td>vb</td>
<td>543</td>
<td>506.2</td>
</tr>
<tr>
<td>Börja/Begin</td>
<td>vb</td>
<td>760</td>
<td>732.6</td>
</tr>
<tr>
<td>Svår/Difficult</td>
<td>adj</td>
<td>573</td>
<td>539.3</td>
</tr>
<tr>
<td>Lång/Long</td>
<td>adj</td>
<td>584</td>
<td>659.1</td>
</tr>
<tr>
<td>Alltså/Accordingly</td>
<td>adv</td>
<td>580</td>
<td>532.1</td>
</tr>
<tr>
<td>Ofta/Often</td>
<td>adv</td>
<td>638</td>
<td>616.0</td>
</tr>
</tbody>
</table>

RESULTS

The obtained proportions were subjected to an ANOVA on the factors frequency and syntactic category (3x4), which resulted in a significant interaction effect, $F(6,265)=p < .001$. The main effect of syntactic category was also
significant, $F(3,265) = 5.26$, $p < .001$. The interaction is presented in Figure 1. Table II presents significant contrasts calculated with the aid of Scheffé's method. It appears that the pattern is somewhat unsystematic, but that two categories do not show any paired contrasts between them, namely verbs and adjectives.

Table II. Schedule of significant contrasts ($p<.05$) between syntactic categories on the three frequency levels I, II, and III.

<table>
<thead>
<tr>
<th>Synt categ</th>
<th>Verb</th>
<th>Adj</th>
<th>Adv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noun</td>
<td>II</td>
<td>II</td>
<td>I</td>
</tr>
<tr>
<td>Verb</td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
<tr>
<td>Adj</td>
<td>I</td>
<td>II</td>
<td>III</td>
</tr>
</tbody>
</table>

Figure 1. The proportion rated comprehension for the four syntactic categories on three frequency levels.
It is also noted that the adverbs show significant contrasts in all paired relations but one. The result thus supports the introductory reservations regarding current syntactic classifications. The adjective can be grouped in the verb category and the remarkable relationship of the adverbs with frequency and the other categories underline the lack of systematics.

In order to find out if the noun possibly occupied a place apart, all nouns were tested against other words on every frequency level. Individual proportions were tested against critical value according to the normal approximation (see David, 1969),

\[ 1.64 \sqrt{n(t-1)/4} + 1/2 \frac{n(t-1)+1}{2} \]

The notation \( t \) designates the number of rated objects and \( n \) stands for the number of ratings. Table III presents the result of this try-out. It seems that the noun is more difficult to understand than the other categories on the two lowest frequency levels, whereas the reverse goes for the highest frequency level.

Table III. The number of significant contrasts when nouns were tested against the combination of other categories on the three frequency levels.

<table>
<thead>
<tr>
<th>Frequency level</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easier</td>
<td>3</td>
<td>2</td>
<td>10</td>
</tr>
<tr>
<td>Not sign</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>More difficult</td>
<td>7</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

The correlation (product moment) between the comprehension values and objective frequencies of all the words were calculated and resulted in significant \( .47, t(22)=2.50, p<.05 \). This coefficient does not deviate much from an earlier one (.51) between the same variables (Backman, 1976 a) and thus emphasizes the stability of the previously obtained value.
The results of the ratings of the two groups were correlated for the purpose of testing if the ratings of comprehension had been contaminated. The co-variation (product moment) was calculated at \( r = 0.20 \) between comprehension - subjective frequency.

This analysis has so far mainly been dictated by linguistic conventions. Nouns, verbs, adjectives, and adverbs are linguistic categories, syntactic classes which must be given psychological relevance on a cognitive level. Further analysis of data has therefore been carried out on the following basis:

The opinion that word comprehension has an internal semantic representation means that the analysis will primarily be concentrating on nouns and verbs. Nouns usually stand for objects and verbs for events. This is, however, not always the case (see e.g. Miller & Johnson-Laird, 1976), but can be accepted as a rough approximation. Semantic or conceptual representations which largely correlate with the categories verb and noun can for example be found in computer simulation of language comprehension where syntactic information is used as "... a pointer to the conceptual information." (Schank, 1973, p. 190).

A certain positive relation between frequency and word comprehension results in a transformation of frequency information to a more psychologically well-founded scale. There is reason to believe that subjects have not been able to discriminate clearly between the two lowest frequency levels in the experiment since the difference between them is small. If the levels are transformed to the standard scale (Standard Frequency Index), which has been suggested by Carroll (1970, following the formula

\[ SFI = 10 \log (F+4) \]

the values will be I=55, II=58, and III=67. If the range for objective frequency calculations usually is around 35-90 (Carroll, 1970), we realize that the difference 58-55
is slight from the point of view of discrimination. It was therefore decided that these two levels would be made into one in the following analysis. This results in a difference of 10 SFI-units between (I+II) and III or one logarithmic unit. The values are calculated according to F-mod.

Figure 2. The proportion comprehension for verbs and nouns on two frequency levels expressed in SFI.

Figure 2 presents the results of the modified analysis. The interactive relationship remains and we observe that comprehension of nouns increases more with frequency than is the case with verbs.

DISCUSSION

These results can first of all be regarded as a methodical confirmation if they are compared with the earlier study (Backman, 1976 a) as regards estimated comprehension. Data have here been obtained via an indirect method and the earlier study presents data from a direct method (magnitude estimation). Despite the minor change of technique the relation to objective frequency was now found to be \( r = 0.47 \) against earlier 0.51 (a negligible difference), i.e.
an explained variance of around 25%. Nor can the estimates of comprehension be explained with reference to subjective frequency, where the co-variation reached $r = .20$. If the effect of objective frequency is partialled out, the relation comprehension-subjective frequency will be $r = -.23$, i.e. still not significantly separate from the 0-correlation. Word comprehension can, in other words, partially be predicted from knowledge of objective frequency. This appears as an observation worth continued investigation since the co-variation between objective and subjective frequency often is of about $r = .90$ (see e.g. Backman, 1976 a). This result once again supports the opinion that estimated comprehension constitutes another and probably a higher order variable.

The substantial analysis also confirms previous knowledge of syntactic categories. Both linguists and psychologists stress the distinction noun-verb as a reflection of a (probably universal) general cognitive distinction - the one between objects and relations between objects (see e.g. Chomsky, 1965 and Miller, 1972). Other syntactic categories are only of secondary importance. The contrast tests verified a linguistic point of view that adjectives can be classified in the verb category or belonging to the same deep structure - a point of view which has also been adopted by psychologists see e.g. Simmons, 1973). The ambiguous position of the adverbs is supported by the lack of systematics in the relation to frequency and other syntax categories which have been tested here.

The more obviously accelerated development over frequency for nouns compared with verbs can possibly be explained by the latter being more context dependent in their function of carrying meaning. Verbs often require additional syntactic elements for definition of the meaning. Consequently, the verb "hit" mostly requires an object, "run" a direction or "give" a recipient. The relational character of verbs which was made explicit by Fillmore (1968) has later also been adopted by Miller & Johnson-Laird (1976) and by "network
theorists" like Andersson & Bower (1973) and Norman & Rumelhart (1975). In the absence of such complementary relational elements the degrees of freedom of the verb is assumed to be comparatively constant over frequency and may help to explain the stability of the frequency in the outcome. The nouns have, however, a more independent character and are thus not so context dependent (probably one of the reasons why this category has been surrounded by such massive empiric by the researchers). Chomsky (1965) exemplifies this by first substituting nouns by means of context free rules to phrase markers and then verbs. The strongly increasing development of nouns can now be explained by higher frequencies also meaning a larger amount of meanings or variants of meaning. There are, in other words, a larger number of entries in the subjective lexicon of the individual, which makes it easier to understand the nouns with increasing frequency.

The study admits, however, no general statement on the difference between noun and verb since it is regarded as fairly certain that concrete nouns differ from abstract ones on the levels of word and sentence. Concrete nouns are regarded as having higher imagery value (see Paivio, 1971) and are therefore for example easier to learn. The nouns in this report are mainly abstract ones and can thus not claim to cover the whole noun category. An orthogonal variation in frequency and imagery is also required to separate the effect of these two variables, since they have a tendency to be correlated.
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