PERCEPTION OF POLYSEMY

Jarl Backman
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ABSTRACT

A seldom expressed assumption in word comprehension studies, that words have invariant semantic qualities, was tested in three experiments. The first experiment showed that subjects produced different interpretations from polysemous words. There always, however, seemed to be a most frequent representation. In the second experiment subjects rated degree of polysemy and a striking jump was found in the transition from two to three meanings in a polysemous word. The third experiment also tested perceived degree of polysemy but with the addition of objective frequency and syntactic category as independent variables. A theoretically predicted triple interaction was confirmed. It is concluded that the phenomenon of polysemy has to be incorporated in research on word perception and comprehension. Theoretical alternatives for representation of polysemous and homonymous words are presented. The invariance hypothesis in word comprehension is finally recommended to be substituted by a variance hypothesis.

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There is an assumption which, however, is seldom expressed in both theoretical and empirical bases of the attempts to describe or explain simple word comprehension: individual words have invariant semantic qualities. A word is, in other words, interpreted in a similar way by all individuals and thus results in a given semantic representation. However, that this is not the case can be illustrated by the following sentence where the choice of verb (in parentheses) determines the coding of the noun chair.

The man (sat on) (took up) (kicked) (painted) (photographed) the chair.

Different qualities of the word chair will thus be emphasized owing to the choice of verb. The variability of the word (and sentence) as regards meaning in a wider context has also been pointed out (see e.g. Bransford & Mc Carrell, 1974). The most explicit theories of simple word comprehension (see e.g. Rips, Shoben & Smith, 1973) do not, however, take care of the context dependence.

Another annoying factor in studies of word comprehension is the phenomenon called homonymy, which means that the same word can appear in various syntactic categories. The word "function" can, for example, either be a noun or a verb. Such a word is theoretically treated as having different semantic representations. Only contextual information can in this case determine which of the two representations is being activated.

Another factor to be borne in mind about words is polysemy, which means that one representation of meaning probably has a varying number of variants (groups of meaning or multiple meanings). The word work has, for example, the following variants: "performance", "employment", "something to be done, not necessarily for payment", "the place where one is employed". A normative approach in research overlooks the fact that words (probably without exception) show polysemy, that they have multiple meanings. Polysemy is extremely important for the construction of theories.
of word comprehension and the current grouping in
approaches (network theories vs set theories) cannot
directly predict language behaviour with the incorpora-
tion of what appears as a clear ecological fact, namely
polysemy. A set theory of the type "Feature Comparison"
(Smith, Shoben & Rips, 1974) does not even separate hómo-
nymy from polysemy. A possible solution has later been
proposed by Rosch (1975), who treats semantic categories
as networks of overlapping attributes. This means that
words are regarded as belonging to a category on the
basis of their resemblance with (in terms of overlapping
attributes) other words in the same category (family
resemblance). This categorization is also predictable
from prototype ratings, i.e. estimations of representa-
tativeness. The words "chair" and "mirror" have over-
lapping attributes and belong to the category "furniture"
but vary in degree of typicality in the category. A digital
approach to categorization has by Rosch been substituted
by an analogous one to take care of what Barclay et al
(1974) call semantic flexibility. Even if Rosch does not
treat polysemy the starting-point is a step in the direction
away from the static invariance approach to how words are
comprehended. It is probably also possible that every indivi-
dual word has a typical representative variant of meaning
or, in other words, a prototype for other variants.

An earlier study (Backman, 1978 b) showed that comprehension
of words is related to the specification of the polysemy
of the words. The number of multiple meanings of the words
dictated for example the choice of the interpretation of
homonymy for sentence production. The purpose of this study
is to make further investigations of the semantic represen-
tation in the case of polysemy of individuals. The following
predictions, made from the above observations, are tested
in the first experiment:

I. The interpretation of a word in polysemous form is not
   invariant over individuals
II. A certain meaning for a certain word is more frequent, more typical than others.

EXPERIMENT I

Method and Procedure

Ord för ord (Word for Word, 1964) supplied information of meanings for a number of words which satisfied the following selection criteria: 1) they should be either verbs or nouns, 2) they should be taken from approximately identical frequency levels in Allén's (1970) frequency dictionary. The final verbal material, presented in Table I, consisted of 18 different words with 2-4 variants of multiple meaning. The words were presented on a sheet of paper and the subjects were asked to produce a sentence for every given word. The words were taken down in a randomized order.

The produced sentences were analyzed according to their variant of meaning and the obtained frequencies were transformed to proportions.

Table I. The 18 different words with syntactic category (SC where V=verb, N=noun) and number of multiple meanings (Mm) in experiment I.

<table>
<thead>
<tr>
<th>Word</th>
<th>SC</th>
<th>Mm</th>
<th>Word</th>
<th>SC</th>
<th>Mm</th>
<th>Word</th>
<th>SC</th>
<th>Mm</th>
<th>Word</th>
<th>SC</th>
<th>Mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Väntan/Wait</td>
<td>N</td>
<td>2</td>
<td>Period/Period</td>
<td>N</td>
<td>2</td>
<td>Författare/Author</td>
<td>N</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glida/Glide</td>
<td>V</td>
<td>2</td>
<td>Tyda/Interpret</td>
<td>V</td>
<td>2</td>
<td>Använd/Use</td>
<td>V</td>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Läger/Camp</td>
<td>N</td>
<td>3</td>
<td>Utrymme/Space</td>
<td>N</td>
<td>3</td>
<td>Problem/Problem</td>
<td>N</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dirigera/Conduct</td>
<td>V</td>
<td>3</td>
<td>Lida/Suffer</td>
<td>V</td>
<td>3</td>
<td>Behöva/Need</td>
<td>V</td>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Svaghet/Weakness</td>
<td>N</td>
<td>4</td>
<td>Perspektiv/Perspektive</td>
<td>N</td>
<td>4</td>
<td>Arbete/Work</td>
<td>N</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Spara/Save</td>
<td>V</td>
<td>4</td>
<td>Rymma/Hold</td>
<td>V</td>
<td>4</td>
<td>Börja/Begin</td>
<td>V</td>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Subjects

26 students at the Umeå School of Education served as subjects during regular lessons.

RESULTS AND DISCUSSION

The proportional distribution of multiple meanings (Mm) for different numbers is presented in Table II which is arranged in falling proportion for every number of Mm (horizontal reading A-D).

Table II. Distribution of proportions on different multiple meanings (A-D) for different numbers of possible variants for words (Mm2-Mm4).

<table>
<thead>
<tr>
<th>Number</th>
<th>MmA</th>
<th>MmB</th>
<th>MmC</th>
<th>MmD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mm2</td>
<td>.81</td>
<td>.19</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mm3</td>
<td>.86</td>
<td>.11</td>
<td>.03</td>
<td>-</td>
</tr>
<tr>
<td>Mm4</td>
<td>.68</td>
<td>.22</td>
<td>.07</td>
<td>.03</td>
</tr>
</tbody>
</table>

The proportions are calculated on the base number 156, i.e. the number of subjects (26) multiplied with the number of produced sentences (6) on every Mm-level. We can easily see that the invariance hypothesis can be discarded. The interpretation of a particular word varies for individuals when they are asked to produce a sentence from a given word. This means in theoretical terms that polysemous words activate different semantic representations in individuals.

The second prediction also gets support. An ANOVA for every number of Mm gives for 4 Mm, $F(3,100)=4.79, p<.01$, for 3 Mm, $F(2,75)=5.83, p<.01$ and for 2 Mm, $F(1,50)=4.28, p<.05$. Contrast tests with Scheffé's method resulted in all 3 cases in significance ($p<.05$) for the most frequent variant (MmA) compared with the other paired combinations. There is thus, irrespective of number of possible meanings, one
which is more attractive than the others. The most frequent variant can, with a term borrowed from Rosch (1975) be described as more "typical". It should, however, be pointed out that such a "typicality" tends to decrease with number of multiple meanings. Only 0.68 was obtained for 4 multiple meanings, an embarrassingly low proportion for the normative theorist.

EXPERIMENT II

Theories of word comprehension and semantic memory separate and/or stress different stages and processes in the cognitive handling of verbal information which affects the choice of dependent variables. Response registrations can thus vary from simple measurements of reaction time to structural analyses of verbal protocols. An active sentence production can make other claims on the cognitive processing of semantic information than for example a direct subjective rating of words or attributes of words. Experiment II was therefore carried out with the aim of answering the question if individuals can discriminate between words with varying numbers of multiple meanings if they are asked to directly rate the difference.

Method and Procedure

Twelve words were chosen from the categories verb and noun. Three of these words represented the Mm-levels 1-4. The objective frequency of the words were checked on every level, so that there would be no differences in this respect between the levels. The number of letters in each word was as before approximately the same. The words are presented in Table III which also presents the number of multiple meanings for every word. Thurstone's paired comparisons was chosen as rating method because of its comparative simplicity in the task. All paired combinations were presented in written form in a randomized order. The subjects were asked to underline the word which they "believe appears in the largest number of meanings". 
Table III. Words in experiment II with number of multiple meanings (Mm).

<table>
<thead>
<tr>
<th>Word</th>
<th>Mm</th>
<th>Word</th>
<th>Mm</th>
<th>Word</th>
<th>Mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skänka/Give</td>
<td>1</td>
<td>Använda/Use</td>
<td>2</td>
<td>Läger/Camp</td>
<td>3</td>
</tr>
<tr>
<td>Tillvaro/Existence</td>
<td>1</td>
<td>Väntan/Wait</td>
<td>2</td>
<td>Utrymme/Space</td>
<td>3</td>
</tr>
<tr>
<td>Veta/Know</td>
<td>1</td>
<td>Tyda/Interpret</td>
<td>2</td>
<td>Problem/Problem</td>
<td>3</td>
</tr>
</tbody>
</table>

Subjects

The values of the proportion matrix were transformed to angular deviates since they satisfied the criteria for such a transformation (see Bock & Jones, 1968). An ANOVA on these with the factor Mm resulted in $F(3, 75) = 7.43$, $p < .001$. A contrast test (Scheffé's method at $p < .05$) resulted in a significant difference between Mm 2-3 and the combination of 1 and 2 against 3 and 4. The combinations 1-2 and 3-4 were not significantly different. The relation between ratings and objective numbers of Mm are rendered graphically in Figure 1.

Figure 1. Estimates (column sums) for different numbers of multiple meanings.
The estimates in the figure are made up of the column sums of the proportion matrix. The result supports on the whole the findings of experiment I. Individuals differentiate between numbers of Mm. A very striking difference occurs in the transition from 2 to 3 meanings, which makes you think of some kind of discrimination threshold for the perception of the number of meanings of words. It should also be noted that the addition of a meaning to one already existing or to three already existing ones does not change the perception of the subject of the number of multiple meanings. The results obtained in experiment II are extremely important for the construction of theories of word comprehension and are commented on in more detail under the heading General Discussion.

EXPERIMENT III

This experiment was carried out with the aim of testing the range of the result which was obtained in the preceding experiment, but this time with systematic variation of other operating variables in word comprehension and word perception. It has for example repeatedly been observed that objective frequency of words is an influential (and probably the most studied one from an empirical point of view) variable. The picture is, however, not clearly unambiguous. It has recently (Backman, 1978 a) been observed that syntactic category (nouns and verbs) interacts with frequency when the dependent variable is represented by comprehension. This is explained with reference to the relational character of the verbs, that they are more context dependent than the nouns in their functions of carrying meaning (see Backman, 1978 a. This tends to make the verbs more resistant to objective frequency manipulations, since these do not introduce any direct context for the ratings. The nouns, regarded as more independent units in the activation of representations are, on the other hand, affected by frequency. Thus, comprehension and subjective frequency of nouns increase, for example, with increasing objective frequency. The two
syntactic categories have accordingly an interactive relationship to frequency. The introduction of numbers of multiple meanings should lead to a decrease and possibly to the elimination of such an interaction when there is an increase in the number of Mm. A subjective judgement is for the verbs still comparatively context-free whereas an increasing Mm is supposed to imply more semantic accesses in the semantic memory. The following predictions are thus formulated for experiment III in a concurrent orthogonal variation of the factors multiple meaning (Mm), syntactic category (SC) and objective frequency (OF):

1. a triple interaction between the three variables objective frequency, syntactic category, and multiple meaning

2. a discrimination "threshold between 2 and 3 Mm for nouns.

Method and Procedure

Twentyfour words were distributed over the factors according to the following:

Mm: 4 levels (1, 2, 3, and 4)
SC: 2 levels (nouns and verbs)
OF: 3 levels (low, middle, and high)
Table IV. Words in experiment III, their syntactic category (SC, where N=noun, V=verb), number of multiple meanings (Mm), objective frequency (OF), modified frequency (F-mod), and rank number (R-no).

<table>
<thead>
<tr>
<th>Word</th>
<th>SC</th>
<th>Mm</th>
<th>OF</th>
<th>F-mod</th>
<th>R-no</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grundval/Foundation</td>
<td>N</td>
<td>1</td>
<td>37</td>
<td>29.69</td>
<td>2513</td>
</tr>
<tr>
<td>Skänka/Give</td>
<td>V</td>
<td>1</td>
<td>37</td>
<td>28.11</td>
<td>2513</td>
</tr>
<tr>
<td>Väntan/Wait</td>
<td>N</td>
<td>2</td>
<td>37</td>
<td>32.42</td>
<td>2513</td>
</tr>
<tr>
<td>Glida/Glide</td>
<td>V</td>
<td>2</td>
<td>37</td>
<td>32.05</td>
<td>2513</td>
</tr>
<tr>
<td>Läger/Camp</td>
<td>N</td>
<td>3</td>
<td>37</td>
<td>29.12</td>
<td>2513</td>
</tr>
<tr>
<td>Dirigera/Conduct</td>
<td>V</td>
<td>3</td>
<td>37</td>
<td>28.75</td>
<td>2513</td>
</tr>
<tr>
<td>Svaghet/Weakness</td>
<td>N</td>
<td>4</td>
<td>37</td>
<td>31.76</td>
<td>2513</td>
</tr>
<tr>
<td>Spara/Save</td>
<td>V</td>
<td>4</td>
<td>37</td>
<td>29.91</td>
<td>2513</td>
</tr>
<tr>
<td>Tillvaro/Existence</td>
<td>N</td>
<td>1</td>
<td>82</td>
<td>69.46</td>
<td>1296</td>
</tr>
<tr>
<td>Upprepa/Repeat</td>
<td>V</td>
<td>1</td>
<td>82</td>
<td>67.76</td>
<td>1296</td>
</tr>
<tr>
<td>Period/Period</td>
<td>N</td>
<td>2</td>
<td>82</td>
<td>63.87</td>
<td>1296</td>
</tr>
<tr>
<td>Tyda/Interpret</td>
<td>V</td>
<td>2</td>
<td>82</td>
<td>63.73</td>
<td>1296</td>
</tr>
<tr>
<td>Utrymme/Space</td>
<td>N</td>
<td>3</td>
<td>82</td>
<td>76.02</td>
<td>1296</td>
</tr>
<tr>
<td>Lida/Suffer</td>
<td>V</td>
<td>3</td>
<td>82</td>
<td>79.68</td>
<td>1296</td>
</tr>
<tr>
<td>Perspektiv/Perspective</td>
<td>N</td>
<td>4</td>
<td>83</td>
<td>70.98</td>
<td>1279</td>
</tr>
<tr>
<td>Rymma/Hold</td>
<td>V</td>
<td>4</td>
<td>83</td>
<td>72.23</td>
<td>1279</td>
</tr>
<tr>
<td>Hand/Hand</td>
<td>N</td>
<td>1</td>
<td>482</td>
<td>473.4</td>
<td>188</td>
</tr>
<tr>
<td>Veta/Know</td>
<td>V</td>
<td>1</td>
<td>647</td>
<td>600.1</td>
<td>137</td>
</tr>
<tr>
<td>Författare/Author</td>
<td>N</td>
<td>2</td>
<td>536</td>
<td>464.2</td>
<td>170</td>
</tr>
<tr>
<td>Använda/Use</td>
<td>V</td>
<td>2</td>
<td>458</td>
<td>428.2</td>
<td>202</td>
</tr>
<tr>
<td>Problem/Problem</td>
<td>N</td>
<td>3</td>
<td>559</td>
<td>526.1</td>
<td>165</td>
</tr>
<tr>
<td>Behöva/Need</td>
<td>V</td>
<td>3</td>
<td>543</td>
<td>508.2</td>
<td>168</td>
</tr>
<tr>
<td>Arbete/Work</td>
<td>N</td>
<td>4</td>
<td>512</td>
<td>475.3</td>
<td>178</td>
</tr>
<tr>
<td>Börja/Begin</td>
<td>V</td>
<td>4</td>
<td>760</td>
<td>732.6</td>
<td>118</td>
</tr>
</tbody>
</table>

The design thus provides 24 level combinations in a factorial arrangement.

The words have been tabulated in Table IV where the modified frequency (F-mod) is also indicated (see Allén, 1970) like the rank number of the words in the objective list.
Paired comparisons were used in this experiment by analogy with the preceding one and with the same instruction. The subjects were asked to mark the words they considered to have the largest number of meanings.

**Subjects**

The experiment was carried out at the school for nursing professions in Umeå with 45 students from a two-year line during regular lessons.

**RESULTS AND DISCUSSION**

The proportions were once again transformed angularly and the result of an ANOVA is presented in Table V.

Table V. Summary of ANOVA in experiment III.

<table>
<thead>
<tr>
<th></th>
<th>df</th>
<th>SS</th>
<th>MS</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multiple meaning (Mm)</td>
<td>3</td>
<td>.3478</td>
<td>.1159</td>
<td>5.84 &lt;.001</td>
</tr>
<tr>
<td>Objective frequency (OF)</td>
<td>2</td>
<td>.2274</td>
<td>.1137</td>
<td>5.73 &lt;.001</td>
</tr>
<tr>
<td>Syntactic category (SC)</td>
<td>1</td>
<td>1.1586</td>
<td>2.1586</td>
<td>108.83 &lt;.001</td>
</tr>
<tr>
<td>Mm x OF</td>
<td>6</td>
<td>.9489</td>
<td>.1582</td>
<td>7.98 &lt;.001</td>
</tr>
<tr>
<td>Mm x SC</td>
<td>3</td>
<td>.1839</td>
<td>.0613</td>
<td>3.09 &lt;.05</td>
</tr>
<tr>
<td>OF x SC</td>
<td>2</td>
<td>1.1138</td>
<td>.5569</td>
<td>28.08 &lt;.001</td>
</tr>
<tr>
<td>Mm x OF x SC</td>
<td>6</td>
<td>2.3158</td>
<td>.3860</td>
<td>19.46 &lt;.001</td>
</tr>
<tr>
<td>Experimental error</td>
<td>253</td>
<td>5.0182</td>
<td>.0198</td>
<td></td>
</tr>
</tbody>
</table>

All main effects and interactions are significant with p<.001 except the interaction Mm-SC, which is "only" significant on the 95 %-level. The analysis is made according to the model of fixed factors. Df for the error term has been calculated according to (n-1)(n-2)/2 where n=the number of words in the proportion matrix. A continued analysis of the interaction SC x OF on different levels of Mm resulted in significance on all 4 Mm-levels with
p<.01, except Mm=3, where F(2,253)=4.54, p<.025. The interaction was most striking at Mm 2: F(2,253)=35.86, p<.001.

An examination of the interaction SC x Mm also results in significance on all three OF-levels. For the middle frequency level at p<.001. The interactive relations are illustrated in Figure 2.

The purely theoretical interest in the "discrimination threshold" between 2 and 3 Mm justifies a multiple comparison between the Mm-means. Tukey's test was used for this purpose which resulted in significance for the difference Mm 2 and 3 (p<.01) with the other differences insignificant. Tukey's test was also used to try the difference between the means in every syntactic category. This led to significance in the noun category between Mm_2 and Mm_3, but also between Mm_1 and Mm_3 (p<.01). There were no significant Mm-differences in the verb category. The tendency is, however the same as for nouns if the values are examined irrespective of significance. The predictions formulated for experiment III are thus supported by the analysis of variance: the introduction of multiple meaning to an already existing interaction between syntactic category and objective frequency results in a triple interaction. The discrimination threshold between 2 and 3 Mm obtained in experiment II is also confirmed. This proved to be true especially for nouns whereas the verbs, in accordance with the theoretical assumption, were less affected by the number of Mm.
Figure 2. Estimations of multiple meaning on different frequency levels (OF_L, OF_M, and OF_H) for nouns (N) and verbs (V).
GENERAL DISCUSSION

The outcome in all three experiments can be said to support a variance hypothesis rather than the prevalent invariance strategy. Normative approaches to word perception tend to conceal the fact that separate words are perceived in a non-uniform way by different individuals. The number of multiple meanings or, in other words, the degree of polysemy should be introduced in research on word comprehension since it has, as has been shown here, an obvious psychological-perceptual correlate. The theoretical approaches dominating today represented by Collins & Loftus (1975), Smith, Shoben & Rips (1974) and Holyoak & Glass (1975) have, besides the restrictions which have been pointed out in other contexts (Backman, 1978 c), no room for polysemy, sometimes not even for homonymy. There are at least three possible theoretical alternatives for representing a word in a homonymous as well as in a polysemous form. This is schematically shown in figure 3 and 4. The word BANK can syntactically be classified as a noun or a verb and polysemously in two variants:

\[
\begin{align*}
\text{BANK}_{D} \quad (\text{"dam up"}) \\
\text{BANK}_{B} \quad (\text{"beach"}) \\
\text{BANK}_{M} \quad (\text{"for money"})
\end{align*}
\]

Figure 3. The word BANK and an example of polysemy and homosemy.

The three theoretical possibilities consist of a) separate representations for every meaning e.g. for BANK three representations b) only homonymous representations leading to a common representation for BANK_{B} and BANK_{M} c) like b) but polysemous variants are separated a "typicality" dimension.
The only empirical study which has been presented so far (but with other aims, definitions, and methods than in this study) of polysemy and its semantic effects (Grober, 1976) tends to give priority to alternative c) just as we have done. Grober maintains that every polysemous word is represented by a general and an abstract kernel meaning and that variants are constructed via a set of "instructions rules." The similarity between a kernel meaning and a "typical" meaning is striking.

This discrimination threshold for the perception of multiple meanings also affects the construction of theories of word comprehension since it restricts the representation of meanings. It is probably not possible to regard polysemous words as continuously variable around a central meaning. The results obtained here imply discrete relations and possibly continuous relations around groups of kernel sentences.
The theoretical status of the "threshold" is, however, difficult to determine at this stage when for example only 4 Mm are used in the experiments. Continued research should aim at answering the question what happens with >4 Mm.

Nor has the difference between the categories nouns and verbs been pointed out before. The hypothesis of the context dependance of the verbs and their resistance to Mm-manipulations is worth further investigations.

It should, as a last conclusion, be pointed out that word comprehension is a complex cognitive activity which cannot be satisfactorily examined with the current strategy. The current approach is almost exclusively directed towards the category of nouns and seldom allows more than two dimensions to operate in independent variable position. Such an approach probably fails to provide information of semantic representations that is representative.
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