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The Acquisition of Word Meanings as a Cognitive Learning Process

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In Experiment 1 subjects who were relatively high or low in verbal comprehension learned the meaning of neologisms from series of sentences while thinking aloud. Differences between high- and low-verbal subjects were found in the way they use a known word meaning as a model for the neologism's meaning and in the way they transform the sentence contents accordingly. In Experiment 2 these findings were replicated and a corresponding difference in learning products was found. The "analytic" way in which high verbals use a model unit provides them with directions into which to transform the sentence contents, whereas the "holistic" model utilization of low verbals does not. Implications of these results for verbal comprehension from a psychological point of view are discussed.

In daily life word meanings are more often acquired from contextual information than from explicitly given definitions. When an unfamiliar word is met in a sentence some idea about the meaning of the word may be developed from a general understanding of the sentence. If the same word comes up in different contexts and if the learner (listener, reader) is intent upon detecting its meaning, processing of the new word in light of the different contexts may result in a new unit in semantic memory. It is the necessity of performing transformational operations on presented information that lends the acquisition of word meanings from context its preeminently cognitive character. The importance of a learner's autonomous transformational activities for the acquisition of knowledge is stressed among others by Wittrock (1974), Resnick (1976), and Frijda (1978). On the other hand, the research on scripts (Schank & Abelson, 1977), frames (Minsky, 1975), story schemas (Thorndyke, 1977), macrostructures (van Dijk, 1977), and the like is concerned with the influence of existing knowledge structures on the processing of new information.

The present study pertains to both aspects of the process that leads to acquisition of word meanings from context. The following questions are tackled:

1. What is the nature of the transformational operations, required for this task?

2. How are these operations related to the relevant stored knowledge? We used an experimental task comparable to the one designed by Werner and Kaplan (1952). The meaning of a neologism had to be learned from a series of sentences in which the neologism occurs. As our interest focused on the essential characteristics of an efficient acquisition process, we chose subjects that varied substantially on a measure of verbal comprehension. Hoping to find process characteristics that would differentiate between high- and low-verbal subjects, we asked the subjects to think aloud.

First we will describe the learning material and the acquisition process as hypothesized for an ideal subject. Subsequently two experiments are discussed.

THE LEARNING MATERIAL

Exposition of one item is sufficient to explain the nature of the learning material, as all three items used were constructed along

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the same lines. By an item we mean the neologism (the new word) plus the five sentences in which it is presented. The neologisms are Dutch-sounding words, referring to a realistic but not yet existing hyponym of a familiar superordinate, that is to be differentiated from other hyponyms by two specifications. For example: a "kolper" is "a window that transmits little light because of something in front of it." (This kind of window is quite common in the Netherlands). Subjects have to find out the meaning of "kolper" from five serially presented sentences that read:

1. When you're used to a broad view it is quite depressing when you come to live in a room with one or two kolpers fronting a courtyard.
2. He virtually always studied in the library, as at home he had to work by artificial light all day because of those kolpers.
3. During a heat wave a lot of people all of a sudden want to have kolpers, so the sales of sun-blinds then reach a peak.
4. I was afraid the room might have kolpers but when I went and saw it turned out that plenty of sunlight came into it.
5. In these houses you're stuck with kolpers all summer, but fortunately once the leaves have fallen out that isn't so any more.

This series of sentences consists of three examples for "kolper" and two counterexamples; it is built up as follows: in sentence 1 the superordinate is roughly indicated ("a kolper is a window"); sentence 2 conveys the first specification, discriminating a kolper from other windows ("it transmits little light"); and in sentence 3 the second specification ("there is something in front of it") is indirectly given; the absence of the first specification makes the fourth sentence a counterexample; and in sentence 5 it is shown that a kolper stops being a kolper as soon as the second specification is not true. The sentences for the other two items were constructed in a similar way.

The Ideal Acquisition Process

The process of acquiring a new word meaning from context is analogous in some respects to the acquisition of a concept like "arch" from examples of block structures, as incorporated in a program of Winston (1977). This program, on being shown an example of an arch, builds a structural description of it in terms of objects and their relations, which description is then taken as a *model* (a provisional representation) for the concept; this model is gradually adapted in the light of later presented examples and counterexamples ("near misses") on the basis of differences between these and the model.

In analogy to this program the acquisition of a word meaning as hypothesized for an ideal subject can be described as follows: the first sentence is an example of the use of the neologism on the basis of which a rough notion of the word meaning (a first version of the model) can be formed. Replacing "kolpers" by "windows" would result in a comprehensible sentence, so the provisional representation for "kolper" will be modeled after that of "window," with slots reserved for more specific information to differentiate kolpers from other windows. This model (stating that a kolper is a kind of window) can be retained when tested in the second sentence. Extraction of more specific information about what special kind of window a kolper is, is hypothesized to require at least two steps:

1. a reformulation of the sentence content so that it is brought to bear directly upon the neologism, for example, into "kolpers in a house mean having artificial light on all day";
2. a transformation of the reformulated information into an aspect of the meaning of "kolper," or (what amounts to the same thing) into an aspect that fits one of the slots in the provisional model. Ideally the above reformulation of sentence 2 is transformed into "kolpers transmit little light."

We will refer to these steps jointly by the term "decontextualization." The result of this process means filling a slot in the model or adapting one of its aspects: if, for example, "transmits light" is an aspect of the model of "window," the product of contextualization must change this into "transmits little light."

In the same way the reformulated content of sentence 3 can be transformed into "kolpers have something in front of them." The model for "kolpers" would now contain all the necessary information: that it is a window that transmits little light and has something in front of it. From sentences 4 and 5, the near misses, it is to be learned that the two (already found) specifications are obligatory. If the subject tests the model in sentence 4 the first specification is confirmed. He may, however, look for more specifications and the decontextualization process would then ask for an extra step: if sentence 4 is reformulated into: "if plenty of sunlight comes into a room it has no kolpers," a first transformation is required into: "if a room does have kolpers it is not so that plenty of sunlight comes into it" and this in its turn must be transformed into: "kolpers transmit little light." The decontextualization process thus yields a specification that is already part of the model, and as a result a must-be pointer (in terms of Winston's program) is attached to it. In the same way the second specification ("there is something in front of it") is to get a must-be pointer on the basis of sentence 5.

Although there are parallels between Winston's program and our learning task we must keep in mind that in the acquisition of a word meaning the examples and counterexamples are semantic instead of perceptual; the ambiguity inherent in semantic material may well be of crucial importance. It is more difficult to make unequivocal descriptions than it is in Winston's case and as a consequence comparisons with the model (the provisional representation) might be less straightforward. We will use the above description of an ideal process as a frame of reference for what subjects actually do in our experiments.

Experiment 1

Subjects for Experiment 1 were selected on the basis of two measures: a vocabulary test ("Vocabulaire test"; Elshout & Keizer, 1968) and an English sentences-test ("Engels lezen"; Elshout & Koning, 1974). The first test consists of 50 four-choice items; each item is a difficult Dutch word, the correct meaning of which must be selected from four given possibilities. A (translated) example would be

nostalgia a. attention, b. home-sickness, c. nose cold, d. bitterness.

The second test is made up of 40 short English sentences, selected from an introductory textbook of psychology; in each sentence one word, that has proved to be difficult for first-year students, is underlined. Subjects are required to give a translation for this word. One of the items reads: ". . . the issue is a *devisive* one. . . ." If the meaning of the underlined word is not known, an attempt can be made to infer it from the given context, so this test probably measures a mixture of English vocabulary size and an aspect of the ability to infer word meaning from a short sentence. The tests are part of a large battery and are run every year in obligatory sessions with about 200 first-year psychology students as subjects. Both tests have proved to be stable markers for the verbal comprehension factor CMU (Cognition of seMantic Units) in the Structure of Intellect Model (Guilford, 1967). The sum of the two standardized test scores was our measure of verbal comprehension. Out of a pool of 216 psychology students, 8 subjects with a score of at least 0.75 standard deviations above the mean score and 8 subjects who scored at least 0.75 standard deviations below that were selected by an assistant. For convenience we will refer to these subjects as high and low verbals, respectively, keeping in mind

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that the low verbals are only relatively low, and still well above average in intelligence (the mean IQ for Dutch psychology students being 126, with a standard deviation of 8). The experimenters did not know which of the 16 subjects (10 male and 6 female) were high and which were low in verbal comprehension.

Procedure

In order to collect thinking-aloud protocols, subjects were tested individually. The three items were presented in separate booklets in a different order to different subjects; each sentence was printed at the top of a page, so only one sentence at a time was in view. The last page of a booklet was reserved for the subject's definition of the neologism. The exact nature of the task is best explained by citing the instruction:

> This experiment is about the way people acquire the meaning of a new word. You will be presented with five sentences, in which an unknown word is used (it is made up for the experiment). Your task is to find out what the word means. The sentences are printed on separate pages of this booklet and under each the same question is asked: "What does this sentence tell you about the meaning of the new word?". The way we would like you to proceed is as follows: read the sentence aloud, and try to comprehend what it generally says; then try to deduce information from the sentence about the meaning of the new word while thinking aloud; when you have inferred something about the word meaning, write it down in your booklet, under the sentence. You can work for 2 minutes on every sentence; I will tell you when to move to the next one. Keep in mind that the word meaning should fit all five sentences and that afterwards you will be asked to give a definition for the new word. Bear in mind that there is no synonym for it and that you'll have to describe its meaning by one or two short sentences."

After the experiment the tapes were typed out into the booklets of the subjects, that from now on will be referred to as their "protocols."

The analysis and scoring of the protocols. The purpose of Experiment 1, exploratory in nature, is to find the essential characteristics of an efficient acquisition process. In our experimental setup we can expect to find these characteristics in the 8 of the 16 protocols that were produced by the high-verbal subjects. Not knowing, however, which protocols are the high-verbal subjects', we set out to find *all* process characteristics that might contribute to a successful differentiation of the protocols of the high and low verbals. The hypothesis that the 16 protocols can in fact be categorized correctly on the basis of these characteristics remains to be tested after we have decided on the characteristics as such.

The protocols were observed to differ in two major respects that can be described in terms of the ideal acquisition process given earlier: differences were found in the way the model is utilized in the various protocols and in the products of the decontextualization process. We will discuss these differences in detail. Examples that will be given in what is to follow are always chosen from the data for "kolper," but the points made could be as easily illustrated by findings for the other items.

The use of a model. All subjects at one moment or another chose a familiar word that, when substituted for the neologism in a particular sentence, made it into a meaningful whole. Such a substitution functions as a model (in the sense of Winston's program) for the new word meaning. However, the manner in which the meaning of the word, serving as a model, is utilized to gain information about the meaning of the neologism differed strikingly among the various protocols. We distinguished an analytic and a holistic way of using a model: analytic model utilization implies viewing the model's meaning as a bundle of components that can each be employed separately during the decontextualization process, whereas holistic utilization means handling the model as an indivisible whole. How these approaches are manifest in the protocols will be elucidated below.

Analytic model utilization. An example: one subject reads the first sentence and says: "When you come to live in a room with one or two windows . . . that would

make sense, so I guess it is some sort of window, let's see if that fits the second sentence.'' Sentence 2 reveals that ''windows'' just like that does not fit, but the rough notion of ''windows'' does: ''. . . so it is a kind of window alright, it is part of a room and it has to do with the incoming light, maybe the glass is different for a kolper, it might be ground glass or something like that. . . .'' This subject, using ''window'' as a model for ''kolper'' from the outset, actualizes different aspects of the model's meaning to direct the decontextualization process and sees whether adaptation of one of these aspects in the light of the sentence content gets him closer to the meaning of ''kolper.'' As the subject proceeds from one sentence to the next, the adequacy of ''window'' is confirmed, and by transforming some of its aspects the model is gradually changed into the meaning of ''kolper,'' in a way that approximates the ideal acquisition process.

An analytic approach can find expression in the use of one model as described above, or in taking several local models as guides to decontextualization. An example: one subject substitutes ''kolper'' by ''blind wall'' in the first sentence, which fits the second sentence as well. Reading the third one, however, he thinks ''shutter'' more feasible, switching to ''small window'' and ''shadow'' for sentences 4 and 5, respectively. Each of these substitutions appears to be used as a local model for ''kolper,'' as becomes clear from the fact that the subject isolates the one component from the meaning of each of them that is most salient in the particular sentence. Thus the above quoted subject dissociates the following components from his local models: ''causes absence of view,'' ''causes darkness inside,'' ''can be fitted in front of a window,'' ''transmits little light,'' and ''may be caused by trees in front of it,'' respectively. These components are set aside for the meaning of ''kolper'' during the acquisition process, and are subsequently put together in a definition that reads: ''a kolper is something in front of a window that keeps the sun out.'' One might say the subject reserves an empty model for the new word meaning and fills this with components from local models.

Holistic model utilization. Quite a few of the subjects who replace ''kolper'' by ''window'' in the first sentence, instead of using the substitution analytically, seem to view it as a unit, indicating the domain within which the meaning of the neologism is to be found. The approach of these subjects finds expression in the fact that in the rest of the sentences they choose more specific substitutions for ''kolper'' within this delimited domain. An example is given by the subject who replaces ''kolper'' by ''windows,'' ''small windows,'' ''blinded windows,'' again ''small windows'' and ''shaded windows'' in sentence 1 to 5, respectively. An approach like this yields various kinds of definitions: sometimes one of the substitutions is arbitrarily selected (''a kolper is a small window''), sometimes a few of them are concatenated (''a kolper is a small window, or a window high up in the roof, or a prisonlike window''). Some subjects look for a word meaning that comprises only the information that the different substitutions have in common which may lead to the conclusion that ''a kolper is a window, that's all I know for sure''; others try to find a word that captures all of the substitutions in a more general meaning, resulting in, for example, ''a kolper is a window with something wrong.'' This last way of constructing a definition may yet produce a fairly adequate result as in: ''a kolper is a window that transmits little light for one reason or another.''

A second indication for holistic model utilization is the rejection of the model as a whole in the face of contextual information that is not compatible with one of the model's aspects. An example is given by the subject who rejects ''window'' as a suitable model for ''kolper'' because the gist of sentence 5 (''it has to do with shadow'') in his eyes is in contradiction with the light-transmitting aspect of ''window.''

It was mentioned earlier that some sub-

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jects use local models for the various sentences. The analytically working subject isolates aspects from each of these local models to construct the eventual definition. Holistic model utilization, however, does not permit the retention of one component of a model if other components of the same model are rejected. The following protocol fragment illustrates the subsequent problem: "at first I thought it was a kind of window, but then in this other sentence it was a sunsheltering device, and in the last one it appears to be shadow, I can't make head or tail out of it." When asked to construct one coherent word meaning, the several local models must somehow be weighed. The options are mentioned above: One substitution can be selected as the most feasible one (e.g., "a kolper is a shutter"), a concatenation can be formed (e.g., "a kolper is an obstacle, or a tree, or a blind wall"), a formulation which incorporates the minimal overlap between the various substitutions can be chosen ("a kolper is sunsheltering") or a more general concept, encompassing all local models, can be formulated ("a kolper is a nuisance").

Summarizing we can say that when a model is utilized analytically, it is seen as a bundle of separable components, each of which can be handled in a relatively independent way to process the context into the direction of the new word meaning. Holistic model utilization, on the other hand, means taking or leaving the model unit as a whole; in consequence the subject is more dependent on the specific content of the sentences. Sentence-based hypotheses that are in conflict with the prevailing model do not lead to progress (e.g., revising or adding components of the model), they lead to crises: can the model somehow be sustained and saved or must it be rejected? Can the several local models be combined in a satisfactory manner or is it necessary to give up one model in favor of the other?

As we assumed that the analytic–holistic characteristic might be relevant for the categorization of the protocols (produced by high- versus low-verbal subjects) the protocols were scored independently by the two experimenters (per item over subjects). Analytic model use was given a score of 1 and holistic model use a score of 0. The interrater reliability was .88. By summing over items and judges each protocol received a model-utilization score in the range 0 to 6.

The products of decontextualization. The second feature on which the protocols were found to differ was the nature of the decontextualization products. An example will clarify this. From the third sentence (During a heat wave a lot of people all of a sudden want to have kolpers, so the sales of sun-blinds then reach a peak) the following data about the new word meaning were written down by different subjects:

—kolpers are much asked for during a heat wave.

—kolpers in some respects resemble sun-blinds.

—kolpers have a cooling effect.

The first inference is a reformulation of part of the sentence and does not go beyond the first step of the decontextualization process as described before; the second inference is the result of a (minor) transformation, and a substantial transformation has taken place to arrive at the third one. While outlining the ideal processing of a counterexample we have seen that in that case reformulations, minor transformations and substantial transformations of the sentence content can also be discerned. As this too seemed a relevant feature of the protocols, a scoring procedure was designed. The data written down during the experiment by the subjects, as a result of their decontextualization activities, were evaluated by the two judges per item. Reformulations were given a score of 0, minor and major transformations a score of 1 and 2, respectively. Each judge then computed a quotient per item by dividing the sum of these scores by the maximum to be obtained (i.e., the number of decontextualization products multiplied by 2, the maximum score per product). This quotient, converted to a percentage and averaged over the three items,

formed the Decontextualization score per judge for each subject. The interrater reliability was .86. Eventually the two scores were summed to obtain each subject's "decontextualization score," the possible total being 200.

The learning product. Given the two scores that reflect differences in the process characteristics it seemed wise not to neglect a more conventional indicator of the efficiency of a learning process: the quality of the learning product. Both judges scored the definitions that were formulated by the subjects. The judgements were based on four criteria: two for content and two for form, and were made with reference to the *norm:* the word meaning as intended by the experimenters, consisting of a superordinate and two specifications. The content criteria were:

a. Is the correct superordinate given (score 0–2)?
   The correct superordinate (e.g., "window" for "kolper") is given score 2 and a more general one (e.g., "device in a house") score 1; other "superordinates" that are too narrow, too general or wrong (like "fan") are not counted;
b. Are the correct specifications given (score 0–2, per specification)?
   A specification that is part of the norm (e.g., "transmits little light") or an equivalent thereof is credited with score 2, and statements in the direction of a specification ("half-specifications" like "shadowed") with score 1. Other additions to the superordinate (like "that can be opened" or "that gives no agreeable view") are disregarded.

The formal criteria were:

c. When is the superordinate mentioned (score 0–2)?
   Score 2 is given if the superordinate opens the definition ("a kolper is a window that. . .") and score 1 if it is stated only later, as an after-thought;
d. How conventional is the formulation if compared with what is usually found in a dictionary? (score 0–2). This conventionality comprises two aspects, length and wording:

d1. If the definition is short (25 words at most) 1 point is given and
d2. Another point is added if it is stated in customary terms.

Thus the maximum score for a learning product is 10.

Below, three examples are quoted from the protocols to illustrate the scoring:

1. "A kolper is a window that is in the shade for some reason, for instance because of a tree in front of it."

a.	"window" is the correct superordinate	2
b.	"in the shade" is considered a half-specification	1
	"for some reason, for instance, etc." is considered a half-specification	1
c.	the superordinate opens the definition	2
d1.	the definition is not too long (23 words)	1
d2.	and stated in customary terms	1
	total score	8

2. "A kolper is an object that causes shadow, has a (refreshing) "cooling" effect, is found (mostly) in summer, especially during a heat wave when they are "consumed" very much; in winter people are glad to get rid of them".

a.	"object" is too general	0
b.	"that causes shadow" is considered a half-specification of "transmits little light"	1
c.	the superordinate is given at the beginning	2
d1.	the definition is too long (39 words) and	
d2.	not very conventionally worded (as among other things the use of quotation marks indicates)	0
	total score	3

3. "A kolper prevents direct light; it is a construction in a house".

a.	the superordinate "construction in a house" is too general	1

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b. "prevents direct light" is seen as a half-specification	1
c. the superordinate is given at the end	1
d1. the definition is not too long (12 words) and	1
d2. conventionally worded	1
total score	5

All protocols were scored per item (over subjects) by both judges. The interrater reliability was .86. Again the final score per subject was computed by summing over items and judges, with a possible total of 60.

Prediction

We predicted that high-verbal subjects would achieve higher scores than low-verbal subjects on the three measures model utilization, decontextualization, and learning product, as high verbals were expected to act in accordance with the ideal process to a larger degree than low verbals.

We now obtained the verbal comprehension scores of the subjects. Our prediction was tested by application of the one-tailed Kolmogorov–Smirnov test for small samples (Siegel, 1956). This nonparametric test is suitable for the comparison of two distributions of scores, which are both samples. The hypothesis H_0 is that the two distributions arose by random sampling from the same population.

Results

With eight cases in each distribution statistic K, being the largest difference between the cumulative distributions in parallel categories on the score scale, must be as large as 6 or larger to be significant at the $\alpha = .01$ level. As the values of K are 7, 6, and 3 for model utilization, decontextualization, and learning product respectively, the difference between high- and low-verbal subjects is significant for the first two measures, but not for the third one.

To give the reader an impression of the magnitude of the effect, the means for the various conditions are given in Table 1. From the results we tentatively conclude that:

1. High-verbal subjects predominantly use semantic units in the way we have called analytic, whereas low-verbal subjects do this holistically.

2. High-verbal subjects perform substantial transformational operations on the sentences, whereas low-verbal subjects often do not go beyond superficial reformulations of the sentence contents.

3. The different approaches do not lead to (significantly) different learning products.

Discussion

The findings suggest that the approach of the typical high-verbal subject approximates the ideal acquisition process as hypothesized in analogy to Winston's program. The subjects do indeed use models and they gradually adapt these in the light of the presented examples and counterexamples ("near misses"). The description of the ideal process can be supplemented, however. It should be noted that the model is of crucial importance in the transformational operations indicated earlier as the "decontextualization process." The prevailing model guides the processing of the presented semantic information by representing descriptions that can be tested and slots that are to be filled. The way the model directs the description of the presented information is not described in Winston's program. Its prevalence in the protocols of our subjects is presumably related to the fundamental characteristic of the used materials, that is, to the ambiguity of semantic information. Out of the many possible reformulations of the sentence content the subject must choose one, and the model serves to guide this process. The first reformulations are made *in anticipation* of the next ones and the ambiguities are solved in anticipation of the transformational operations which eventually lead to the adaptation or adjustment of the model. If a description steered by a general model does not succeed, the subject, like the program, makes an objective description of the sentence. Note, again, that not infrequently a local model is used to aid this process. The most salient aspect

TABLE 1
MEANS OF HIGH- AND LOW- VERBAL SUBJECTS ON THREE SCORES FOR THE EFFICIENCY OF THE WORD MEANING ACQUISITION PROCESS

	Model utilization score[a]	Decontextualization score[b]	Learning product score[c]
High (n = 8)	4.5	52.3	50.9
Low (n = 8)	1.0	27.8	45.3

[a] Possible total: 6.
[b] Possible total: 200.
[c] Possible total: 60.

of such a model is then selected to become a part of the new word meaning. As for the near-miss sentences, a typical high-verbal subject processes these in a way that is very similar to what the program does; an example is given in the following protocol fragment produced for sentence 5 (sentence 5: In these houses you're stuck with kolpers all summer, but fortunately once the leaves have fallen that isn't so any more): "... it is said here that there are kolpers during the summer ... and as soon as the trees are leafless there are no more kolpers ... yes ... I think a kolper is a window ... obviously a window doesn't vanish in winter ... what does vanish is the shading effect of the tree ... so apparently a kolper is only a kolper if there is something shading it...." As a result of this reasoning the subject writes down: "there has to be something that shades the window." As a product of decontextualization this statement is credited with a score of 2. This subject indeed may be said to add a must-be pointer to the second specification in the meaning of "kolper."

The typical low-verbal subject approximates the ideal process to a lesser degree. He too uses models to solve ambiguities. However, step 1 of the hypothesized decontextualization process, the reformulation of the sentence content in order that it is brought to bear directly upon the neologism, is guided less stringently by the model. The model delimits the domain for the new word meaning, but imposes no further constraints. The task at hand is to find a reformulation that is not contrary to the model. If such a reformulation is found it may serve to delimit the domain some more; if it is not found the prevailing model is no longer of use and a new model is chosen. This procedure is compatible with the conception of the word meaning as an indivisible whole. The model can be maintained, replaced, or rejected; it does not represent a bundle of components that can each be maintained, replaced, or rejected. In this respect the model differs from the model in Winston's program and the model in the high-verbal subject's protocols. In consequence the low-verbal subject meets problems and tasks not described by Winston nor by our hypothesized ideal process. The following fragment shows how a low-verbal subject who sticks to his model handles a near-miss sentence: "... once the leaves have fallen it isn't so that you're stuck with kolpers ... so when you've got kolpers in summer ... you don't have them in winter ... strange ... I thought it had to be some kind of window but ... a vanishing window ... I don't know what to make out of that...." This subject writes down: "kolpers are found only in summer" which gets score 0 as a product of decontextualization, as no information transformation has taken place. The problems met by the low-verbal subjects will not be described in more detail here. They are mainly weighing and decision problems. It is noteworthy that the low verbals do remarkably well in the learning task. The learning product score is not significantly different from the high-verbal subjects' scores.

It may be concluded that Winston's program provides a frame of reference that proves fruitful in the description of the word meaning acquisition processes of our subjects. The description points out the

similarities as well as the essential differences between the program's handling of perceptual information and our subjects' handling of semantic information. Also, some differences between the processes of high and low verbals are brought to light. As it seemed both necessary and worthwhile to replicate and supplement the findings, a second experiment was designed.

Our first concern was the replication of the findings that high- and low-verbal subjects can be discriminated on the basis of the protocol characteristics: "model utilization" and "decontextualization product." In the second place we wished to obtain more information on the learning product scores of high- and low-verbal subjects. In the third place we were eager to find some additional support for the analytic versus holistic distinction concerning the models used by high- and low-verbal subjects. In order to get this information an additional task was given to the subjects. This task and its rationale will be described in the following paragraph.

EXPERIMENT 2

Design

The design of Experiment 2 differs from that of Experiment 1 in two respects. First, each neologism's superordinate was presented to the subjects as a part of the instruction. In other words, a model unit was presented. The rationale for this change in instruction is that differences in model utilization were expected to come out even more clearly when all subjects use the same (given) model units. So before handing out the booklet with the sentences for "kolper" the experimenter would say: "the word "kolper" refers to a kind of window. Your task is to find out what kind of window it specifically refers to." In the booklet the question printed under each sentence now ran: "What does this sentence tell you about the kind of window the word "kolper" refers to?"

Secondly, an additional task was given to the subjects. After completion of the learning task they were asked to define each of 10 well-known words while thinking aloud and to subsequently write down the definition; 3 of these 10 words were the superordinates for the neologisms, among which was "window." If the analytic–holistic distinction holds true, it must be reflected in the word definitions in a predictable way. High verbals were expected to produce a relatively clearcut conventional definition (a superordinate followed by some specifications). Low verbals were not expected to match this norm so closely; not because they are not perfectly aware of the meaning of a well-known word like window, but because it is quite a challenge to make a description of a semantic unit that is essentially an indivisible whole. If a subject does not readily dissociate word meaning components in the word meaning acquisition task he might show this characteristic in the word meaning definition task as well.

Fourteen subjects were recruited by an assistant, in the way described for Experiment 1. The experimenters again did not know which of the 14 subjects belonged to the high- or low-verbal group.

Scoring Procedures

By now we knew exactly what to score:

1. Model utilization. Scored per item per subject per judge. Score 1 was given if the given superordinate (e.g., "window") was handled as a bundle of components from which separate components can be dissociated, and/or if the processing of the contextual information was governed by the model, leading to adaptation of the model's components. Score 0 was given if the presented superordinate was used to delimit a domain of meaning and if the processing of the contextual information provided a test on the adequateness of a model that could either be sustained or rejected (and replaced by another model). The interrater reliability proved to be .82.

2. Decontextualization score (scored and computed in the way described for Experiment 1). The interrater reliability was .88.

3. Learning product score (see Experiment 1). The interrater reliability was .88.

4. Definition score. The definitions of the 10 word meanings were scored on the basis of the same criteria for content and from as the neologism definitions. The norms had to be constructed; in some cases alternatives were asked for. For "window," for instance, the superordinate can be chosen on the basis of structural or functional information and the specifications are related to this first choice. Two examples of subjects' definitions for "window" are given below, each followed by the scores obtained.

1. "A window is a glass partition, providing light inside and giving a view on the outside world."
   - a. "a glass partition" is an acceptable superordinate 2
   - b. "providing light" and "giving a view" are correct specifications according to the norm) 2 + 2 = 4
   - c. the superordinate is given at the beginning 2
   - d1. the definition is not too long and 1
   - d2. worded in conventional terms 1

   total score 10
2. "A window has a form (square or round) and can be divided into smaller parts, it can be opened, there are curtains to prevent people from looking inside, it is a part of the wall".
   - a. "part of the wall" is an acceptable superordinate 2
   - b. no specifications or half-specifications are present 0
   - c. the superordinate is only given at the end 1
   - d1. the definition is too long but 0
   - d2. stated in conventional terms 1

   total score 4

The interrater reliability was .85. The final definition score per subject was computed by summing over the 10 items and the two judges, with a possible total of 200.

Prediction

We predicted, once again, that high-verbal subjects would achieve higher scores than low-verbal subjects on the four measures. The verbal comprehension scores of the subjects were obtained. As in Experiment 1 the one-tailed Kolmogorov-Smirnov test for small samples was applied to the data.

Results

For model utilization and decontextualization K has a value of 6, which is significant at the $\alpha = .01$ level with seven cases in each distribution; for learning product and definition score the value of K is 5, which is significant at the $\alpha = .05$ level. An impression of the magnitude of the effect can be gained from the means for the various conditions, presented in Table 2. As the difference between high- and low-verbal subjects is significant for all four measures, the results of Experiment 2 lend support to our previous findings that the protocols of high- and low-verbal subjects can be discriminated on the basis of the process characteristics "model utilization" and "decontextualization product." This is to say that two groups of subjects, composed on the basis of scores that essentially represent the quantity of the students' word knowledge, differ qualitatively in a task which requires knowledge about words known to all students. The implications of this result will be discussed below. First, it must be observed that in Experiment 2 the low-verbal subjects do not keep up with the high-verbal subjects on the learning product score. The minor difference in Experiment 1 reached statistical significance in Experiment 2. The small number of items (in both experiments) may well be responsible for the instability of the results. The findings suggest, however, that it is very difficult for the low-verbal subjects to equal the learning products of their high-verbal fellow students. Finally, the scores on the word meaning definition task confirm the hypothesis. High-verbal subjects give definitions more in accordance with the "conventional norms" than the low-verbal subjects do. Again, it should be kept in mind

TABLE 2
MEANS OF HIGH AND LOW VERBAL SUBJECTS ON THREE SCORES FOR THE EFFICIENCY OF THE WORD MEANING ACQUISITION PROCESS AND ONE WORD MEANING DEFINITION SCORE

	Model utilization score[a]	Decontextualization score[b]	Learning product score[c]	Definition score[d]
High (n = 7)	4.7	63.0	51.4	167.1
Low (n = 7)	1.4	33.4	34.7	125.0

[a] Possible total: 6.
[b] Possible total: 200.
[c] Possible total: 60.
[d] Possible total: 200.

that the target words are quite well known to low- and high-verbal subjects.

GENERAL DISCUSSION

We can now give some preliminary answers to the questions raised in the introduction. Regarding the nature of the transformational operations we conclude:

1. In a word meaning acquisition task, the processing of the contextually presented information is guided by models. An initial model is chosen on the basis of the interpretation of the new word's meaning in the first sentence and subsequently this model guides the search for relevant information.

2. The processing of each new piece of information can lead to an adjustment or filling of one of the model's slots and the initial model can (temporarily or permanently) be replaced by a new model.

3. To act efficiently as a target structure (a structure that actually guides the abstraction of relevant information from the presented sentences) the model has to meet one prerequisite. It must unequivocally state its description so as to enable the subject (or the program) to actively search for the relevant information and to evaluate if and how the data fit into the model. If this prerequisite is not met (as in our low-verbal subjects) the model-based search is readily overruled by sentence-based processes; in this case, the sentence meaning is reformulated so as to bear directly upon the neologism (step 1 of the decontextualization process hypothesized in the description of the ideal process) but the second transformational operation is omitted. The information is not transformed so as to fit one of the slots of the provisional model.

4. In consequence, the high- and low-verbal subjects do not construct the neologism's meaning in the same manner. The high verbals act in accordance with the ideal process (and thus with Winston's program). The processing of each piece of information is aimed at filling or refining the initial model; the transformed sentence content is put to use to fill slots, to add must-be pointers and the like. When the fifth sentence is processed the (by now refined) model equals the subject's conception of the neologism's meaning. In low-verbal subjects, however, the various sentence-based word meanings coexist and compete with the initial model, as do the occasional local models. Before a definition can be formulated a weighing process has to take place. As the sentences are no longer available, the subject has to sum up whatever he remembers so as to evaluate how strong the evidence for the various hypotheses exactly was. There can be several outcomes of this weighing process (the neologism's definition), depending on the relative strength of the hypotheses and on their compatibility with the competing models.

The second question pertains to the relation of the efficiency of the transformational operations to the relevant stored knowledge of the learner. We may safely assume that all subjects know enough about

windows and the like. Differences are not to be sought in the amount of knowledge but in its organization. Here we should like to refer to the discussions in artificial intelligence about competence versus performance and declarative versus procedural knowledge representations (Winograd, 1975; Pratt, 1977; Wielinga, 1978). The gist of these discussions is that the better understood a particular knowledge domain is, the better this knowledge can be represented in a declarative instead of procedural form, and the more one can say about the competence underlying performance. In other words, there is a correspondence between the simplicity of procedures, executed on knowledge units, and the degree of structure of those units. We hypothesize that a similar relation holds for our subjects, which means that analytic model utilization, demonstrated by high verbals, is made possible by a well structured knowledge representation (e.g., in the form of what Bobrow & Winograd, 1977, would call a set of "descriptions"). This degree of structure of the available knowledge might well be of utmost importance in the semantic domain. In the handling of word meanings one of the main problems is to maintain a certain invariance of meaning, however widely the specific meanings of a word may differ in various contexts (Elshout, 1978). The flexibility in the attachment of meanings to words must be tremendous, but on the other hand, the complexity and ambiguity of the information must be somehow reduced. The word meaning representations of our high-verbal subjects are up to the demands in the word meaning acquisition task as well as in the word meaning definition task:

1. the model serves as a retrieval plan for the actualization of knowledge (we have seen evidence for this in the definitions for well-known words);
2. the model functions as a schematic anticipation (Selz, 1924) for a new word meaning (witness the utilization of models during acquisition);
3. the model embodies a plan for efficiently coding information about a new word meaning (see the learning products) and reduces memory load.

The one characteristic that our experiments show to be critical in regard to the efficiency of the model in these three respects, is that the model's components are *not* interwoven in a way to *prevent* useful operations on each of the components separately. This is not to say that the interrelatedness of the various word meaning aspects is denied by the subjects. The point is that the internal organization permits one component to be described without necessarily activating several others at the same time. Moreover, it permits one slot to be filled or emptied without any direct need to rearrange the whole structure or to adjust or adapt the other components. This quality of the organization of the word meaning representation is certainly no all-or-none affair. Subjects who are neither high nor low in verbal comprehension will probably proceed in a way that is in accordance with the analytic approach to a greater or lesser degree.

Finally, it should be kept in mind that the conclusions of the reported research are restricted. The "holistic approach" is most probably not shown to full advantage in the experimental tasks. We do not conclude therefore that, in general, high-verbal subjects prefer the "analytic approach." It is merely stated that the high-verbal subjects were observed to use the "analytic approach" in the experimental tasks and that it was profitable for them to do so. Moreover we suggest that the experimental findings can probably be generalized: under real life conditions, calling for the acquisition of new word meanings from contextual information, it may likewise be profitable to have available word meaning representations which permit analytic use. During the experimental period the gain of the high verbals in learning product score was small, but it can be easily imagined how small gains accumulate in the long run. The "holistic approach" on the other hand may show its merits under different conditions,

not embodied in the present experiments. It remains to be seen whether, under those conditions, the high-verbal subjects switch to an appropriate "holistic approach" and, once again, profit from the presumed well-structuredness of the word meaning representations.

Summarizing, it is concluded that the present research adds something to the already available knowledge about "what it means to be high verbal" (Hunt, Lunneborg, & Lewis, 1975). Being highly verbal means, among other things, that word meanings can be utilized as units, composed of word meaning components which can be operated on separately. Further research under conditions in which the analytic approach is not profitable or even unprofitable, is needed to decide whether the medal has a reverse side. A second intriguing research question is whether low verbals will profit from a training in the high verbals' strategies.

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