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Centering on figurative features during the comprehension of sentences describing scenes

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Summary. Subjects were asked to read sentences which described scenes containing objects. In the scene described in each sentence, a specific part of a particular object was necessarily implied as having an important role. The object was named but none of its parts were. The assumption was that the subjects, while processing the sentence and immediately afterward, would cognitively "center" on the important part, as a function of the context created by the sentence. Immediately after reading the sentence, the subjects were probed with a picture of either the important part, or of an unimportant part of the object. Judgments of the compatibility of this picture probe with the sentence were faster for pictures of important parts than for pictures of other parts. This was taken as supporting the hypothesis of cognitive centration. In a second experiment, in which words were used as probes instead of pictures, a purely verbal process to account for the results was ruled out. In a third experiment, subjects were given instructions to intentionally form visual images of the scenes described by the sentences. In this case, overall response times to the picture probes were shorter than in the absence of such instructions, but this decrease was greater for pictures of unimportant parts. This finding was interpreted as showing that imagery instructions increase the rate of activation of features to varying degrees as a function of the previous level of activation.

Most researchers interested in the psychological meaning of sentences would probably agree that this meaning is the end product of elaboration processes which take place during comprehension. The main function of these processes is to assemble, presumably by predication, different units of meaning retrieved from some kind of semantic store, after processing of perceptual information obtained from discourse or text. However, aside from those processes that may be considered specific to comprehension, such as lexical access, identification of syntactic structures, and predication, more general ones may also take place. Among these, selective attention, which enters into a wide range of psychological activities, is certainly involved in comprehension. In this paper, we will mainly deal with a particular form of selective attention, we have termed "selective activation", or "centration", with the assumption that it applies to lower-level meaningful units of sentence meaning.

The first question is whether such a selective process can be directly evidenced in tasks involving comprehension, and if indeed this is the case, what kinds of meaning units such a process can act upon. It is generally assumed that during comprehension or subsequent memorization of discourse, selective processing may be applied to relatively large units of meaning, such as those conveyed by sentences or phrases, as well as by words (cf. Clark & Clark, 1977; van Dijk & Kintsch, 1983; Le Ny, 1979; Le Ny, Carfantan, & Verstiggel, 1982). Does selective activation act on infra-lexical units of meaning, namely semantic features, as well? The research presented here was designed to investigate the selective activation of such semantic features assumed to deal with the content of sentence describing scenes.

Whether lexical meaning can be decomposed into lower-level units is a very controversial issue. An extreme view – far removed from ours – is that semantic information is stored in the form of features *instead* of lexical units. Under this assumption, often referred to as a "constructivist" view, the token meaning of any word occurring in a sentence is *constructed* during processing from elementary lower-level features. In this view, there are no lexical meanings that would correspond to all occurrences of the word. However, although we do not deny the existence of lexico-semantic units, we assume that some kinds of lower meaning units, that is, some kinds of features, also exist, and that selective activation may act on these.

The basic assumption of our model is that, as regards word meaning, the most elementary significant cognitive units that must be taken into account are these features. Thus, semantic representations activated by lexical items are assumed to be stored in the human mind not only as units in their own right, but also as composite structures in which more elementary units, the semantic features, reflect properties or parts of the corresponding objects or sets of objects. For instance, the type representation potentially activated by the word *eagle* would include semantic features such as HAS BEAK, HAS WINGS, HAS CLAWS, IS BROWN, HAS EYRIE, IS WILD, IS DANGEROUS. Some of these features may also contribute to other semantic representations, but in the present example their particular arrangement in someone's mind is assumed to constitute, as the end product of former learning processes, the semantic type representation (or meaning) of *eagle*. This componential structure of semantic representations is essential to the idea of selective activation developed below.

One important characteristic of some semantic features in cognitive representations of objects is their relatedness to physical, perceptible aspects of the objects represented. It is clear, for instance, that among the features that are assumed to

Offprint requests to: M. Denis or J.-F. Le Ny constitute the semantic representation of *eagle,* some, such as HAS BEAK, HAS WINGS, HAS CLAWS, IS BROWN, directly refer to physical properties or parts of eagles, that is, properties or parts that have in some way been perceptually experienced by the individual. These features have been characterized as "figurative features" (see Denis, 1979, 1982; Hoffmann, 1982), in that they clearly refer to aspects of the *appearance* of objects. As a corollary, such aspects can be illustrated in pictures of these objects. Furthermore, they can readily be assumed to have imaginal counterparts in the visual images that people form of these objects. In fact, the richness of semantic representation in such figurative features is actually predictive of the imagery value of the corresponding words, as well as of the latency of image formation (Denis, 1983; Hoffmann, Denis, & Ziessler, 1983). According to the same criterion, other features cannot be qualified as "figurative". In our example, this would be the case for IS WILD or IS DANGEROUS. Although many people claim they can visualize, or draw pictures that reflect the wildness or the dangerousness of eagles, it appears that they do so only through some associative elaboration. Thus, imagery of the corresponding properties is not directly figurative, as is imagery for HAS CLAWS or for IS BROWN.

Figurative features can be experimentally evidenced more frequently in the meaning of so-called "concrete" words, that is, words denoting physical, visible objects, as our example of *eagle* does, whereas a larger proportion of non-figurative features can be found in the meaning of so-called "abstract" words (e.g., Denis, 1983). Figurative features themselves may be further differentiated. For instance, a distinction can be made between features reflecting properties such as color, size, texture, and the like (as IS BROWN for *eagle*), and spatial features reflecting parts of objects (as HAS WINGS, etc.). The salience of figurative features, especially "part-of" features, in the cognitive representation of objects has been documented in several experimental studies (e.g., Katz, 1978, 1981; Schreuder, Flores d'Arcais, & Glazenborg, 1984; Tversky & Hemenway, 1984; see also McKoon, 1981).

As an introduction to the experiments reported here, the following three relevant points of the model are summarized below.

1. The decomposable semantic representations we are postulating should be considered not as simple unorganized sets of features, but as sets of features with an *internal structure*. There would be dependencies between features, such as those which reflect the spatial relationships between parts of objects. These dependencies can be expressed in predicative form. For instance, for *eagle,* BENEATH (CLAWS, WINGS) would specify the spatial relationship between eagles' claws and wings (when eagles are seen in their most typical orientation). We will not dwell further on this aspect in this paper.

2. Besides these specific relationships assumed to occur in the representation, a more general property of features should be noted, namely, their *degree of salience.* Since all features in a representation are not equally salient, it is convenient to consider in any type representation an internal salience hierarchy of its features. For a given type of representation, this hierarchy may presumably be captured through a standard experimental method; for instance, subjects are presented with an out-of-context token of the word, and asked to give descriptive words or phrases attributable to it in response (e.g., Ashcraft, 1978; Denis, 1983; Hoffmann, 1982; Rosch, Mervis, Gray, Johnson, & Boyes-Braem, 1976; Tversky & Hemenway, 1984). For instance, for *eagle, claws* is given more often than *eyes*; furthermore, *claws* is more frequently listed before than after *eyes* (Denis, unpublished data). This may be taken as an indication that for most subjects the feature HAS CLAWS is more salient than HAS EYES in the type representation of eagles.

3. A very important aspect of our model is that the hierarchy of any set of features belonging to a type representation is *flexible,* that is, it may be transiently reorganized when this type representation is activated into a certain token representation. Such reorganization is assumed to depend on factors such as the linguistic or extra-linguistic context, and, more generally, subjects' spontaneous or induced cognitive orientation (Barclay, Bransford, Franks, McCarrel, & Nitsch, 1974; Denis, 1984; Johnson-Laird, Gibbs, & de Mowbray, 1978; Le Ny, 1979; Tabossi, 1982; Tabossi & Johnson-Laird, 1980). For instance, in Barclay et al.'s (1974) investigation, it was shown that the expression "something heavy" was a better cue for remembering than "something with a nice sound" when subjects had heard the sentence *The man lifted the piano,* whereas just the opposite was found when subjects had heard the sentence *The man tuned the piano.* In this investigation, semantic flexibility was studied in situations involving solely verbal material and features corresponding to properties of the referred objects. Flexibility was evidenced with respect to long-term memory by using variations of cue efficiency.

The experiments presented below focused mainly on the property of flexibility, applied to the category of figurative features in the cognitive representations of objects, and more specifically to the subcategory of "part-of" figurative features. In addition, these experiments were directly concerned with sentence processing in comprehension, more precisely with the nature of the transient representation constructed in a subject's mind immediately after reading and comprehending a sentence.

In what general way may selective activation, or centration, be hypothesized to work in sentence comprehension, given the above-mentioned assumptions about representational structures? In this framework, centration may be assumed to work not only by activation of lexical meaning units corresponding to the words present in the sentence, but also by activation of meaning units corresponding to parts of the objects referred to, even though no use of words denoting these parts has been made in the sentence.

Let us consider two sentences containing the word *eagle*:

1.1 *The eagle suddenly swooped down to the earth and snatched the weasel*;

1.2 *The eagle soared slowly and majestically into the heavens.*

According to the hypothesis of centration, readers of sentence 1.1 are expected not to activate equally all the features that compose their cognitive representations of eagles, earth, and weasels (i.e., everything they know about them); with regard to *eagle*, for example, it is assumed that readers would center their cognitive processing more readily on some kind of representation of eagles' claws than eagles' wings. Conversely, it is assumed that people reading sentence 1.2 would center on eagles' wings rather than claws.

These assumptions were tested in a first experiment using a variant of the sentence-picture paradigm.

Experiment 1

In Experiment 1, subjects had to read sentences which described events involving one or several objects. Each sentence described a scene in which a specific part of a particular object was implied as playing an important role. The object was named in the sentence, but none of its parts were. It was hypothesized that the subjects, while processing the sentence and immediately afterward, would cognitively "center" on the (in the context) important part. Immediately after reading the sentence, the subjects were shown a picture of either the important part of the object or an (in the context) unimportant part of it. Subjects were instructed to judge whether or not the picture illustrated a part of an object present in the scene described. Thus, the (context-dependent) part importance was the main factor of this experiment. Response times were measured. On the basis of the hypothesis of cognitive centration, it was predicted that the subjects would more quickly judge the picture of the important part to be compatible with the sentence than they would the picture of the unimportant part of the same object.

Some other, possibly relevant factors that are sometimes involved in experiments using judgment times for pictures must also be taken into account, for example, the strength of association between the part and the object to which it belongs, or the identifiability of the pictures themselves. For this reason, every sentence was paired in the design with another sentence in which the same object was named but a different part was implied as important. This procedure was intended to provide an internal cross-control that did away with the need to systematically check object-part association. The identifiability of the pictures was controlled in preliminary experiments.

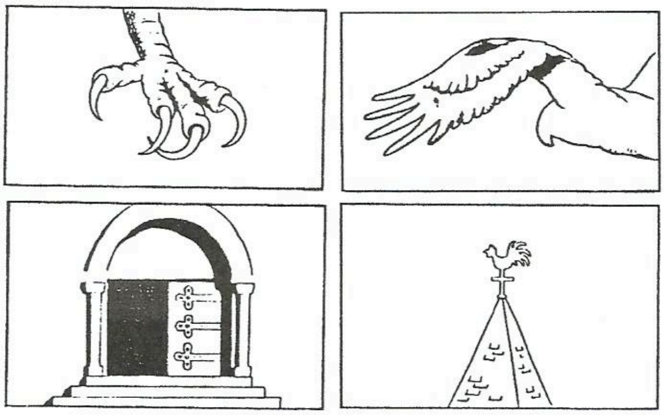

Fig. 1. Examples of pictures used in the experiment

Method

Materials. Sixteen nouns referring to objects with identifiable parts were selected as "themes". For each theme-noun, two short sentences describing scenes were constructed; in each sentence, an important role was implied for a specific part of the object referred to by the noun. In addition to the example given above (with the theme-noun *eagle*), here is a pair of sentences with the theme-noun *church:*

2.1 *Every Sunday morning at Cormainville church a beggar stood, holding out his hand to people coming out after the mass* (intended to imply an important role for the church's porch);

2.2 *As Cormainville came into view, the first building one could see was the church, proudly dominating the roofs of the village* (intended to imply an important role for the church's steeple).

The mean number of words per sentence for the original 32 sentences in French was 16.4.

Black-and-white line drawings, each illustrating one of the object parts assumed to be implied by a sentence, were prepared and photographed in slide form. The implied part was always a physically centered detail of the object illustrated as if it were seen through a window or a viewfinder (see Figure 1). For a given object, the two pictured parts were arbitrarily called *a* and *b*, and the corresponding sentences were likewise called *A* (implying part *a* as important) and *B* (implying part *b* as important).

These materials were used as "positive items". Sixteen extra sentences describing scenes were prepared, as well as 16 pictures illustrating parts of objects not referred to by any noun in any of these 16 sentences. These materials were used as "negative items", or distractors.

Preliminary experiments. In two preliminary experiments, pictures designed to be used as positive items were checked for identifiability. In the first one, the pictures of an entire set, that is, all *a* or *b* pictures, were presented in succession on a screen for the subjects to identify. The 24 subjects participating in this experiment belonged to the same population of subjects as those used for the main experiments described below. The subjects were requested to identify the pictures, and to press a button (with their preferred hand) as soon as they had identified what was illustrated in these pictures. Instructions stressed that the subjects were not required to think of the specific name of the pictured object before pressing the button, but were to press it as soon as they had recognized the picture, even if no particular label came immediately to mind. However, they were requested to give a verbal response after having pressed the button.

In the second preliminary experiment, all the *a* or *b* pictures were presented to another group of subjects drawn from the same population ($n = 16$). Each picture was preceded by the written noun of the object whose picture illustrated a part. For instance, the noun *eagle* appeared on the screen; then, after an interval of 1.5 s, a picture appeared of either an eagle's claw or an eagle's wing. Subjects were instructed to press a "yes" button (with their preferred hand) if the picture matched the word and a "no" button (with their other hand) if they thought that the noun and the picture were unrelated. Sixteen "negative" items were interspersed among the positive items. A negative item was an object noun followed by a picture of an apparently unrelated object part. The negative items were in all other respects similar to the positive items.

Analysis of the data from the preliminary experiments indicated that: (a) The overall error rate was very low (0.021 in the first experiment, and 0.008 in the second). This was considered as showing that the pictures were highly identifiable. (b) There was no overall significant difference between the mean response times for the positive items in the two experiments (799 ms and 817 ms, respectively). This was interpreted as a further indication of high noncontextual picture identifiability, since the presentation of a previous relevant object noun did not prime identification.

Design of the main experiment. For a given theme, the four possible types of sentence/picture pairing were prepared, namely, Aa, Ab, Ba, and Bb. Aa and Bb pairings are later referred to as C+ items, that is, items with high sentence/picture compatibility according to the hypothesis of cognitive centration. Ab and Ba pairings will be referred to as C- items, that is, items with low sentence/picture compatibility according to the hypothesis. In accordance with the instructions (which are presented below), all these pairings required positive responses and they thus constituted positive items. A given subject was shown only one of the four pairings for a given theme, with a Latin-square design allowing a total of 8 C+ (Aa or Bb) and 8 C- (Ab or Ba) pairs. Sixteen negative items, that is, sentence/picture pairs requiring negative responses, were randomly interspersed among the positive ones. Thus, the experimental material for each subject was a total of 32 sentence/picture pairs, 16 positive (with 8 C+ and 8 C-) and 16 negative. Four practice pairs (2 positive, 2 negative) were presented immediately before the 32 experimental pairs. The set of 4 practice pairs and the 16 negative pairs were the same for all the subjects, so that only the 16 positive pairs varied from subject to subject.

In all, four 32-item sets of experimental sentence/picture pairs were used, which were established as follows. A basic ordered set of 32 experimental sentence/picture pairs was randomly drawn up, in which the positive items were half Aa (C+) and half Ab (C-) pairs, with the constraints being (a) that there be no more than two pairs in succession requiring the same response, and (b) that each successive block (i.e., quarter of the set) contain 4 positive items (2 C+ and 2 C-) and 4 negative items. From this basic set, three other sets were derived by permutation of pairs within themes, with Aa pairs replaced by Ab, Ba, and Bb pairs, respectively, and with Ab pairs replaced by Aa, Bb, and Ba pairs, respectively. In addition, the positions of the items were partially permuted. For each of the four sets of items, presentation order I corresponded to the basic (random) order of the set, as defined above. From this presentation order I, presentation order II was derived by simple exchange of the two successive halves of the list. Presentation orders III and IV were derived by reversing presentation orders I and II, respectively. Thus the total number of subjects required by this design was a multiple of 16 (4 sets × 4 presentation orders).

Procedure. The subjects were examined individually. During the experimental session, they sat in front of a screen onto which slides were projected. They were told that they would be presented with sentences, which they would have to read carefully at their own rate in order to fully understand their meaning. They should then give the experimenter an OK response, signaling the end of their comprehension process; a picture would then be presented. This picture actually appeared approximately 1.5 s after the OK signal. The instructions mentioned that the picture either would or would not illustrate the preceding sentence. In the positive cases, the picture would be not of the whole scene described in the sentence, but of a detail, or a kind of close-up of the scene. In these cases, the response should be "yes". It should be "no" whenever the picture was unrelated to the sentence content. Subjects had to respond by means of two buttons ("yes" and "no"), and they were requested to use their preferred hand for "yes" responses. Subjects were instructed to respond as fast as possible, without impinging on accuracy. They were asked to correct wrong responses if they detected them. Pressing a button made the slide disappear. Response times were recorded by means of a timer, which was automatically started at the onset of the picture slide.

Subjects. Thirty-two subjects (9 male, 23 female) participated in this experiment, with two subjects in each cell of the design. They were students in introductory psychology from the Universities of Paris VIII and Paris-Nord, all volunteers, and all native French speakers.

Results

The overall error rate for positive items was 0.025; all the wrong responses were spontaneously corrected by the subjects, but the analysis of response times only took the originally correct responses into account. The mean correct response times for C+ and C- items for the four successive blocks of items are shown in Table 1.

Table 1. Experiment 1. Mean correct response times as a function of type of pairing in successive blocks (in ms)

	Block				
Type of pairing	1	2	3	4	Mean
C+	784	726	672	683	716
C–	898	788	811	731	807

Two analyses of variance were performed on these data, both having Types of Pairing (C+ vs. C-) and Blocks (1 through 4) as main factors.

The first analysis took Subjects as a random factor, crossed with Types of Pairing and Blocks; random observations were in turn nested within the Subjects × Types of Pairing × Blocks design.[1] According to this analysis, the response times for C+ pictures were significantly shorter than those for C- pictures, $F(1,31) = 37.08$, $P < 0.001$. The mean difference was 91 ms. Twenty-eight of the 32 subjects produced shorter mean latencies to C+ than to C- pictures. There was an overall decrease of response times through the successive four blocks of the experimental session, $F(3,93) = 8.58$, $P < 0.001$, with a significant linear trend, $F(1,93) = 23.09$, $P < 0.001$, and no significant interaction between Types of Pairing and Blocks, $F(3,93) = 2.16$.

The second analysis of variance was performed with Themes as a random factor, crossed with Types of Pairing and Blocks; random observations were nested within the Subjects × Types of Pairing × Blocks design. A significant effect was found again for Types of Pairing, $F(1,15) = 11.50$, $P < 0.005$. Mean response times were shorter for C+ than for C- pictures with 13 of the 16 themes. There was also a significant effect for Blocks, $F(3,45) = 8.11$, $P < 0.001$, with a significant linear trend, $F(1,45) = 21.82$, $P < 0.001$, and no interaction of this factor with any other.

Discussion

The main question in Experiment 1 was whether the response times for C+ pictures were shorter than those for C- pictures. The data clearly showed that they were. Such a result was predicted from the hypothesis of cognitive centration, applied to figurative features. The magnitude of this effect was consistent over successive blocks.

However, a crucial question was whether the effect was related to the use of pictorial stimuli. This aspect of the experi-

[1] Given the structure of this design, whicht is typical of those where F' statistics are not relevant according to Clark (1973, p. 348), only F values were computed here and in the analyses below

mental situation may increase the likelihood that readers will elaborate quasi-pictorial (imaginal) representations of the scenes described by the sentences in their working memory. Not very differently, in the theory of mental models (Johnson-Laird, 1983) or in rather similar views (see, for example, Perrig & Kintsch, 1985), it is assumed that understanding descriptive sentences not only involves the elaboration of some abstract, propositional representation of their meaning, but also the generation of some "model" of the concrete situations the sentences are about.

On the other hand, facilitation effects of sentential context on semantic decisions have also been evidenced in situations where solely linguistic materials were used as probe stimuli. For instance, in addition to Barclay et al. (1974) mentioned earlier, Tabossi and Johnson-Laird (1980) demonstrated that subjects were faster at producing and recognizing relevant characteristics of a word when it was preceded by a sentence which primed a particular aspect of the word's meaning, than by a nonpriming sentence (cf. also Barsalou, 1982; Tabossi, 1982).

Consequently it might be hypothesized that just after reading the sentence, subjects generated some purely linguistic representation of the object part implied as important by the sentence. For instance, after reading sentence 1.1, subjects could possibly continue the sentence with the implicit word corresponding to the most likely (relevant) instrument: ... *with its claws* (cf. Dosher & Corbett, 1982). In this case, when presented with a picture of claws, subjects would decide whether the implicit verbal response they have just produced applies to the picture. This would suffice to account for the observed C+/C- effect. Experiment 2 was designed to examine this possibility.

Experiment 2

If the verbal-account interpretation stated above is true, the C+/C- effect should at least hold – and perhaps increase – when subjects are required to judge the compatibility of word rather than of picture probes. To test this, Experiment 1 was replicated, with one additional condition: The sentences were followed by nouns designating the object parts the subjects were assumed to center on while reading the sentences.

In addition, if an implicit verbal continuation of the sentence is involved, the implicit verbal response would be matched more readily against word probes than against picture probes. Thus, responses to words would be expected to be faster than to pictures.

Method

Materials. Themes and sentence/picture pairs were identical to Experiment 1, except that every picture was required to have a nonambiguous, one-word verbal designation. Four themes had to be discarded because the corresponding pictures did not meet these requirements. Typewritten nouns, labelling the remaining 24 pictures, were photographed as slides, subtending approximately the same (horizontal) visual angle as the pictures.

Design. The design was similar to the design used in Experiment 1, with 12 positive (6 C+ and 6 C-) and 12 negative items, plus 4 practice items (2 positive, 2 negative).

A basic sequence of the 24 experimental items, with half Aa and half Ab pairs as positive items, was randomly set up. The only constraints were (a) that there be no more than two successive pairs requiring the same response, and (b) that the two successive halves of the list each contain 3 C+ and 3 C- pairs. Consequently, for a given block, half of the subjects were presented with 2 C+ and 1 C- items, while the other half was presented with 1 C+ and 2 C- items, in such a way that all subjects received a total of 6 C+ and 6 C- items during the experiment. The total number of C+ and C- items was equal across the whole design. From the basic set, three other sets were derived and permutations were completed as in Experiment 1, leading to a 16-cell Latin square.

Two conditions were used, that is, sentence/picture (S/P) and sentence/noun (S/N). Two independent groups of subjects were tested, one in each of these conditions.

Procedure. In the S/P condition, the procedure was exactly the same as in Experiment 1. In the S/N condition, the instructions were only modified to instruct subjects to respond "yes" whenever the noun referred to a part of the scene described in the sentence, and "no" whenever the noun was completely unrelated to the sentence content.

Subject. Sixty-four subjects (18 male, 46 female) belonging to the same populations as in Experiment 1 participated in this experiment. Each was randomly assigned to one of the two conditions.

Results

The overall error rate for positive items was 0.023 in the S/P condition (all errors being spontaneously corrected by the subjects), and 0.049 in the S/N condition (0.018 spontaneously corrected). The mean correct response times for C+ and C- items are presented in Table 2.

Table 2. Experiment 2. Mean correct response times as a function of type of pairing in successive blocks, for the sentence/picture and the sentence/noun conditions (in ms)

	Block				
Type of pairing	1	2	3	4	Mean
	Sentence/picture condition				
C+	852	734	740	713	760
C-	1020	889	828	745	870
	Sentence/noun condition				
C+	1037	943	934	958	968
C-	1057	1058	1000	1005	1030

As in Experiment 1, two separate analyses of variance were performed. The first had Subjects as a random factor, with Conditions as between-subject, and Types of Pairing as within-subject factors. Overall response times were shorter in the S/P than in the S/N condition, $F(1,60) = 11.44$, $P < 0.005$, and overall they were shorter to C+ than to C- items, $F(1,60) = 23.37$, $P < 0.001$.[2]

[2] In this particular analysis of variance, Blocks were not taken as a within-subject factor, due to the structure of the design described above

The main effects were confirmed in the second analysis, which had Themes as a random factor, with Conditions, Types of Pairing, and Blocks as main factors. Significant effects were found for Conditions, $F(1,11) = 26.91$, $P < 0.001$, for Types of Pairing, $F(1,11) = 12.25$, $P < 0.01$, and for Blocks, $F(3,33) = 8.83$, $P < 0.01$. There was a significant interaction between Conditions and Blocks, $F(3,33) = 2.93$, $P < 0.05$. This latter interaction reflected the fact that the response times decreased across blocks more sharply in the S/P than in the S/N condition.

A larger C+/C- difference was observed in the S/P than in the S/N condition (110 ms vs. 61 ms, respectively). However, the interaction between Conditions and Types of Pairing did not reach significance, $F(1,11) = 1.91$; planned partial comparisons showed that Types of Pairing had reliable effects in the S/P condition, with shorter response times for C+ than for C- items, $F(1,11) = 10.05$, $P < 0.01$, whereas response times for C+ items did not reliably differ from those for C- items in the S/N condition, $F(1,11) = 3.16$, $P > 0.10$.

Discussion

Experiment 2, involving both sentence/picture and sentence/noun conditions, confirmed that on the whole, response to C+ items were faster than those to C- items. The S/P condition of Experiment 2 produced the very same pattern of results as in Experiment 1. Response times were again shorter for C+ than for C- items. This further supports the hypothesis of selective activation of figurative features.

The somewhat higher absolute values of response times in Experiment 2 than in Experiment 1 could be due to the shortening of the list: Experiment 1 showed a strong effect of the position of items in the list, and it is therefore not surprising that when the last fourth of the original list had been deleted, the mean absolute response times for the whole list were longer. Furthermore, the apparently greater magnitude of the difference between response times for C+ and C- items in Experiment 2 than in Experiment 1 may be similarly accounted for. In fact, for the 12 themes common to both experiments, mean response times in Experiment 1 were 691 ms and 803 ms for C+ and C- items, respectively. This difference is quite similar to the difference observed in Experiment 2. In short, the replication part of Experiment 2 confirms the findings of Experiment 1.

The difference in response times for C+ and C- items was unreliable in the S/N condition. However, the interaction between Conditions and Types of Pairing was not significant. Thus, at this point, it cannot be claimed that replacing picture with nouns abolished the C+/C- effect. This finding indicates that selective activation may actually be involved in conditions of Experiment 2 when nouns are used as probe stimuli. However, as response times are shorter for picture stimuli than for verbal ones, it is doubtful that an implicit additional verbal continuation of the sentence was involved in the response. Such an operation would have produced an implicit verbal response, which would have been matched more readily against verbal probes than against pictorial ones. In addition, the fact that pictures elicited overall faster responses than nouns is in line with a number of findings, especially those which are taken as evidence that pictorial stimuli access mental representations of objects faster than verbal stimuli do (cf. Carr, McCauley, Sperber, & Parmelee, 1982; Irwin & Lupker, 1983; Nelson, Reed, & McEvoy, 1977; Rosch, 1975; Snodgrass, 1984).

Therefore (a) the data from Experiment 2 suggest that a hypothesis based on a purely verbal process cannot entirely account for centration; (b) the absence of any significant interaction between Conditions and Types of Pairing allows for an interpretation of the C+/C- effect in terms of a fairly general activation mechanism. Moreover, the results suggest that selective activation is more readily apparent when judgments are given on pictorial than on lexical stimuli.

If centration on components of representation does take place during the comprehension of sentences, it might be useful to formulate more detailed hypotheses about the nature of this process. What exactly does it mean that a subject's processor "centers" on the figurative features corresponding to the object parts implied as important?

Experiment 3

A local model of the processes underlying the situation under study may be presented as follows.

1. The features that are assumed to be involved in the transient representation constructed after sentence reading are activated to various levels: features corresponding to important object parts would be activated to a higher level than features corresponding to unimportant ones. Thus, matching them with a picture stimulus would be faster for the former category of features, producing shorter response times for C+ items.

2. As all these features are assumed to be figurative, such an activation hypothesis could be investigated through use of imagery techniques. For instance, instructing the subjects to intentionally imagine the scene described by the sentence should step up activation of such features, thus resulting in overall shorter response times: such a prediction derives from previously observed effects of imagery instructions on various aspects of sentence processing (e.g., Belmore, Yates, Bellack, Jones, & Rosenquist, 1982; Eddy & Glass, 1981; Paivio & Begg, 1971).

3. However, since according to the assumption made earlier the features would already be at various levels of activation, three alternative subhypotheses can be put forward concerning the effects of imagery instructions:

3.1. Heightening of activation is approximately equal for all features, thus producing an equal decrease in response times for both C+ and C- items;

3.2. Heightening of activation is greater for the centered than for the noncentered features, due to their level of importance; this would produce a greater decrease of response times for C+ than for C- items;

3.3. Heightening of activation concerns the noncentered features more than the centered ones; this could be the case, in particular, if the selective activation caused by centering in standard situations attains some kind of ceiling value; thus, the effect of imagery instructions would, in this case, result in both overall heightening and flattening of the activation levels; this would produce a greater decrease of response times for C- than for C+ items.

Experiment 3 was devised to test which of these subhypotheses on the various activation levels and the role of imagery instructions was the most pertinent. A new sentence/picture condition was used: it was similar to those in Experiments 1 and 2, except that subjects were now instructed to intentionally form a visual image of each scene described in the sentences. Data from this new condition were collected for a comparison with the data from the S/P condition in Experiment 2.

Method

Materials. Themes and sentence/picture pairs were the same as those used in Experiment 2.

Design. The design was exactly the same as for the S/P condition in Experiment 2. Subjects from the S/P condition in Experiment 2 served as the control group in Experiment 3. A new group of subjects was tested as the experimental group in a condition hereafter called the SI/P condition.

Procedure. The procedure for the SI/P condition was the same as for the S/P condition in Experiment 2, except for additional standard instructions to intentionally form a visual image of the scene described. These instructions emphasized that subjects would be asked to judge later whether the presented picture illustrated a part of the scene, or not, but in no case whether this picture matched their own image or not.

Subjects. Thirty-two subjects (6 male, 26 female) belonging to the same populations as those used in the previous experiments participated in Experiment 3.

Results

The overall error rate for positive items was 0.029 in the SI/P condition (0.023 spontaneously corrected by the subjects). Mean correct response times are presented in Table 3 for the SI/P condition.

The data from the SI/P condition were compared with those from the S/P condition in Experiment 2, in two analyses of variance whose designs replicated those used in Experiment 2.

With Subjects as a random factor, response times were overall shorter in the SI/P than in the S/P condition, but the difference did not reach significance. There was a significant overall effect of Types of Pairing, with shorter response times for C+ than for C- items, $F(1,60) = 26.50$, $P < 0.001$. Smaller C+/C- differences were observed in the SI/P than in the S/P condition, and an interaction between Conditions and Types of Pairing was found to have a reliability close to significance, $F(1,60) = 3.69$, $P < 0.06$.

In the analysis with Themes as a random factor, significant overall effects were also found for Conditions, with shorter response times in the SI/P than in the S/P condition, $F(1,11) = 33.57$, $P < 0.001$; for Types of Pairing, with shorter latencies to C+ than to C- items, $F(1,11) = 10.47$, $P < 0.01$; and for Blocks, $F(3,33) = 17.66$, $P < 0.001$. Smaller C+/C- differences in the SI/P than in the S/P condition were reflected in this analysis by a significant interaction between Conditions and Types of Pairing, $F(1,11) = 5.28$, $P < 0.05$.

Planned partial comparisons were also performed. While responses were significantly faster to C+ than to C- items in the S/P condition, $F(1,11) = 10.05$, $P < 0.01$ (a comparison previously made in the analysis of Experiment 2), there was no significant difference between the response times for C+ and for C- items in the SI/P condition, $F(1,11) = 2.06$. Lastly, according to partial comparisons between S/P and SI/P conditions, the imagery instructions did not significantly speed up responses to C+ items, $F(1,11) = 3.92$, $P > 0.10$, whereas in the case of C- items they did so, $F(1,11) = 38.61$, $P < 0.001$.

Table 3. Experiment 3. Mean correct response times as a function of type of pairing in successive blocks, for the sentence/picture condition with imagery instructions (in ms)

	Block				
Type of pairing	1	2	3	4	Mean
C+	803	731	711	681	732
C-	849	793	765	721	782

Discussion

Asking subjects to intentionally imagine the scenes described by the sentences produced an overall speeding up of further decisions about the appropriateness of pictures illustrating parts of these scenes. Such a result is in line with the findings concerning the positive effects of imagery on sentence processing.

However, the facilitating effect of intentional imaging was not equivalent for all probe stimuli, and C- items were more sped up than C+ items. This result is only congruent with subhypothesis 3.3 above. It goes along with the idea that activation during sentence processing may be produced at many various levels, and underly many various degrees of increment, depending on the characteristics of the processed text, of the situation, and of subjects' preparatory state elicited by instructions. Moreover, this result is in accordance with the idea of a ceiling level for such an activation.

General Discussion

In the experiments presented above, we examined the assumption that, after processing of a sentence, what is kept in a reader's recent memory about an object mentioned in the sentence depends on some cognitive "centration" performed by the reader during sentence comprehension on meaningful components of the corresponding representation.

The obtained data are compatible with three main ideas:

1. Lexical meaning components in a sentence – conveyed by words – are also processed at a sublexical level, corresponding to what is called "features" in this paper. This general result is in line with Barclay et al.'s (1974) previous results. It holds, in particular, as concerns figurative features. This additional set of data is compatible only with a componential view, and not with a purely lexical view.

2. Selective attention to, or processing of these features, depending on the context, may be shown by using probe picture stimuli. There is no evidence that this selective effect is due only to verbal implicit responses; it may be thought of as involving an *integrated perceptual-semantic representation*. In addition, the data from Experiment 3 illustrate the relevance of taking the role of imagery in the comprehension of concrete sentences into consideration (cf. Eddy & Glass, 1981; Glass, Millen, Beck, & Eddy, 1985).

3. The features can be activated at various levels, and receive various rates of additional activation. These degrees of activation depend on several different situational factors, including sentence context, and specific instructions; such degrees of activation appear to summate, in an unknown way, up to a maximum. Other results show that this activation also underlies a progressive decrease as a function of time in working memory (Le Ny et al., 1982; Le Ny, Achour, Carfantan, & Verstiggel, 1983).

In addition, our data clearly suggest that relevant sentence contexts can differentially activate (out-of-context) highly salient features of a semantic representation, and not only features that are the lowest in the hierarchical structure, as claimed by Barsalou (1982). However, a question which still has to be elucidated is that of the precise time a context-specific feature is first activated, that is, during reading of the target word, or at some later point in sentence processing (cf. Forster, 1981; Seidenberg, Waters, Sanders, & Langer, 1984).

Whatever the case, the experiments reported above have demonstrated that when one reads a sentence about an object, context, situation, and instructions selectively tune the representation which is transiently held in the mind just after processing. While in the present research the argument for cognitive centration was limited to spatial, figurative features, it may be the case that abstract, non-figurative features as well are affected by similar cognitive processing.

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