ABSTRACTING IDEAS FROM SENTENCES

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Acquisition sentences were constructed by combining three or fewer single propositions; four of which defined a main idea. Although the main idea sentence was not presented in acquisition, subjects reported having heard it in subsequent recognition testing. It is argued that the listener abstracted the idea during acquisition by integrating information from acquisition sentences. Idea abstraction, however, can be inferred only if the listener can distinguish between recognition test sentences. When probe sentences are discriminated from the acquisition sentences in recognition, the listener abstracts information about specific features of sentences in addition to their meaning.

Abstraction has a long philosophical history. The problem is perhaps rooted in the question of how a novel instance is recognized as a member of a class of previously experienced instances. The problem is even more acute when it is recognized that "all generic concepts extend over potentially infinite ranges of instantiations" (Weimer, 1973, p. 29). How can novel instances be classified as generically similar without their prior exposure? The emphasis of Platonic epistemology on the role of abstract identities suggested a possible answer. According to Weimer (1973)

> The only way known for organisms to make 'infinite use of finite means'—such as they do in recognizing an indefinitely large class of objects as members of the same concept—is to employ 'grammars' of perception or behaviour whose rules make use of abstract entities (p. 29).

The problem is without immediate resolution. Yet recent research indicates that the organization and classification of sensory input that characterizes abstraction is primary in perceptual and cognitive functioning. In the nervous system, for example, there is considerable reorganization of neural information as it is transmitted from one level to the next. At the retinal level, brightness gradients are classified as contrasting contours through lateral inhibitory interaction between retinal ganglia (Ratliff, 1965). In the visual cortex the single cell analyzers of Hubel and Weisel (1968) serve the organizing function of responding selectivity to specific features of the environment. Gestalt psychology presents countless instances demonstrating organization in perception and behaviour (Kohler, 1947). Such organization and classification makes sense if the organism is to deal with its environment in an *economical* fashion (Welford, 1968; Vickers, 1971).

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An important feature of organization or abstraction is that it is an active process of construction (Neisser, 1967). Bartlett's (1932) classic experiments demonstrating the constructive nature of perception and memory introduced Head's notion of schema into psychology. Schema formation is in fact just another way of describing abstraction. According to Bartlett 1932),

> Schema refers to an active organization of past reactions or of past experiences, which must always be supposed to be operating in any well-adapted organic response. That is, whenever there is any order or regularity of behaviour, a particular response is possible only because it is related to other similar responses which have been serially organized, yet which operate, not simply as individual members coming one after the other, but as a unitary mass (p. 201).

Schema formation is thus an active process of abstracting information about various aspects of the environment and integrating that information to form schemata. Because the schema is abstracted from the specific stimulus properties of the exemplars, the exemplars necessarily provide two kinds of information. First there is information concerning the absolute or specific stimulus features, and second there is information about relationships between the stimuli. It is the relational aspect which is constructed in the schema. Consider for example what happens once a subject has experienced a number of different triangles. When a novel triangle is presented, it is perceived in relation to the specific instances encountered before, and also in relation to the relationship of triangularity which integrates the previous instances. If the subject has to remember what triangles were presented to him, then he retains information about the specific triangles and he also retains the schema for triangle.

In Experiment I, it was asked what happens when the experimental conditions are chosen to maximize retention of the specific exemplars. If retention of the exemplars is not emphasized, is a schema abstracted? The present experiments employed a procedure devised by Bransford and Franks (1971) for examining abstraction of ideas from sentences. Four sentences, each expressing a single proposition, are combined to produce sentences containing two, three and four propositions. The sentence combining all four propositions (the FOUR) embodied the "idea" to be abstracted in the first phase of the experiment. In the first phase, the subject listens to sentences combining one, two or three propositions. In the second phase, the previous sentences are presented along with the novel FOUR. If the subject most confidently and most frequently recognizes the FOUR as having been heard before, then abstraction is inferred. That is, it is assumed that during the first phase the subject abstracted the idea represented by the FOUR sentence from the information provided by the sentences containing one, two or three propositions.

In a review of research using their method, Bransford and Franks (1972) reaffirmed their conclusion that subjects both recognise and recall sentences which were never experienced in acquisition but which were derivable from the semantic structures acquired. Abstraction was demonstrated for both concrete (Bransford and Franks, 1971) and abstract (Franks and Bransford, 1972) sentences and for prose (Bransford and Franks, 1972) and logical relations (Bransford, Barclay and Franks, 1972). Singer and Rosenberg (1973) confirmed that a listener integrates the linguistic information he receives, and in particular behaves as a "very active processor of linguistic input, not only integrating, but also pruning or emphasizing portions of the received information" (p. 283). Franks and Bransford (1971) have also applied their method in demonstrating the abstraction of schemata from geometric shapes.

EXPERIMENT I

Experiment I examined the extent to which linguistic ideas were abstracted when retention of specific exemplar information was emphasized. In Bransford and Franks' experiments abstraction occurred in the context of an incidental learning task in which subjects were asked various questions relating to the sentences and other material. In the present experiment, incidental acquisition was compared with an intentional condition where subjects were instructed to remember the particular exemplar sentences for the purpose of later recognition testing.

Method

Four complex sentences were chosen, two from Katz (1973) and two from Franks and Bransford (1972). These "main idea" sentences, called FOURSs, were as follows: (a) The arrogant attitude expressed in the speech led to immediate criticism. (b) The unrealistic goals proposed by the leader resulted in frequent disillusionment. (c) The rock which rolled down the mountain crushed the tiny hut at the edge of the sea. (d) The barking dog chased the black cat which jumped on the table.

Each complex sentence was analyzed into four separate sentences, each declaring a single semantic idea. The sentences expressing one proposition (ONEs) were recombined into sentences expressing two ideas (TWOs) or three ideas (THREEs). Table 1 presents the various sentences for idea-category A. In addition to the ONEs, TWOs, THREEs and FOURs, passive and noncase sentences were constructed for each idea category. The passive was simply the FOUR put into the passive tense. The noncase was constructed by combining two ONEs from one idea category with two ONEs from a different idea category.

For acquisition, a tape recording comprised 24 sentences, two ONEs, two TWOs, and two THREEs from each of the four idea

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TABLE 1

Sentences in idea-category A

FOUR:		The arrogant attitude expressed in the speech led to immediate criticism.
THREEs:	(1)	The arrogant attitude expressed in the speech led to criticism.
	(2)	The attitude expressed in the speech led to immediate criticism.
	(3)	The arrogant attitude led to immediate criticism.
TWOs:	(1)	The arrogant attitude was expressed in the speech.
	(2)	The attitude expressed in the speech led to criticism.
	(3)	The attitude led to immediate criticism.
	(4)	The arrogant attitude led to criticism.
ONEs:	(1)	The attitude was arrogant.
	(2)	The attitude led to criticism.
	(3)	The attitude was expressed in the speech.
	(4)	The criticism was immediate.
Passive:		Immediate criticism was led to by the arrogant attitude expressed in the speech.
Noncase:		The arrogant attitude expressed in the speech resulted in frequent disillusionment.

categories. The acquisition sentences were chosen such that each of the ONEs from an idea category occurred once in each of the THREEs and twice in the TWOs. The acquisition sentences did not contain any FOURs.

In the acquisition phase, each sentence was read twice to a group of subjects. The beginnings of different sentences were 15 seconds apart. The acquisition sentences were randomly ordered with the constraint that a sentence was not immediately followed by another from the same idea category. Successive blocks of four sentences contained one sentence from each idea group.

Following the acquisition phase, the subjects heard 56 recognition sentences. These sentences comprised the original 24 sentences (OLD) from acquisition, together with 32 NEW sentences. The NEW sentences were the FOURs, the remaining ONEs, TWOs and THREEs, four noncases and four passives.

There were two groups of subjects. Nine subjects in the Incidental condition were instructed to rate each acquisition sentence for its imagery value. They were not told that there would be a later recognition test. Eleven subjects in the Intentional condition were instructed to listen to each of the acquisition sentences carefully in order to remember it for a later recognition test. The conditions of the recognition test were identical for both groups of subjects. They were asked to listen to each of the test sentences and to write Yes or No on a response sheet according to whether they recognised that sentence as having been heard before in the acquisition phase. They were also asked to write a number from 1 to 5 which expressed the degree to which they were confident in their Yes/No judgment.

Results and Discussion

Following Bransford and Franks' (1971, 1972) analysis, a plus was assigned to each confidence rating for the Yes or positive recognition responses, and a minus to each confidence rating for the No responses. Thus each sentence received a rating on a scale from +5 for a highly confident Yes, to —5 for a highly confident No. The confidence ratings for both Yes and No responses for each sentence were averaged over all subjects in each group. Again, following Bransford and Franks, mean ratings were averaged over both the OLD and NEW sentences.

Figure 1 presents the mean confidence ratings for each type of sentence. The data for the Incidental condition exhibit close similarity to those of Bransford and Franks (1971, 1972) in that the FOURs received the highest mean ratings, followed by the THREEs, TWOs, and ONEs in that order. What this is taken to mean, at least according to Bransford and Franks, is that while the subjects were listening to the THREEs, TWOs and ONEs, they abstracted the general idea expressed by the FOUR. The FOURs were therefore recognized most confidently and most often as having been heard before, despite the fact that they were never presented before. Furthermore, the more a sentence contributes to the general idea abstracted, the greater the probability of its being recognized, as indicated by the effect of sentence complexity on recognition.
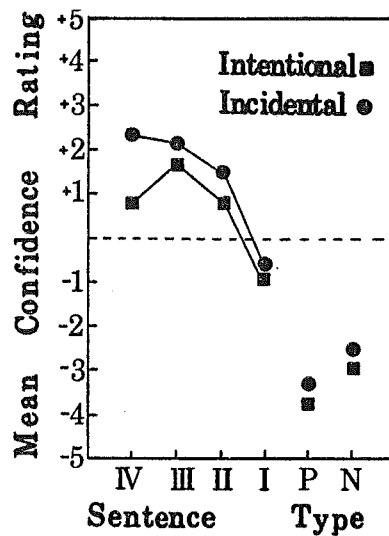

Figure 1. Mean confidence ratings for the different sentence types. P. and N are the passive and noncase sentences.

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In the Intentional condition, the FOURs did not receive as high ratings as did the THREEs. We could say, then, that when the specific features of sentences are emphasized in a recognition memory task, there is a weaker tendency to abstract general ideas from the exemplar sentences.

Now there are some problems with the above analysis. Firstly, the confidence rating response is confounded with the recognition response when the scale running from +5 to —5 is derived. There is no reason to believe that the two response types are related. Indeed, in signal detection analysis Type 2 ROC curves based on confidence ratings are apparently very different in shape from the corresponding Type 1 ROC curve. It seems more appropriate to consider the recognition response separately from the confidence response. Secondly, the data in Figure 1 were averaged over the Yes and No recognition responses from different subjects. That is, for each sentence the hits from some subjects were combined with the false positives from others. Bransford and Franks (1972) consider that the notion of false positives is inappropriate because recognition ratings are a function of the wholistic ideas acquired during acquisition. The NEW sentences are recognized as having been heard before because they are derivable from the total semantic structures acquired. But when confidence ratings are considered separately from recognition responses for OLD versus NEW sentences, it becomes clear that they are not necessarily related.

First, the Yes recognition responses were considered for each subject. The total frequency of Yes responses was calculated separately for the OLD sentences and the NEW sentences from each category. The mean frequencies averaged over subjects are shown in Figure 2. In the Incidental condition NEW sentences were recognized just as frequently as OLD sentences, except in the relatively unimportant case of the ONEs ($t(8)=5.18$, $p<.001$). In the Intentional condition, OLD THREEs were recognized more frequently than were the NEW FOURs ($t(10)=3.32$, $p<.01$), and OLD sentences were recognised more often
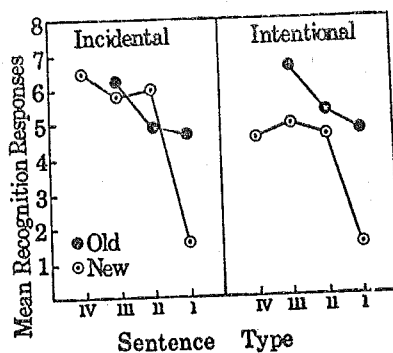

Figure 2. Mean frequencies of positive recognition responses for each type of Old and New sentence.
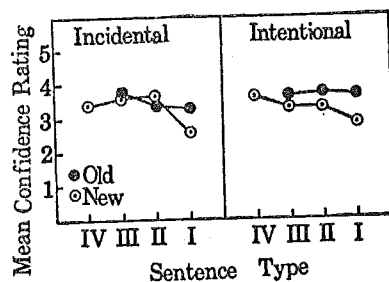
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Figure 3. Mean confidence ratings for positive recognition responses to each type of Old and New sentence.

than NEW sentences for the THREEs ($t(10)$=4.00, p<.01), and ONEs ($t(10)$=4.88, p<.001). The difference between OLD and NEW TWOs failed to reach significance.

Second, the confidence ratings for the Yes response were averaged separately for the OLD and NEW sentences. The average ratings (Figure 3) did not change reliably between OLD and NEW sentences or across the four sentence types. Confidence rating data therefore give no indication about the relative recognizability of the various sentence types. It is the recognition response data which provide the more reliable index of recognizability.

In the Incidental condition there was no difference between recognition of the NEW FOURs and the OLD THREEs. This is perhaps the important comparison as far as inferring abstraction is concerned. The data for the Incidental condition indicated that the subjects abstracted the general ideas from the exemplar sentences. But in the Intentional condition the OLD THREEs were recognized significantly more often than were the NEW FOURs. The conclusion is then that, with a greater emphasis on retention of specific sentences, there is a lesser tendency to abstract the general idea which integrates the sentences.

EXPERIMENT II

Posner among others has demonstrated abstraction of schemata from random-dot patterns in the context of a procedure differing somewhat from that of Bransford and Franks (Posner and Keele, 1968, 1970; Posner, 1969; Strange, Keeney, Kessel and Jenkins, 1970; Reed, 1972; Homa, Cross, Cornell, Goldman and Shwartz, 1973). In these experiments the subject first learns to categorize a number of exemplar patterns. In the second phase, new exemplars are introduced along with the prototype pattern from which all exemplars were originally generated. In the test phase the subject must continue to sort the test

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stimuli into their appropriate categories. Abstraction of the prototype from the exemplars has occurred if the novel prototypes are the most accurately identified stimuli. In Experiment II, abstraction of ideas from sentences was examined in the context of this categorization procedure.

Method

There were two groups of subjects. The 11 subjects in the "Category" condition were read the same list of 24 acquisition sentences as in Experiment I. Each sentence of the acquisition list was prefaced by a label A, B, C or D according to the category it belonged to. The subjects were instructed to listen carefully to remember the category that each sentence belonged to. In the subsequent recognition test the subjects were read the same recognition sentences as in Experiment I, that is, the 24 OLD THREEs, TWOs, and ONEs, mixed with the NEW FOURs, THREEs, TWOs, ONEs, Passive and Noncases. Instead of having to say whether they recognized each sentence, the subjects were asked to write A, B, C, or D according to which category seemed appropriate for each sentence. They were also asked to rate their confidence in the category judgment.

Nine subjects in the "Actual" condition were run in order to find out how much information about the specific exemplar sentences could be retained in the category task. In the acquisition phase these subjects were treated exactly as the subjects in the category group. That is, they were asked to listen for the categories. But in the recognition phase they were asked to write Yes or No according to whether they recognized the *actual* sentence as having been heard before. They were not asked to identify the category each sentence came from. As before, they gave confidence ratings. Thus the Actual group was treated like the Category group in acquisition and like the groups of Experiment I in recognition testing.

Results

In the category condition not only did the subjects categorize each sentence with high accuracy, but also they were highly confident in their judgments regardless of the type of sentence. The mean frequency of correct categorizations for all sentence types, both OLD and NEW, was 8.0. The mean confidence ratings for correct categorizations ranged from 4.4 for the NEW ONEs to 4.8 for the FOURs and OLD THREEs. The mean rating for most sentence types was about 4.7. The result demonstrates that when subjects are quite explicitly required to categorize sentences according to the general idea integrating them, they do so without difficulty. Presumably the subjects did abstract general ideas in acquisition, otherwise accurate classification of the NEW sentences would have been difficult. The data are consistent with those of Katz (1973), for a recognition memory task in which subjects were required to recognize the "meaning" of each test sentence.
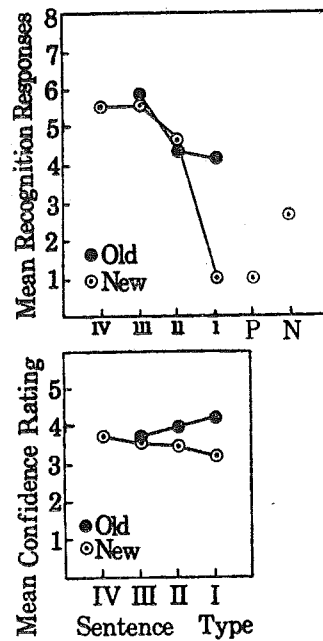
Figure 4. Mean frequencies of positive recognition response and mean confidence ratings for the positive recognitions of each type of Old and New sentence (Actual condition).

How much information about the specific exemplar sentences did the subjects in the Category group retain? The Actual condition was run in an attempt to answer this question. The result for the Actual group (Figure 4) was very similar to that for the Incidental group of Experiment I. Indeed, acquisition for the Actual condition did involve incidental learning. Apparently the subjects in the Actual condition acquired very little information about the specific sentences. The subjects could not discriminate the OLD sentences from the NEW sentences, except in the case of the ONEs ($t(8)=6.44$, $p<.001$).

DISCUSSION

In the Incidental condition of Experiment I and both conditions of Experiment II NEW FOUR sentences were recognized as frequently as the OLD THREE sentences, despite the fact that the FOURs were never presented in acquisition. According to the rationale of experiments by Posner and Keele (1968, 1970), and Bransford and Franks (1971, 1972) among others, the result indicates that the semantic ideas represented by the FOURs were abstracted in acquisition from the

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THREE, TWO and ONE exemplar sentences. But in the Incidental and Actual conditions where recognition was incidental, the OLD THREE and TWO sentences were not differentiated from the NEW FOUR, THREE and TWO sentences. In the Intentional condition, however, subjects did distinguish the OLD sentences from the NEW sentences. But then, these subjects did not abstract the main ideas from the acquisition sentences. Apparently the tendency to abstraction weakens when the exemplar items can be discriminated from the probe items. When there is abstraction, there is little discrimination. Abstracting ideas is thus confused with failure to discriminate. That is, in the conditions involving incidental recognition, the subjects did not necessarily abstract ideas but quite simply could not distinguish OLD from NEW sentences. Bransford and Franks' method does not seem to allow reasonable inferences to be drawn about the occurrence of abstraction.

There is a more plausible explanation for the data. The meaning of individual sentences is retained for quite long periods of time, but memory for the actual syntactic structure of a sentence decays very rapidly (Sachs, 1967; Johnson-Laird, 1970; Johnson-Laird and Stevenson, 1970; Flores D'Arcais, 1974). In the present experiment common semantic structure of sentences within an idea category was more marked than between-idea common semantic structure. If, because of rapid decay, the syntactic structure of the sentences was not retained, the meaning of each sentence provided the only basis on which it could be distinguished from another novel sentence. The semantic communality of the OLD and NEW sentences therefore made their differentiation difficult. It was not necessarily the case that absence of discrimination indicated schema formation by integration of the meanings of the exemplar sentences.

The experiments set out to examine the extent to which specific exemplar information was retained in relation to the schematic content. It was found that specific exemplar information was retained only when subjects were instructed to remember the sentences for the purpose of a later recognition test. Absence of discrimination between the OLD sentences and the new FOUR sentences expressing the main idea cannot be regarded as evidence for schema formation. What is needed before schema formation can be demonstrated is an experimental procedure in which a specifiable task can be accomplished if and only if a schema is formed by integrating previously experienced exemplars.

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