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MODALITY EFFECTS AND THE RELATIONAL DIMENSION  
IN THE ABSTRACTION OF MEMORY SCHEMA

A thesis presented in partial fulfilment of the  
requirements for the Degree of Master of Arts  
in Psychology at Massey University.

Margaret Shannon Roache

1976

ACKNOWLEDGEMENTS

I would like to thank my supervisor, Mr. Kerry Chamberlain for the encouragement, advice and generous allocation of his time given throughout this research. I would also like to thank Dr. Elisabeth Wells for her assistance with the statistical power analysis, and Professor George Shouksmith for the freedom he extended in the choice of topic.

To the children and teachers of Standard 3 and 4 classes at Roslyn School, Palmerston North, whose co-operation made this research possible, special thanks are due.

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ABSTRACT

This study investigated the nature of memory representations constructed from explicit and implied information about two different types of relationships between the objects or actors described in a set of ordered propositions. The propositions described a situation which referred to either an action sequence or to a set of spatial relationships and were presented to subjects in two forms, verbal and pictorial. Ten year old children were given a recognition memory task based on the paradigm used by Bransford, Barclay and Franks (1972). The results showed that subjects had difficulty in distinguishing old recognition items from new situation preserving propositions based on inferences derived from the acquisition sequence, but readily rejected those new propositions that were not consistent with the relationships described in the original premises. This was the case when the original premises were presented in either verbal or pictorial form, and when the relational term used referred to either action sequences or to spatial relationships. An analysis of the results for specific combinations of modality and relational term showed some variation in the general pattern of responses. The construction and integration of inferences into memory representation was facilitated when action sequences were presented in the verbal modality, and when spatial relationships were portrayed in the pictorial modality. Action verbs were found to be particularly sensitive to modality effects.

The concept of 'abstraction' is discussed in the light of the results. It is suggested that this concept is not a unitary one, and that research concerned with the abstraction of memory schema refers to two different types of abstractive process. The distinction between paradigmatic and syntagmatic relationships, originally outlined in Sussure's (1916) study of linguistics, is proposed as a useful way to characterise these processes.



## INTRODUCTION

"We act on meanings, not on uninterpreted perceptions."

Chase and Clark (1972, p.226).

A model of remembering and perceiving requires a consideration of the functional and integrative aspects of these processes in order to have utility and relevance at the level of 'psychological reality'. From the late 1960's there has been a considerable shift in emphasis in both memory research and linguistic analysis in this direction. For example a growing concern is evidenced in the research literature with a more detailed analysis of the constructive processes involved in the formation of cognitive representations from verbal and non-verbal stimuli (Wells, 1973).

A central concept emerging from recent studies in these areas is that of schema. The notion of schema is not a new idea in psychology -the first formal statement of the idea was made by Head in 1926 and restated in a modified form by Bartlett (1932) in his influential book Remembering. Bartlett's definition of abstract schema as 'what is learned' was considered as theoretically interesting but difficult to operationalise, and somewhat too 'mentalistic' for the behaviourist orientation of experimental psychology at that time. Recently, however, there have been attempts, in several different areas of psychology, to operationalise the concept so that it could be tested experimentally. For example studies on perception and memory for visual patterns (Evans, 1967a; Posner and Keele, 1968, 1969, 1970), on the recognition and recall of linguistic information (Barclay, 1973; Bransford and Franks, 1971, Bransford, Barclay and Franks, 1972), and experimental work on motor skills (Schmidt, 1974) have all been based on the concept of schema, or the abstraction and representation of patterns or sets of relationships from different types of stimulus information. This interest in abstractive, organizational and constructive processes suggests that future research will bring the fields of language, memory, concept formation and perception into a closer relationship with one another.

This was proposed by Neisser (1967) who utilized the concept of schema in his thesis that perception is not only an active, but also a selective process in which some sort of organization is present even in the simplest of perceptual tasks. The central theme of his book is that 'seeing', 'hearing' and 'remembering' are all constructive acts which make more or less use of stimulus information. The emphasis is not on the properties of the stimulus situation alone, but on the interaction of this with the internal environment of the perceiver. As Vernon (1955) pointed out it is essential in any analysis of our perceptual reactions, to take into account the organized classifications of knowledge about the physical and social environment which inform and influence these reactions. This view is supported by Pylyshyn (1973) who claims that to refer to a cognitive representation from sensory stimulation is to imply that sensory events are highly abstracted and interpreted into a finite set of concepts and relations in order to be represented; what we know about some event or object is therefore equivalent to a finite set of descriptive propositions. Attaneave (1974) presents a similar view and also suggests that future research into memory processes will need to be concerned with a closer analysis of the relational aspects of cognitive representations; research studies will need to take account of the fact that objects in the world are not simply associated, but that they are associated by particular relations. These have quite as much fine structure as objects or classes of objects and it is therefore necessary that these relations be differentiated one from another.

A closer analysis of the relational aspects of the abstractive process in schema theory may well resolve some of the difficulties of this theory as it stands at present. Firstly the concept of schema as originally proposed by Bartlett is perhaps too global to be of very great use in experimental psychology; secondly the concept of abstraction as it applies to the theory is in need of more precise definition and clarification of its referents. Current experimental work based on schema theory reflects both of these difficulties.

The aim of the present study is to examine more closely the relational aspect of the abstractive and constructive cognitive processes which have been suggested by research relating the concept of schema to language and memory processes (Barclay, 1973; Bransford and Franks, 1971; Bransford et al. 1972), and to perception and memory for visual patterns (Evans, 1967b; Posner and Keele, 1968, 1969, 1970).

## LITERATURE REVIEW

### The Bransford and Franks Approach: The Original Experiments and Related Studies

The contextual approach to meaning illustrated by the Bransford and Franks studies emphasizes the active construction and integration of semantic relationships by the subject. This approach has been labelled "assimilation theory" (Barclay, 1973) and reflects both Piaget's idea of mapping new experience onto existing structures in order to understand the meaning and Bartlett's (1932) account of schema formation which emphasizes the constructive nature of perception and memory.

A classic experiment by Sachs (1967) can be seen as an influential antecedent of this approach. Sachs presented subjects with a recognition set of sentences, some of which preserved the form and others the meaning of sentences embedded in a previously presented prose passage. The results of this experiment indicated that memory for the syntactic features of particular sentences decayed rapidly, whereas the semantic content or 'gist' of a sentence was remembered very much better and for a longer period of time.

In a series of experiments Bransford and Franks (1971), Franks and Bransford (1972), Bransford Barclay and Franks (1972), have demonstrated that adult subjects, when given a list of sentences, integrate meaning relationships into wholistic situational descriptions and forget syntactic information such as which relationships occurred in separate sentences. On the basis of these experimental studies the authors contend that the information available in memory is a function of the linguistic input and of general extra-linguistic information or the subject's knowledge of the world. Sentences are not viewed from this approach as information to be remembered but as information that subjects can use to construct conceptual descriptions of situations. Support for this view has come from several studies, among them Anderson and Ortony (1975), Barclay (1973), Flores D'Arcais (1974), Kintsch and Monk (1972), Singer and Rosenberg (1973).

In their 1971 experiments Bransford and Franks used as materials groups of sentences in an acquisition - recognition paradigm. Four complex sentences were constructed each of which represented the relations among four simple declarative sentences. Each complex sentence was then broken down into its four component simple sentences which were recombined in a number of ways.

The set for each of the four complex sentences consisted of (a) the complex sentence (FOUR); (b) the four simple sentences of this complex sentence (ONES); (c) sentences constructed by combining two simple sentences from the complex sentence (TWOS); (d) sentences constructed by combining three simple sentences from the complex sentence (THREES). No FOURS were included in the acquisition lists. Acquisition sentences from each set consisted of two ONES, two TWOS, and two THREES. These sentences were chosen so that they exhausted the information contained in the complex sentence from which they were derived. A five minute break was given after the acquisition phase and then the recognition list was presented. Subjects were asked to decide, for each sentence, whether they had heard it during acquisition or not and to give a confidence rating to their judgment.

Recognition sentences included sentences actually heard during acquisition (OLD sentences); sentences not actually heard before but consistent with the general ideas expressed in acquisition sentences (NEW sentences); and sentences not actually heard before and not consistent with the general ideas expressed in acquisition sentences (NONCASE sentences).

In general it was found that subjects could not discriminate novel sentences (NEWS) from those heard in acquisition (OLDS) although there was a slight recognition advantage of OLDS over NEWS at the level of ONES. Although subjects were very confident in their recognition responses to novel sentences (NEWS) they were equally confident that they had not heard NONCASE sentences before. Results from this experiment showed that the confidence ratings ordered recognition sentences as follows: FOURS > THREES > TWOS > ONES. This ordering effect has also been referred to as a linear

effect. These results were interpreted by Bransford and Franks as an indication that subjects became less confident of having heard particular sentences as a function of the degree to which a sentence failed to exhaust all the semantic relations characteristic of a complex main idea or situational description. The authors further suggest that their results are reliable evidence that subjects acquired something more general and abstract than simply a list of sentences experienced during acquisition; and that their experimental technique provides a means to investigate the phenomenon of abstraction in considerable detail.

Franks and Bransford (1972) replicated their 1971 study using sentences based on abstract rather than concrete ideas. This replication was indicated by the implications of a research study by Begg and Paivio (1969) which had suggested that concrete sentences may be stored in memory differently from abstract sentences. However results very similar to those of their 1971 experiment were obtained by Franks and Bransford. Subjects in general did not discriminate novel sentences from those heard in acquisition; the highest confidence ratings were given to complex sentences despite the fact that subjects had not previously heard these sentences, nor had they heard any sentences as long as these in acquisition.

These results suggest that there is some similarity in the process of constructing memory representations of both concrete and abstract ideas communicated by sentences. The phenomena demonstrated in these experiments seem clear and are replicable (e.g. Singer and Rosenberg, 1973). The interpretations of abstractive and memory processes made by Bransford and Franks on the basis of these results have not, however, been without critics.

#### Replications and Critiques. The Role of Instructions

Katz (1973) has argued that the linear effect illustrated in these experiments is an artifact of the procedure used and not anything central to the study of semantics. He considers that

although subjects do attend to semantic meaning and context they also attend to linguistic context and structure; and that task demands are critical in determining which aspects are central in recognition experiments. Despite fairly widespread belief to the contrary Bransford and Franks have never denied this point. They have explicitly stated (1971, p.349) that the boundary conditions for the phenomenon of linguistic abstraction require further investigation and explication and that the effect of instructions on this phenomenon is in particular need of additional research.

Katz used two groups of subjects to replicate Bransford and Franks' (1971) study. The purpose of his experiment was to determine whether the Bransford and Franks results could be obtained when non-semantic criteria are disregarded and recognition is based solely on meaning. The experimental conditions for each group differed only in terms of the type of instructions given. Subjects under one condition were asked to evaluate sentences only according to whether they had actually been heard before (Actual Instructions). Under the other condition subjects were asked to rate sentences using the criterion of whether they meant exactly the same thing as did those heard in acquisition (Meaning Instructions). Two special classes of test sentences were added to the recognition list, 'passives' and 'non-cases'. These were included to check whether the instructions were properly understood. 'Passives' were constructed by using the passive grammatical form of complex sentences heard in acquisition and were very similar or identical in meaning to their active counterparts. 'Non-case' sentences were sentences very similar in form to, but incompatible with the meaning of the complete ideas presented in the acquisition sentences.

Results for this experiment showed that subjects gave high recognition responses to complex sentences (FOURS) under both conditions. In the Actual Instructions condition the linear effect obtained was very similar to that shown by Bransford and Franks. However under the Meaning Instructions condition a large number of recognition responses were given to component idea



sentences thereby markedly attenuating the linear effect. There were no differences between the two groups for 'non-case' sentences. Subjects under both conditions were very sure that they had not heard 'non-case' sentences before. This seems to suggest that extreme changes of meaning are readily detected by subjects even when this aspect of the sentences is not the principal focus of their attention. A main effect for instructions was, however, obtained for 'passive' sentences. In the Actual Instructions condition 'passives' were given the lowest rating of all, indicating that subjects did attend to structure as well as to meaning. Under the Meaning Instructions condition 'passives' were given the highest recognition response indicating that structural differences played little or no role in recognition.

Katz interprets the findings of this experiment as evidence that,

- (1) The linear effect is an artifact of the procedure used and not anything central to the study of semantics.
- (2) Reliable and fundamentally different processes operate under the two different conditions.

The first point can be conceded as a valid one on the basis of the results of this experiment and the following argument presented by Katz. The explanation of the linear effect offered by Bransford and Franks (1971), namely that recognition is a function of the number of basic ideas in the integrated idea exhausted by the semantic representation of the input, is unrealistic. If true it would mean that individuals are literally unable to recognize small components (basic ideas) in isolation from the whole. The results from the Meaning Instruction condition indicate otherwise.

Katz has effectively shown that the linear effect is sensitive to task demands. However the linear effect is only one aspect of the theoretical assumptions made by Bransford and Franks and it is not by any means the central issue. The basic concern has been rather to demonstrate the occurrence and the nature of abstractive and integrative processes in deriving conceptual knowledge from linguistic information.



The validity of the second point made by Katz above might therefore be questioned on the following basis. Katz has shown that subjects gave high recognition responses to complex sentences that they had never seen before under both sets of recognition instructions. This integrative process cannot, therefore, be considered as an artifact of the experimental procedure only. His results do not seem to provide adequate support for the assumption that 'reliable and fundamentally different processes operate under the two different conditions'.

Overall the value of Katz' experiment has been to underscore a point also emphasized by Jenkins (1974). Recognition phenomena do change when the quality of the event experienced by subjects is changed. The validity of this point does not, however, diminish the evidence in support of the presence of integrating processes in recognition memory. Research to date, (e.g. Barclay, 1973; Flores D'Arcais, 1974; Singer and Rosenberg, 1973) seems to suggest that the integration of linguistic information is, to some extent, dependent on the availability of a global event that makes it possible for subjects to discriminate true descriptive sentences from false ones even though they may not usually be able to discriminate on the basis of the syntactic form or specific content of historic sentences. However from the fact that subjects do not usually discriminate sentences on the basis of specific syntactic information, unless there has been a massive syntactic change as there is with passives, it does not follow that they cannot remember these aspects when specifically asked to do so.

White (1974) has shown that subjects do remember specific syntactic information when exposed to appropriate experimental conditions. White replicated the procedure used by Bransford and Franks (1971) using as materials sentences composed of both abstract and concrete ideas. The abstraction of ideas under an incidental learning condition was compared with an intentional condition where subjects were expected to remember the particular exemplar sentences for the purpose of later recognition testing. For the incidental

learning condition results closely resembled those obtained by Bransford and Franks (1971, 1972) in that the same linear effect  $\text{FOURS} > \text{THREES} > \text{TWOS} > \text{ONES}$  was obtained. Data from the intentional learning condition, however, indicated that OLD THREES were recognized significantly more often than the novel FOURS. White concludes from this that with a greater emphasis on the retention of specific sentences there is a lesser tendency to abstract the general idea which integrates the sentences. This is a valid point which is given additional support from the results obtained in a study by Barclay (1973).

However the major theoretical thrust of White's paper is his criticism of the interpretation made by Bransford and Franks of the phenomenon illustrated under the incidental learning condition; that is that subjects could not, in general, discriminate novel sentences from those heard in acquisition. In particular the high recognition responses given to FOURS was taken as evidence that the semantic ideas represented by these complex sentences were abstracted from the simpler sentences presented in acquisition.

White argues that a failure to discriminate is confused by these authors with the process of abstraction whereas the method used does not allow reasonable inferences to be made about the occurrence of abstraction. He suggests that when there is abstraction there is little discrimination and therefore seems to view abstraction as a process which can take place independently from the process of discrimination. This contention has some validity if the concept of abstraction is taken as a unitary one with sole reference to the representation of information at a high level of generality or in terms of abstract rather than concrete concepts. However the concept of abstraction is a complex one which is surrounded by a great deal of ambiguity in its reference to memory research. The issue has been further confused by the somewhat cavalier use of the term by Bransford and Franks themselves as in the following example.

"Subjects acquired something more general or abstract than simply a list of sentences" (1971, p.348).

Posner (1973) has observed that the term 'abstraction' is often loosely used but can be taken to refer to either,

- (1) The classification of information input at a higher level of generality as in the formation and use of abstract concepts (Piaget, 1954; Vygotsky, 1962).
- or (2) Selection of part of the information input which is either generalised or combined with other selected aspects to create a new integration (Bartlett, 1932; Gibson, 1969; Neisser, 1967).

This use of the term 'abstraction' is consistent with the theoretical assumption that perception and cognition are active processes of selection, organization and construction.

This second definition of abstraction is referred to by White in his paper and can be taken as related to his argument. White has shown that a greater emphasis on the retention of specific sentences lessens the tendency to abstract the general idea that integrates the sentences. Under these conditions sentences are likely to be regarded as separate entities and discrimination or perception of differences as a process can therefore stand alone. Within the context of Posner's second definition of abstraction, however, it seems reasonable to suggest that the processes of abstraction and integration cannot stand alone but necessarily entail the assumption that a prior process of discrimination has taken place. White's contention that when there is abstraction there is little discrimination does not seem applicable within this context for the following reasons. The phenomenon illustrated by Bransford and Franks (1971, 1972) where subjects integrated separately experienced ideas into wholistic descriptions, suggests that these ideas had been previously discriminated from their original syntactic context in order to be so integrated. If conceptual representations are constructed on the basis of the discrimination of a selected aspect of the input (such as ideas) it does seem likely that

subjects will fail to discriminate on the basis of other aspects of recognition sentences (such as syntactic form) which have not been integrated into their conceptual representations. Failure to discriminate at this level, however, does not seem to be a reliable indicator that discrimination and abstraction have not taken place in constructing the semantic description of the situation that the subject does recognize or recall.

### The Integration of Extra-Linguistic Inferences

The criticisms made by Katz and White refer only to the claims made by Bransford and Franks on the basis of their earlier experiments (Bransford and Franks 1971, Franks and Bransford 1972). However in these particular experiments the authors did not specifically investigate the construction of wholistic descriptions allowing extra-linguistic inferences. Reid (1974) has pointed out that despite fairly general acceptance of the fact that memory for meaning or the 'gist' of a sentence (Fillenbaum, 1966) is better than verbatim memory, the fact remains that little progress has been made in determining the reason one remembers certain 'gist' and is unable to remember other. This point can also be made in reference to extra-linguistic inferences made in comprehension. Although Sachs in 1967 had suggested that we need to find out more about just what kinds of information people tend to add in comprehending language very little research attention had been given to this question prior to the Bransford, Barclay and Franks (1972) experiments.

The basic assumption underlying the constructive approach to language processing is that the comprehension-memory system is a selective one which uses information from the input sentences combined with stored knowledge about the world and contextual constraints such as task demands to generate a conceptual representation of the situation that is meaningful to the subject. Extra-linguistic inferences contribute to these representations to a variable degree. The occurrence of inferred relational and conceptual information in subject's recall of

discourse has been noted by Dawes (1966) and Frederiksen (1975). Bransford et al. (1972), in a series of experiments examined the hypothesis that certain types of information may facilitate the construction of semantic descriptions that contain more information than is explicitly stated in the acquisition sentences.

Experiment III is selected from this series as a prototype of the approach used. Two groups of subjects were given the acquisition task of listening to a number of descriptive passages like the following.

"There is a tree with a box beside it and a chair is on top of the box. The box is to the right of the tree. The tree is green and extremely tall." (1972, p.201).

Following acquisition subjects were presented with one of two recognition sets and asked to indicate which sentences from each block they had actually heard before. The first recognition set, (Set A) contained sentences that were in the acquisition passages (OLDS) and sentences that were not (NEWS). Some of the NEWS were consistent with the overall situational description presented in acquisition, (e.g. the chair is to the right of the tree) and some of them were not (e.g. The chair is to the left of the tree). The recognition set for this example was.

#### Set A

- |    |  |     |
|----|--|-----|
| A. | The box is to the right of the tree.   | OLD |
| B. | The chair is to the right of the tree. | NEW |
| C. | The box is to the left of the tree.    | NEW |
| D. | The chair is to the left of the tree.  | NEW |

Bransford et al. reasoned that according to the constructive approach subjects would be likely to remember something about the particular style, but given that they should forget this, they should not be reduced to total guessing. Instead they should pick sentences consistent with the overall situational description even if such sentences were not heard in acquisition. They predicted that for Recognition Set A subjects would be very likely to pick sentences based on situation-preserving inferences such as sentence B above.

A second recognition list was constructed based on the fact that there are a number of linguistically different ways to describe the same basic situation. Recognition Set B was identical to Set A except that the subject and object nouns were reversed as well as the relational terms. Although there were no sentences that were actually OLD for this set, sentences such as A below were referred to as OLD since they preserved the semantic relations between objects referred to in the acquisition passage.

- |    |  |     |
|----|--|-----|
| A. | The tree is to the left of the box.    | OLD |
| B. | The tree is to the left of the chair.  | NEW |
| C. | The tree is to the right of the box.   | NEW |
| D. | The tree is to the right of the chair. | NEW |

For this recognition set the authors hypothesised that if recognition is primarily a function of syntactic information subjects should be very confused by these items. If, however, recognition can be based on an abstracted semantic description of the situation then subjects should show a strong tendency to make 'situation-preserving' errors and judge sentences A and B as OLDS more often than sentences C and D.

The results from this experiment supported the predictions generated from the constructive approach. For both groups situation-preserving responses accounted for 70% of the total recognition responses made. For Recognition Set A the greatest number of recognition responses were given to OLD sentences indicating some tendency to remember the linguistic form in which the information was originally presented. However there was also a significant tendency to pick situation-preserving NEW sentences based on inferences derived from the overall description heard in acquisition (such as sentence B) in preference to situation-distorting sentences (such as sentences C and D).

For Recognition Set B in which no sentences were actually identical to those previously heard, there was no significant differences between recognition responses for OLD sentences, and NEW sentences based on situation-preserving inferences (Sentences A and B in Recognition Set B) despite the fact that the OLD sentences preserved the conjunction of the



the content nouns heard in acquisition sentences while NEW inferences did not. However there was a significant tendency to pick situation preserving NEW sentences in preference to situation distorting NEW sentences (such as sentences C and D). Bransford et al. have suggested that these data provide especially strong evidence for the constructive approach to sentence memory. If subjects were simply storing information as to which objects were related to others in the acquisition sentences they should have been very confused by Recognition Set B and should therefore have picked many situation-distorting sentences. However the 70% recognition response given to situation-preserving sentences does not support this expectation.

Bransford et al. in their evaluation of this series of experiments, have emphasized that the role of context in the comprehension and recall of linguistic information refers to more than the information input from the external environment. The internal environment, or the subject's knowledge of the world is also an essential component of these processes. Linguistic theories which restrict the characterisation of comprehension-memory processes to an analysis of syntax and semantics as do those of Katz and Fodor (1963) and Clark and Clark (1968) do not therefore seem adequate as explanatory models of these processes. The constructive approach can be seen as an attempt to overcome these limitations.

#### The Organization of Stimulus Information

Research to date (Barclay, 1973; Green, 1975; Rosenberg and Jarvella, 1970) has suggested that a prerequisite for the generation and integration of inferences is the condition that the stimulus information is organized to outline some overall description of an object or a situation. The inference process fills in or assimilates extra-linguistic information to the general outline of the situation that the subject has in mind.

Some evidence for this contention is provided by a study made by Rosenberg and Jarvella (1970). Noise was introduced as a variable in an incidental learning experiment utilizing two types of sentences, semantically well integrated sentences (sentences which conveyed a

coherent and meaningful description) and semantically poorly integrated sentences. When a portion of the acquisition sentences was masked by noise to a degree that the masked portion was unintelligible, subjects showed an increased tendency to generate and integrate extra-linguistic inferences over acquisition conditions where sentences were not masked in this way. This effect was limited, however, to sentences presented in acquisition in a semantically well integrated form. Subjects were not able to generate and integrate inferences for those sentences which were semantically poorly integrated.

Barclay (1973) ran a series of experiments designed primarily to investigate the role of logical operations (e.g. transitive operations involving spatial terms such as left-right and comparative terms such as taller-shorter) in the construction of memory representations. In each of these experiments a structured array of objects was described in acquisition in piecemeal fashion by a list of semantically related sentences. The list of sentences embodied both expressed and implied information. This implied information had to be inferred in order to correctly construct a representation of the overall array. The most general finding from these experiments was that in both recognition and recall tasks, subjects not only remembered previously presented sentences but also implied but unstated inferences; they drew a sharp line only between true and false sentences, thinking that they were distinguishing old sentences from new ones.

In one of the five experiments in this series, however, two different sets of instructions were given to two groups of subjects. Those subjects who were informed that the acquisition sentences described an overall array did not discriminate old sentences from new ones, but were able to correctly recognize the array in 82% of cases. Those subjects who were not informed of the existence of an overall array, but who were asked only to memorize the sentences, tended to treat the acquisition sentences as discrete linguistic entities and thus were better able to distinguish new sentences from old ones. However this group of subjects was able to recognize the overall array in only 10% of cases.



This finding provides further substance to the points raised by Katz (1973) and White (1974) which were discussed in an earlier section. Task demands are a critical variable in determining what kinds of memory representations subjects do construct. However the tendency to treat a sentence mainly or only as a linguistic object seems usually to be confined to situations where subjects are specifically instructed to do this.

In summarizing his 1973 paper Barclay outlines the basic assumptions of the constructive approach (or assimilation theory) which is common to the research studies outlined in this and previous sections. He states,

"The fundamental component of assimilation theory is the comprehension device which relates sentential information to one's knowledge system, in part through logical operations. In this respect sentence comprehension is simply one manifestation of the general process referred to as knowledge acquisition. (1973, p.253)."

This view, although intuitively satisfying and supported to some degree by the experimental work outlined, is in essence general and diffuse and leaves open a number of important issues. Two of these issues are noted here.

Clark (1973) has pointed out the fallacy (Language - as - Fixed - Effect - Fallacy) of trying to draw scientific conclusions from studies of verbal behaviour if the effects demonstrated are restricted to the specific language materials used in the experiment. The previously outlined studies by Bransford et al. (1972) and Barclay (1973) examined the role of extra-linguistic inferences in sentence memory only in terms of inferences made on the basis of logical operations and spatial relationships. In the light of Clark's statement it seems necessary, therefore, to ask the following question. To what extent does the relational nature of the stimulus information presented constrain the range and types of inferences generated by subjects?

A further question related to these studies arises from Barclay's outline of assimilation theory quoted earlier, and is based on the claim

that within the context of assimilation theory sentence memory is simply one manifestation of a more general process of knowledge acquisition. If the process of inference generation and integration is a general process then can it be shown to operate if stimulus information is presented in other forms, for example in pictorial rather than in verbal form?

Experimental studies and theoretical views relating to each of these questions will be reviewed in the following sections.

### The Relational Aspects of Sentence Comprehension and Memory

Data from the preceding experimental studies suggests that peoples' internal memory representations of sentences often contain elements which could not be derived solely from the constituent words. Anderson and Ortony (1975) have pointed out that there are only two possible sources of this information: context and existing knowledge. In order to evaluate the relationships that hold among the features from which meaning is extracted it seems necessary to work within some kind of conceptual framework. Craik and Lockhart (1972) have proposed a model which seems to have utility for this purpose. This model suggests that the extraction of meaning is related to varying depths of processing and reflects the influence of theorists from the fields of perception (Neisser, 1967) and linguistics (Lamb, 1966). The central contention of all of these models is that the perception of stimuli involves a number of levels or stages. Physical or sensory features are analysed in the preliminary stages, but later stages involve the interpretation and organization of input in terms of a conceptual representation which is based on prior learning and experience. The application of the model proposed by Craik and Lockhart to memory research indicates a shift away from a strongly linguistic orientation to an emphasis on perceptual events and their relation to the language structure. Some support for this view is given by Craik (1973). He reports several experiments in which depth of processing was varied by requiring subjects to perform different tasks on single word acquisition

items; for example either judging whether the word was in capital letters or whether it fitted into the context of a given sentence. The more semantic tasks were presumed to involve a deeper processing level, and it was found that these tasks took subjects a longer time than did tasks related to the physical features of the acquisition words. Memory over a time delay was also found to be better for those items on which the deeper processing task had been performed. A number of recent experimental studies of memory processes have also been based on this theoretical approach, among them Clark, Carpenter and Just (1973) and Anderson and Ortony (1975).

A further contribution to the clarification of the relational aspects of sentence comprehension and memory has been given by Reid (1974) who has proposed that a sentence is represented at the conceptual level in terms of the structure of the various relational roles connected with key words in the sentence. Constraints on the use of language at the psychological level reflect two different kinds of relationships - paradigmatic and syntagmatic relations. These terms have had a long history in the study of linguistics (Sassure, 1916/1959) and have been reintroduced into the study of language behaviour mainly through the influence of Jakobson's clinical work in aphasia (Jakobson and Halle, 1971). Similarity or paradigmatic relations refer to the shared conceptual features that characterise a given paradigmatic set; these relations are important in experimental tasks that require subjects to detect the presence or absence of features in stimuli and also in classification tasks. Contiguity or syntagmatic relations, on the other hand, are not based on similarity or difference of features but refer to the relationships that hold between the features of a represented situation or event. These relations are important in tasks that require a subject to remember some event or situation in terms of the relationships that hold between objects or actors participating in it.

Statements involving syntagmatic relations can be further distinguished as falling into two broad categories; statements describing the spatial relationships between objects and those which describe one object acting upon another. According to Huttenlocher (Huttenlocher, Eisenberg and Strauss, 1968) these two types of relational statements differ in the

following way. Statements describing spatial relationships merely indicate the order of items along some dimension (such as left-right). The two complementary ways of describing this order are both simple statements, neither has a passive form. A lack of correspondence between the form of a relational statement and the extra-linguistic situation it describes can be corrected by transforming the relational statement to co-ordinate it with the subject's conceptual representation of the situation. This transformation of the relational term is not possible with statements describing one object acting on another without distorting the meaning of the event described in the statement.

In experiments using five and nine year old children as subjects Huttenlocher and Strauss (1968), Huttenlocher et al. (1968) investigated the following hypotheses.

- A. One's understanding of a statement depends upon the relation between that statement and the extralinguistic situation it describes. Therefore comprehension is easiest when there is a correspondence between the perceived actor and the logical subject of the experimenter's statement.
- B. The nature of the intellectual operations involved in co-ordinating the perceived actor with the logical subject will be different for relational statements than for statements describing one object acting on another.

The first of these experiments investigated Hypothesis A in terms of spatial relations. The subject's task was to place a mobile block (MB) above or below a fixed block (FB) in a ladder-like structure with five shelves in order to make a pile. Two types of problems were used; (1) when the subject of the experimenter's statement was the mobile block and the object the fixed block. 'The MB is above/below the FB.' and (2) when the subject of the experimenter's statement was the fixed block and the object the mobile block. 'The FB is above/below the MB'. The results of this experiment showed that for all ages more

errors were made when the mobile block was the object rather than the subject of the experimenter's statement.

The second experiment in this series (Huttenlocher et al., 1968) was analogous to the block task except that it involved statements that described one object acting on another. In this case materials used were toy trucks which were required to push/pull one another. The results showed that the phenomenon observed earlier with relational statements also holds when subject and object are linked by ordinary motion verbs like 'push' and 'pull'. That is, it is easier to place an object described as grammatical subject than vice-versa. This was true for both active and passive sentences.

A comparison of subjective accounts of the intellectual operations engaged in during these tasks suggested that these may differ according to the relational terms used. With spatial terms subjects transformed the experimenter's statement, where necessary, to make the mobile object its subject. With action statements, however, subjects co-ordinated the statement with the extralinguistic situation, when necessary, by imagining that the fixed object was in fact the mobile object.

The major findings of Huttenlocher's experiments have been confirmed in a study by Olsen and Filby (1972) using adult subjects. When a perceptual event is coded in terms of the actor, active sentences are more easily verified than passive ones. The reverse is true when the event is coded in terms of the receiver of the action. Similar results were obtained in an earlier study by Tannenbaum and Williams (1968).

Carey (1964) and Wason (1965) have each suggested that a possible mechanism by which a particular statement may be harder or easier to understand is its plausibility within a given context. Wason found that the main factor influencing whether a negative statement is more difficult to verify than a positive one is whether it is plausible within the context in which it is uttered.

The theoretical views and experimental studies reviewed in this section have each been concerned with some dimension of the relational aspect of language comprehension and memory but do not, either

individually or in combination, constitute an explanatory model of the underlying processes involved. At best they offer descriptive data which suggests in outline some of the components which need to be taken into account in constituting such a model and indicate some directions in which further research could prove productive. Craik and Lockhart (1972) and Huttenlocher et al. (1968) have each emphasised the importance of perceptual events and their relation to the language structure and to the comprehension process in general. However as Trabasso (1973) points out we cannot, on the basis of these or similar studies (e.g. Clark, Carpenter and Just, 1972), assimilate all concepts to percepts despite the fact that some primitive concepts seem to be derived from particular perceptual configurations (Michotte, 1963; Miller, 1972). Michotte's classic series of experiments demonstrated that definite combinations of objects in space and time were conducive to causal interpretations of events, while Miller has provided a comprehensive analysis of verbs of motion showing how the meanings of a large body of lexical items could be expressed in terms of a small set of concepts and conceptual relationships.

These studies provide some basis for a more differentiated conceptual approach to this area. The work of Huttenlocher et al. (1968) in addition suggests, but by no means confirms, that different types of intellectual processes may be brought into play in reconciling linguistic descriptions with the extra-linguistic situations they portray depending on the type of relational concept employed in a particular study; descriptions of spatial relations between objects seem to be processed differently from statements describing one object acting on another.

A further useful distinction is indicated by Jakobson's distinction between paradigmatic and syntagmatic relations. The clinical study of different types of aphasia (Jakobson and Halle, 1971; Luria, 1973) provides some evidence for a psychological reality to this distinction in addition to the semantic one. As Reid (1974) has stated, these two types of conceptual relationships can be shown to be related to the demands of different memory tasks. However with some exceptions



(e.g. Bransford et al. 1972; Miller, 1972) there has been little direct investigation of syntagmatic relations in psychological studies to date.

The importance of context in rendering the described or perceived situation meaningful to the subject has been a pervasive theme in the work reviewed in this and previous sections. Wason's (1966) concept of 'plausibility', the studies on inference generation (Bransford et al., 1972; Barclay, 1973) and Craik's (1973) experiments on depth of processing are examples which illustrate varying aspects of the role of context in memory and comprehension processes. Task demands for recognition or recall of intrinsically meaningless material place a predominant emphasis on the external environmental context; those which facilitate the generation of extralinguistic inferences emphasise the internal environment or the subjects conviction of what is required to construct a meaningful internal representation of the situation or event.

In the light of Barclay's comment, noted earlier, that the constructive approach to sentence meaning is but one manifestation of a more general process of knowledge acquisition, the following section will be concerned with a brief review of studies concerned with the process of abstracting conceptual schema from visual and pictorial information. The relational and contextual aspects of this process will be of particular concern.

#### Schema Formation: Abstraction from Visual and Pictorial Material

Posner (1969) on the basis of findings from a number of experiments using visual patterns as stimulus materials (Evans, 1967b; Posner and Konik, 1966; Posner, Goldsmith, and Wilton, 1967; Posner and Keele, 1968, 1969). has concluded that retention of previously perceived events is not as vivid or complete as the original perception. The two main explanations he proposes for this conclusion are, (a) that selective attention leads to the storage of some aspects of a scene

rather than others, and (b) that stimuli as originally processed may lose specificity as more general classifications are achieved. These principles are in general outline consistent with those found to operate in similar research using prose passages or groups of sentences (Barclay, 1973; Sachs, 1967).

Most studies of schema formation have used some form of random visual patterns. The basic pattern is called the prototype. A number of transformations of the prototype are constructed varying in degree of distortion from the original pattern. The prototype thus represents the central tendency or communalities among the derived patterns and constitutes the 'schema'. A number of studies have shown that in classification tasks subjects are able to separate patterns derived from one central tendency or prototype from those derived from another without prior instruction and without receiving knowledge of results (Evans, 1967b).

Posner (1969) has suggested, however, that the ability of human subjects to learn to identify patterns that are instances of different central tendencies is not in itself sufficient evidence that this type of classification involves the abstraction of a schema. A series of experiments was designed to investigate this question (Posner and Keele, 1968, 1969). Materials used in these studies were patterns of nine dots printed on separate cards. Subjects learned to associate four different distortions from each of a number of prototypes with one another by a paired-associate technique. Subjects were then presented with a list of patterns and asked to classify them in terms of which patterns belonged together. The list consisted of (1) the prototypes which they had not seen before; (2) old distortions which they had just finished learning and (3) control patterns which were within the learned category. Some of the control patterns were designed to have the same degree of distance from the four learned patterns as did the prototype but were not themselves the prototype. The results of this experiment showed that the prototypes were correctly classified significantly more often than any of the control patterns. Posner interprets these results



as an indication that the process of classifying patterns does not rely solely upon the distance relationship from a particular stored exemplar, but rather on the distance of the new pattern from those aspects of the stored pattern that represents qualities common to all the exemplars. This view is consistent with that of Garner (1966) who proposed that one's knowledge is a function of the perception of properties of sets of stimuli rather than of the properties of individual stimuli.

To observe what happens to the process of schema formation over time Posner and Keele (1969) replicated their 1968 experiment with the addition of a control group who experienced one week's delay between learning the original patterns and being exposed to the classification task. Results from this experiment indicated that after one week's delay the schema or prototype was recognized at least as well as the particular patterns the subjects had learned. The time delay increased the number of classification errors made for the memorised patterns in comparison with the number of errors made for these patterns under the no delay conditions. The number of errors made in classifying the schema or prototype patterns did, however, show a definite decrease after one week's delay from the error level recorded under the no delay condition. Posner contends that it is reasonable to interpret these results as evidence that the abstraction of information concerning the central tendency takes place during learning rather than being later mediated through individual stored patterns.

Franks and Bransford (1971) extended the work on schema abstraction from visual patterns as developed by Posner and Keele (1968, 1969) on the basis of their view that the nature of the stimulus materials used in these experiments (configurations of dots) limited the possibility of a structural specification of the nature and genesis of the schema derived. Franks and Bransford constructed a series of structured spatial configurations of well-defined forms (triangles, squares and other geometric shapes), constituting a number of prototypes and from these generated a set of transformations constrained by a set of discrete deterministic rules. In a series of four experiments utilizing an acquisition-recognition paradigm subjects were exposed to items which were instances of patterns that varied in transformational distance from the prototype. In a subsequent recognition test subjects were

given a set of items consisting of (a) the prototypes which they had not previously seen and (b) transformations from the prototype which varied in transformational distance from it. Results from these experiments showed that in all instances the prototype received the highest recognition rating despite the fact that it had not been previously seen by subjects. For all other items subject's recognition ratings were found to be inversely related to the prototype. Franks and Bransford consider that their results support a schema plus transformations model of memory representation for patterned visual materials. According to this view the schema reflects the interrelationships among the acquisition configurations and the communalities abstracted from these. These conclusions are in substantial agreement with those expressed by Posner in summing up his earlier experiments on schema formation (Posner and Keele, 1969).

Evans (1967a) has defined schema theory as referring to a population of objects all of which can be efficiently described by the same schema rules. A schema rule is abstracted as a set of commonly occurring characteristics in a collection of otherwise different instances. The prototype experiments outlined above are in conformity with this definition. However Evans considers that, "Schema theory, as described above,

"is clearly inadequate to deal with ordinary human perception. The environment does not, in general, provide a collection of stimuli belonging to the same schema family. Instead instances of various schema families are normally mixed together (1967a, p.87)."

Evans proposes that the mixed schema condition requires that schema theory be extended beyond an investigation of how people remember patterns to the area of concept formation and concept utilization. It is at this point that schema theory extension can be seen to merge into the constructive approach to meaning that has been the central focus of this review.

Work on the abstraction of schema from visual patterns has been almost solely concerned with the relation of similarity or the

paradigmatic pole of the paradigmatic-syntagmatic distinction in the construction of conceptual representations. To date there has been virtually no experimental work in this area to parallel the investigations of the syntagmatic pole of this distinction as there has been in studies utilizing verbal materials.

One reason for this could be based on a finding by Shepard (1967) that surface recognition memory for pictures is strong and of long duration. Shepard investigated recognition memory for groups of approximately 600 stimuli consisting of either words, sentences or pictures. Correct recognition responses for these groups of approximately 600 stimuli consisting of either words, sentences or pictures. Correct recognition responses for these groups of stimuli were respectively 90%, 88% and 98% under no delay conditions. Even after one week's delay recognition memory for pictures remained as high as 90%. From this it could be concluded that subjects would be very unlikely, in studies using pictorial materials, to confuse implicit information or meaningful inferences with explicit information as has been shown to occur in studies using linguistic materials (Barclay, 1973; Bransford et al., 1972).

However the point is often overlooked that Shepard obtained a very high recognition response also for words and sentences (90% and 88% respectively) although responses for these stimuli did not reach the level obtained for pictures. A possible explanation for the strong surface or verbatim memory illustrated by these results could be that in Shepard's study the three types of stimuli were presented as a series of discrete entities. As noted previously the generation of inferences, which constitutes one source of confusion in recognition tasks, seems to depend on the prior organization of stimulus information in a way that outlines some overall description of an object or a situation (e.g. Rosenberg and Jarvella, 1970).

\* A recent study by Baggett (1975) used an acquisition recognition paradigm to investigate the nature of memory representations for two types of picture stories; surface information arising from pictures which occurred in the stories and conceptual information inferrable when integrating the pictures into a connected story but not originally explicitly presented in the stories. Materials used in this experiment

were stories consisting of four pictures which outlines a simple but coherent series of events. The target picture in each story sequence consisted of two versions, one explicitly portraying an event in the sequence while the other required that inferences be generated about the occurrence of this event from the context and sequence of other pictures in the story. Subjects in the acquisition phase of the experiment saw versions of the story sequence which contained either the explicit or the implicit target picture. The recognition task was to identify whether the explicit target picture was an event in the original story sequence. Baggett proposed two hypotheses. The first of these was that with no delay between acquisition and recognition reaction times for recognition would be faster in those cases where the explicit target picture was included in the original story sequence the subject viewed. In those cases where the event portrayed by the target picture had to be inferred as occurring in the sequence, reaction times for recognition were expected to be slower. The second hypothesis was that with a 72 hour delay between acquisition and recognition the differences in reaction time between the two groups of subjects in recognizing the target picture should markedly decrease. However it was not expected that the difference would entirely disappear in the light of Shepard's (1967) finding that surface memory for pictures is vivid and of long duration.

Results from this experiment confirmed both of the hypotheses. A very much slower reaction time for recognition of the target picture was recorded for subjects who had originally seen the story sequence containing the implicit target picture than for those who viewed the story sequence containing the explicit picture. However after a 72 hour delay the differences in recognition reaction time between the two groups of subjects were found to differ only very slightly.

Baggett interprets these results as an indication that the surface memory trace which aided faster access to recognition of explicitly descriptive pictures under the no delay condition was no longer available after 72 hours; the essential representation

remaining in memory at this point is likely to be a conceptual and probably not a pictorial one.

In an extension to this experiment Baggett investigated the role of instructions on surface memory for pictures. When explicit instructions were given to subjects to memorize only the precise individual pictures seen it was found that even after 72 hours subjects made no false recognition responses at all and reaction times were short. It seems that surface memory for pictures is strong and of long duration under the following conditions; (a) if task demands require this and (b) if pictures are regarded as discrete visual entities rather than as surface cues to an underlying meaningful description of a situation.

Baggett included one further experiment in this study. This was designed to test the hypothesis that reaction time differences would disappear if subjects, after viewing either the explicit or the implicit versions of stories, were asked to respond either 'yes' or 'no' to written questions describing the target event in the story sequence. The rationale given by Baggett for this hypothesis was that subjects who were actually shown the explicit version of the story would have to infer the answers to the verbal questions in much the same way as would subjects who originally saw only the implicit version; this would be so because a direct surface match would not be possible because two modalities, verbal and pictorial were involved. The results of this experiment confirmed the hypothesis. Reaction time differences between the explicit and implicit conditions which operated in the first experiment in this series were virtually eliminated. In fact a very slight reaction time advantage was recorded for those subjects who had earlier viewed the implicit version of the story.

Baggett interprets these results as an indication that subjects, regardless of whether they had viewed the explicit or the implicit story version, were responding from the same basic conceptual representation of the situation. She suggests that this finding gives some empirical support to Pylyshyn's (1973) contention that conceptual memory for pictures is basically propositional or descriptive in nature.

Pylshyn's concept of propositional knowledge is derived from the seminal work of Frege (1879/1960) and is based on the notion that the proposition is a description, an assertion or a meaning which can be conveyed by a number of different symbolic forms but is itself not logically dependent on any particular one of them. Experimental work by Carpenter and Just (1975) and Clark and Chase (1972) has also given support to Pylshyn's theoretical position. In summing up their 1975 series of experiments Carpenter and Just stated that their findings give support to the view that (a) sentences are internally represented as an ordered set of constituents in an abstract propositional format; (b) other information sources (such as pictures) are also represented in similar format.

The experiments reviewed in this section give some support to the view that the processes involved in constructing conceptual representations from visual and pictorial material are, in general, very similar to the processes found to operate when the stimulus information is presented in linguistic form. The constraints which affect the types of memory representations formed are also similar. For example, task demands to some extent determine whether the predominant emphasis will be on the retention of surface form in contrast to a more conceptual representation. However the work of Baggett (1975) and Posner and Keele (1968, 1969) has indicated that this distinction becomes less clear-cut over time. As was illustrated in verbal studies (e.g. Barclay, 1973; Rosenberg and Jarvella, 1970) the subject's awareness of the presence of an overall event in tasks involving pictorial stimuli seems to facilitate the generation of inferences which can be one source of recognition errors. Contrasting the results obtained by Baggett (1975) with those of Shepard (1967) gives tentative support to this view. However both of these studies also suggest that a difference, but one of degree rather than of kind, seems to obtain between memory for pictorial material and that for verbal material; that is, a subject's surface memory for actually viewed pictures, although sensitive to experimental conditions and task demands, tends to remain accurate and extant for a longer time

duration than does verbatim memory for verbal material (Keenan, Kintsch and McKoon, 1974).

This factor could be expected to influence, to an as yet undetermined degree, some differences in responses in memory research involving the abstraction of meaning from visual or pictorial materials in contrast to the responses given when the stimulus materials are linguistic in form.