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ABSTRACT

This paper reports the findings of an investigation into the development of the use and understanding of locative and temporal prepositions in 94 children aged from 18 months to 8 years. The research was carried out as part of the Project "Language Development in Pre-School Children," directed by Gordon Wells, at the University of Bristol, School of Education. The research represents an attempt to integrate the theoretical and methodological orientations of linguistic semantics and Piagetian theory in the study of the acquisition of a limited domain of word-meanings. Detailed analyses are presented of particular strategies utilized by children at various ages and stages of development in the comprehension and production of spatial and temporal relational terms. It is suggested that such strategies result from specific interactions between the developing systems of language, cognition and perception, the overall forms of which are determined by the socio-cultural context of the use of the relational terms. In conclusion, partial critiques are presented of one-sided applications of semantic features theories and Piagetian theory in previous explanations of the acquisition of spatial and temporal relational terms. (Author)

Spatial and Temporal Relations in The Linguistic and Cognitive Development of Young Children

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Report of work undertaken as part of the Project
"Language Development in Pre-School Children"
Director Gordon Wells

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The authors would be grateful to receive any comments on, or criticisms of, the work reported in this paper.

Preface

The work reported in this paper arose from an examination of the developing concepts of space and time in pre-school children, from both a linguistic and a cognitive point of view. The work has been carried out as part of the Project "Language Development in Pre-School Children", at the Bristol University School of Education.

The impetus for this work stemmed from a desire to integrate two different aspects of developmental theory: the cognitive approach, exemplified by work in the Genevan tradition, and recent work on Language Acquisition, which has derived largely from linguistic theory. Hitherto, these two theoretical positions have remained largely insulated from one another. We have therefore found it necessary to make explicit the assumptions underlying both, for the benefit of those readers who may be better acquainted with one of these positions than the other.

This approach has necessarily resulted in a rather lengthy paper, and those readers who are familiar with the material presented in the introductory pages, are advised to turn to the description of the tests and discussion of the results.

The attempt to combine two distinct theories must result in a re-examination of both. We have therefore found it necessary to formulate a developmental model which, while drawing on elements of both positions, introduces new concepts which cannot be derived from either in isolation.

The difficulties of presentation inherent in such an attempt are obvious. We have therefore thought it best to structure the paper from a historical perspective.

The line pursued by the paper therefore progresses from a presentation of results gained from previous work, to a statement of our initial hypotheses. It should be borne in mind that, during the course of the research, these hypotheses did not prove entirely adequate to the complexity of the empirical evidence that we encountered.

This will be followed by a detailed exposition of the tests carried out and the results obtained from them gradually introducing the model that we have evolved during the work. Finally, there will be a summary of the theoretical position which we now hold. This will attempt to draw together the different aspects covered in the paper.

Introduction: Trends in Theories of Language Development

For almost a decade, during the early and mid-sixties, research into the acquisition of language was dominated by ideas stemming from the revolution in linguistic thinking brought about by Chomsky. This period of research was immensely productive, and resulted in much new knowledge of children's syntactic development. This work tended to stress the innate abilities that the child was assumed to bring to bear during the process of acquisition of the grammar of his native language, in order to account for the non-stimulus bound nature of the developing linguistic system. As a result both of the emphasis on syntax, and of the innatist assumptions underlying much of the work, it consisted largely of autonomous grammars written to account for the imputed linguistic competence of the child at different ages. (c.f. R. Brown 1973).

Recently, however, many writers have challenged the assumption that the prior knowledge brought to bear by the child during language acquisition is innate. At the same time, recent work on language comprehension suggests that there is no necessary correspondence between the grammars written by linguists and the actual processes and strategies used by the child (or adult) to produce and understand utterances. (Fodor & Garrett, 1966.) Many theories now emphasise the priority of the cognitive processes which are taken to underly language acquisition. (Sinclair de Zwart, 1972, Slobin, 1973).

A parallel shift in emphasis has occurred within linguistic theory. It has been suggested that Chomsky's syntactic deep structures are not deep enough, and that a true description of the basis of language must start with semantics. (Halliday, 1973, Fillmore & Langendoen 1971).

The confluence of these two theoretical currents has resulted in new work which attempts to provide a detailed characterisation of the developing semantic system of child language, and which sees "meaning as the interface between language and experience" (Wells 1973).

Any theory of semantic development must necessarily include an adequate account of the acquisition of the lexical system of the language. This leads almost inevitably to an investigation of the relationship between language and thought, as it has been frequently remarked that the meaning of a work for a child is not the same as the meaning of the word for an adult.

Theories of Lexical Development

A fundamental concept in lexical theory is that of the semantic field. (Ohman 1953) A semantic field is taken to be a structured arrangement of all the words in the lexis of the language in question which denote aspects of a distinct cognitive, experiential, perceptual or social domain in the linguistic community. A semantic field is therefore a relatively autonomous sub-system of the entire lexis of the language.

Most studies of semantic fields have focussed on areas of intrinsic psychological or social interest, for example the lexes of time, space and motion, kinship terms, colour names, pronouns, prepositions etc. (Fillenbaum & Rapoport, 1971). All the terms within any given semantic field enter into certain relationships one with another, e.g. synonymy, antonymy, hyponymy. That is to say, any semantic field is a specific configuration, the elements of which are in relationships of hierarchical domination and contrastive opposition. The predominant theoretical representation of this actual structure of the lexicon has been provided by the concept of the semantic feature, or component. (Hjelmslev 1953, Ullman 1962). This theory was developed originally by linguists of the Prague and Copenhagen

schools, and received new attention in the formulation of theories of interpretive semantics and selectional restriction stemming from the work of Transformational Grammarians (Katz and Fodor, 1963).

Semantic features are taken to be units of meaning smaller than the full meanings encoded in words, and in some way more basic. They are the molecular "building blocks" out of which the lexicon of any particular language is constructed. All the lexical items which make up any given semantic field will have certain central semantic features in common; the differentiation of word meanings is achieved by the addition to these core features of additional features. Thus semantic features are organized hierarchically. In addition to this, all features are signalled within lexical items with either positive or negative polarity.

Figure I

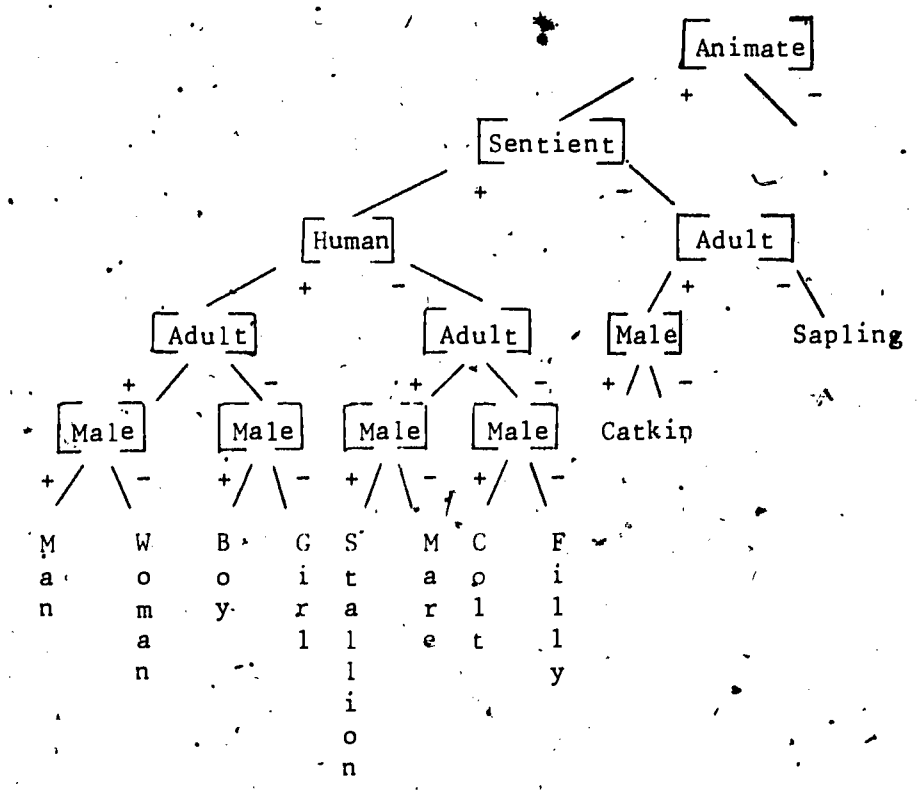


Figure I shows a partial taxonomic representation of nouns. Semantic features are enclosed in square brackets, at the end of each string is one of the possible lexical entries which incorporates all the features and their values found in the path from top to bottom.

If the meaning of any word in a semantic field can be seen as a hierarchical organisation of different semantic features, then clearly any feature in the hierarchy can hold either a positive or negative value. If two words in any semantic field are characterised by an exactly identical feature hierarchy, and differ only in the polarity of the value attached to the terminal feature, these words form a word-pair. Some theorists, notably Eve Clark (Clark 1973), have cited the existence of these word pairs as instances of a more general universal linguistic phenomenon, marking. (c.f. Greenberg 1966).

The theory of marking as traditionally used in linguistic theory has in the main referred to five or six separate but related phenomena. The criteria for

deciding whether a particular lexical or syntactic distinction is of the marked/unmarked variety are as follows:

1) Where there is a morphological difference between the marked and unmarked instances, the unmarked instance will invariably be the morphologically simpler of the two. (E.g. the singular-plural difference in English).

2) Generally speaking, where the unmarked term dominates the marked term in a semantic field, the unmarked term will be the generic term incorporating the marked term in certain usages: the unmarked term will therefore be both an antonym and a hyponym of the marked term. (E.g. in English man can be used as the generic term for humanity).

3) "Distinctions existing in the unmarked member are often neutralised in the marked categories". (Greenberg, 1966). (E.g. in the German plural, the article and both weak and strong forms of the adjectival declension have the same form in all three genders).

4) Where the semantic opposition is one that refers to the presence or absence of a specific attribute, the unmarked term will always be the one denoting presence, and the marked term the one denoting absence, as in the case of the English word-pairs same/different (similarity), more/less (quantity) big/small (size). This is the vaguest criterion.

5) As a result of all these differences, marked and unmarked word-pairs will have slightly different syntactic distribution, and will not in all cases be in perfect paradigmatic opposition. (E.g. one can say "the lake is six feet deep" but not "the lake is six inches shallow").

6) Where the marked/unmarked distinction applies to an adjective-pair denoting poles of a continuum, the noun denoting the continuum will always be derived from the unmarked term. (E.g. long, short, length)

It has frequently been noted in studies of the development of word meaning, that children appear to over-extend the meaning of words. They will tend to use one word to refer a whole class of objects of situations, for only one of which it is appropriate usage in adult language. Recent studies of lexical development have attempted to explain the acquisition of words by reference to the semantic features which are assumed to be contained in the word in adult language. Each of the models proposed is essentially a variation on the same theme that the child acquires the meaning of the word through the addition one by one of the separate features. McNeill (1970) suggested two possible hypotheses: that either when the child first uses a word, he takes it to mean either one or a combination of a limited number of the features, and thereafter gradually acquires additional features until his understanding corresponds with the adult dictionary entry (horizontal development); or that all the features of the word are simultaneously incorporated into the child's dictionary entry, but each feature is coded separately, so that the same features are not necessarily recognised as such in different entries within the lexicon (vertical development).

Both Eve Clark (Clark 1973) and Anglin (1970) argue for versions of the horizontal development hypothesis. Anglin maintains that the addition of features proceeds from "bottom" to "top" - the first features to be acquired are those which terminate the hierarchical sequence, i.e. he acquires the "particular" features before the "general". Clark, more cogently, argues the exact opposite: the earliest features to be acquired are those highest up the hierarchical tree, so that the child will include in the meaning of a word all the other words

which share that feature, or limited set of features. In addition, she suggests that the positive instance of any feature will initially be over-extended to include the negative instance.

Clark specifically situates her hypothesis within one of the many theories of innate linguistic dispositions which have characterised language acquisition studies in the post-Chomsky period. This is the theory of innate semantic primitives as advanced by Bierwisch (1970) and Postal (1966).

They suggest that certain fundamental semantic features are linguistic universals; as such, they may "finally be reduced to components representing the basic dispositions of the cognitive and perceptual structure of the human organism". (Bierwisch, 1970). To effectively test this hypothesis, it is necessary to select an area of the lexicon which is susceptible both to an exhaustive analysis of the acquisition of the actual lexical items, and a detailed investigation of the development of the concepts expressed by means of these terms. Locative and temporal relational terms constitute such an area, and it is these two semantic fields which have been investigated in the study reported here.

Although the semantic fields of time and space are relatively distinct, there are many instances of metaphoric extension of a term from one field into another; e.g. fore and aft in nautical language, running after a bus, behind the times etc. It is therefore apparent that a strong connection exists at a linguistic level between these two fields. Moreover, psychological investigations have suggested that a similar relationship exists at the cognitive level (see below).

The most substantial body of data on the child's acquisition of spatial and temporal relational terms to date is provided by the work of Eve Clark. In particular she has carried out detailed investigations of the acquisition of the relational terms in front, behind (in back), before and after. Both in front/behind and before/after form oppositional word-pairs which differ only in the positive or negative valence of the terminal feature in the structural description of the adult lexical sub-system. For example, she proposes the following characterisation* of the feature hierarchy for certain temporal terms (Fig. 2).

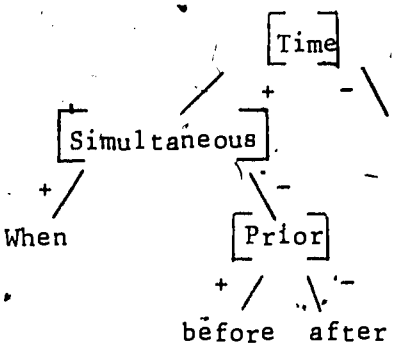


Figure 2

* It should be noted here that Clark's allocation of positive and negative values to before and after depends entirely on the selection of the feature [Prior]. Had she selected the feature [Subsequent] as a constituent of her structural description, the terminal values for these words would have been reversed.

The positive term of each word-pair (before, in front) is referred to by Clark as the unmarked item, and the negative term (after, behind) as the marked item. She cites evidence from the work of Donaldson and Balfour (1968) and Donaldson and Wales (1970) who studied the acquisition of the word-pairs more and less and same and different and demonstrated that the positive, unmarked term was, in each case,

a) The first term to be acquired, i.e. used and understood correctly by the child
b) the more general item of the word pair, in that the negative, marked term was first understood and used in contexts appropriate to the use of the unmarked term

In other words, children initially understand less to mean the same as more, and different to mean the same as same. Clark interprets this as an indication that the positive instance of any feature is acquired earlier than its negative instance. She suggests that the reason for this is that the positive member of each word pair is the generic one, in that it refers to the presence of the property or attribute coded in the terminal feature, e.g. more can refer simply to some, as when a child asks for "more milk", whereas less can only be used as a comparative. In the case of in front/behind and before/after, she directly relates these observations to the notion of the semantic primitives, perceptually derived information is coded in the form of basic semantic features. in front is seen as more "primitive" in the sense that it refers to objects within the visual field, whereas the initial usage of behind is with reference to objects outside the visual field. Similar hypotheses are tendered by her to account for supposed discrepancies in the acquisition of other spatial and temporal terms.

Eve Clark's initial hypothesis that the terms she takes to be positive and unmarked will be acquired earlier than the negative, marked terms, is born out by her results (Clark 1971); in each case, the "unmarked" term is used and understood correctly before the "marked" term. Nevertheless, Clark's theory also logically entails that not only will the "unmarked" terms be significantly easier for children to understand, but also that the "marked" term will be consistently interpreted by young children to mean the same as the "unmarked" word of the pair. However, no evidence of such substitution, or over-extension is presented by her. In a comprehension task involving acting-out-of sentences conjoined by before and after, the most significant predictor of semantic reversal by the children would appear to be the actual temporal sequence of the words describing the events within the actual spoken sentence. (Clark, 1971). Evidently, children aged between 3 years and 4 years 11 months interpret such constructions by employing an order-of-mention strategy. This was recognised by Clark as a factor in the comprehension task, but she still considered it to be secondary to her major hypothesis.

The Acquisition of Concepts of Space and Time: Cognitive Theories

Most systematic accounts of the relationship between language and cognition have hitherto been generated by the work of Piaget. Cognitive development, as seen by Piaget, consists of the gradual construction by the developing child of increasingly effective cognitive schemata based upon successive stages of co-ordination of the logic of actions. Knowledge, for Piaget, is not derived from percepts, i.e. sensory input, or from symbolic representations of such sensory information, as is maintained by most empiricist psychologists, but upon the internalisation (and symbolic representation) of the actions performed upon these objects.

"Logico-mathematical concepts presuppose a set of operations that are abstracted not from the objects perceived but from the actions performed on these objects, which is by no means the same". (Piaget & Inhelder, 1969 p. 49). Cognition, therefore, is not merely a reflection of the real world, even a reflection mediated through symbolic representation. On the contrary, cognition is a constructive act, and one which furthermore constructs its own object. It follows, therefore, that for Piaget, language, in common with other symbolic systems, is a secondary intellectual process. The child can only express in language the conceptual schemata that he has already internalised. "There is a logic of coordination of actions. This logic is more profound than the logic attached to language, and it appears well before the logic of propositions, in the strict sense". (Piaget, 1963) "A symbol (is a) signifier with a figurative content different from, and assimilated to, operative intelligence, which is the symbol's source and referent". (Furth 1969 p. 99). Studies of language acquisition conducted by psychologists in the Geneva tradition have therefore emphasised the investigation through language of the cognitive structures underlying its use. (E.g. Sinclair-de Zwart 1972). In addition to this, investigations of cognitive development have assumed that the language used by the child is merely a direct reflection of the level of cognitive development already achieved. No systematic work has ever been carried out within this tradition to determine whether the lexical items encountered by the child in the experimental situation mean the same for him as for the adult experimenter - the fact of apparent comprehension has been taken to be sufficient in itself.

It is well known that Piaget (Piaget and Inhelder 1956) proposed that the child's conception of time develops out of, and builds upon, the notions that he has acquired in his operations in space. Piaget contends that since time is a more abstract conception, relating to transient events rather than permanent objects, the child will begin to understand space before he can grasp ideas of temporal order. In order for events to be related to each other in time, the child must already be capable of mental representation. The earliest conceptions of space, however, consist of the sensori-motor schemes by means of which the child coordinates the movements of his own limbs, and his actions upon objects. The first conceptions of space are topological:

> "If we think of an object or configuration of objects occurring within a single perceptual field as our given set, a topological geometry deals only with those relations which are internal to the set and are preserved despite stretching and rotation-relations such as proximity, separation, surrounding and order".
>
> (Johnston 1973 pp. 2-3)

It is only later that the concepts of Euclidean space - projective linear relations which are not preserved through rotation, such as above, below, in front, behind, up, down, right, left etc. are understood by the child. These are relations which demand a point of view to define the direction of the referent; if the point of view changes, so does the relation. All relations in time, apart from that of immediate coincidence or simultaneity, are of a similar type to those occurring in Euclidean geometry. They demand a viewpoint. A central notion in Piaget's work on the development of spatial concepts is that of decentering:

> "In the course of the first eighteen months, there occurs a kind of Copernican revolution ... whereby the child eventually comes to regard himself as an object among others in a universe that is made up of permanent objects (that is, structured in a spatio-temporal manner) and in which there is at work a causality that is both localized in space and objectified in things".
>
> (Piaget and Inhelder, 1969, p. 13)

Thus the establishment of object permanence enables the child to recognise that he has a viewpoint of his own. But it is not until about 6 years old that the child can finally "liberate" himself from his own point of view in space, and mentally reconstruct that of another person. It is this process which is known as decentering.

Full mastery of this ability is achieved only with the establishment of operational thinking. Operational thinking is characterised by the existence of group-like structures (Piaget, 1971) which lend to the mental operations internalised and used by the child the attributes of identity, closure, associativity, and reversibility.

In any operation, the elements which are operated on enter into certain relationships. These relationships all bear the properties listed above, in different types of combinations. It is when all these different combinations are available to the child that operational thinking is said to have been attained. Any one particular combination of the different variants of the basic relations listed above, is one concrete operational system. These different operational systems are generally not acquired simultaneously - all the properties of the group-like structure may be present in one concrete operational system, but these properties may not have been extended to the specific forms necessary for the establishment of a different operational system. It is not, therefore, valid to deduce from, for example, the existence of a compensation strategy in a conservation task, the existence of the full structures of operational thinking.

The ability to apply the operational rules in concrete situations involving real objects is known as concrete operational thinking, and according to Piaget develops between the ages of about 6 and 8 years of age

Between the ages of 11 and 14 years the child develops the ability to combine the different concrete operational systems in order to construct hypothetical situations In other words, operations begin to be performed on relations rather than on objects. This stage is called by Piaget formal operational thinking, and is the defining characteristic of adult thought.

A frequently observed phenomenon in the development of concrete operational thinking is what Piaget terms horizontal decalage; this phenomenon is encountered when the child is able to apply certain logical rules to a problem in one situation, but cannot apply the same logical rules to a logically identical problem in a different situation in which different objects are involved For example, conservation of mass is typically observed before conservation of volume The counterpart to this horizontal decalage is vertical decalage, in which there is a similarity between the structures to which operations are applied at different levels of functioning, for example motor as against representational organisation of a certain limited space.

We will now go on to consider some previous work on "decentering" in space and time.

Piaget and Inhelder (1956) investigated the child's ability to recognise and construct a spatial perspective different from his own in the well-known three-mountains experiment. Fromer (1968) adapted this technique for the investigation

of temporal decentering. He noted a developmental change in the nature and quantity of temporal reference produced in the spontaneous speech of three children at around 4 years. Included in this was the first appearance in production of the words "before" and after, as well as increased use of tense markers. He postulated that underlying this change was the onset of the ability to decenter, in time. He constructed tests which involved the selection by the child of a picture, from within a temporal series, which represented a particular viewpoint. Cromer concentrated largely on the understanding and use of verb tense.

The results he obtained, however, did not substantiate his own hypothesis in its initial form. Decentering had not taken place even by the age of 4 years 9 months. He suggested that a more adequate formulation of the process of temporal decentering would be to hypothesize two distinct decentering stages, the first of which these would enable a child to relate an event at Time X (any time) to his "own" TimeC. It is clear that the temporal order system set up by the child at this stage would remain entirely unidirectional. The second stage, it was thought, would consist in the child developing the ability to relate separate events, at Time X and Time Y, to one another, without reference to, or mediation through, his "own" Time C. This decentering would, of necessity, require the child to grasp the bi-directionality of a full relational system, i.e. if X is before Y, Y is after X.

As it is used here, the concept of bi-directionality presents itself as an example of Piagettian reversibility of operations, in this case, the relationship between before and after is one of reciprocity. Thus we hypothesized that the stage of secondary decentering would occur at around the time of onset of concrete operational thinking, i.e. between the ages of 6 and 8 years.

This interpretation of Cromer's results gained support from a reading of the work of Eve Clark (1971) and Ferreiro and Sinclair (1971). Clark administered tests to children to investigate the comprehension and production of before and after, and her results fell into three broad response categories. The first category consisted of children who, in the comprehension task, used an "order of mention" strategy. Niether were these children able to use relational terms to link two events that they were asked to describe in the production task. The second group of children, she claimed, interpreted before correctly in the comprehension task, but not after. They were also capable of using before appropriately in the production task, but did not use after. As mentioned above, Clark interpreted this production task result as support for her thesis that before/after constitute a marked/unmarked word pair. However, it should also be clear that it is unsurprising that children spontaneously used before in preference to after to conjoin two sentences, since the use of before in the mid-clause position does not require the child to reverse in language the actual temporal order of events, whereas the corresponding use of after does. Her third response category consisted of children possessingfull productive and receptive competence in the use of these terms.

Ferreiro and Sinclair, on a production task similar to that used by Clark, were also able to group children in three categories, when testing children between the ages of 4 years and 9 years. In addition to this test, they administered a test of conservation of liquid (Piaget, Sinclair and Bang, 1968). In this way, they hoped to relate the child's performance on the production task to his underlying operative level of development. Their three response categories were as

follows:

Category 1 children, when describing a sequence of two independent actions, used two weakly-linked propositions (e.g. "and then"). When asked when each of these actions occurred, they tended to say "now" or "just then", thus introducing a link between themselves and the event, but not between the two events. When asked to describe the actions in the reverse of the order of occurrence, they tended to reiterate the original description, or to reverse the order without adding any temporal indicators. These children were totally pre-operational on the conservation test.

Category 2 children in the free-choice description used two weakly-linked propositions with verbs in the same tense, but in contrast with the responses in category 1, the links tended to be adverbial (e.g. first, afterwards). When asked when the events occurred, they gave correct answers. In the inverse-order description, children complied with the instructions to start by talking about the second event, but were incapable of using temporal indicators to describe the actual temporal sequence. These children had reached reversibility of action in the conservation tests, but did not conserve.

Category 3 children gave correct answers in each case. They were able to use both before and after appropriately, and succeeded on the conservation test.

However, they do not mention that they found any difference between the child's use of before and after, although they do not fully describe their results on comprehension tasks.

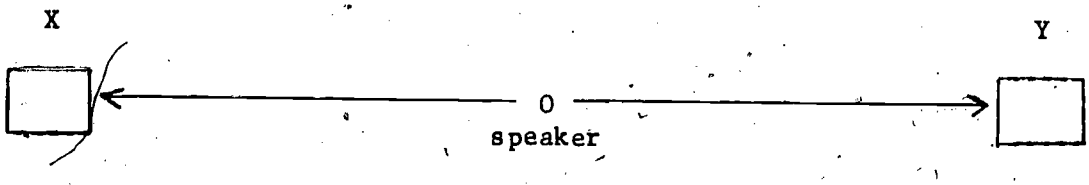
Ferreiro and Sinclair took the lack of reversibility of action and its corresponding comprehension and production level as indicative of childrens' inability to link two separate events in such a way that one is used as an anchor and reference point for the other. Children at the second stage, they deduced, could establish two independent relationships of temporal ordering, but could not integrate them together or deduce one from the other. The similarity between this description and the suggested stage of "primary decentering" (what Piaget, 1968b, refers to as "semi-logic with one-way mapping") was striking. The category 3 children succeeded in relating two events in time without interference from their own viewpoint. This would appear to correspond to the stage of "secondary decentering".

Summary

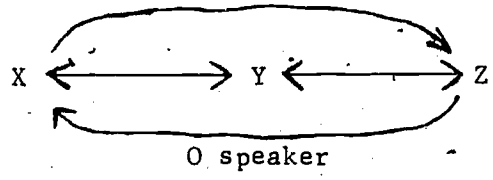
We can summarise the conclusions that we drew from the above-mentioned work on the production and comprehension of spatial and temporal relational terms as follows: in the work of Eve Clark there would appear to be two possible lines of investigation. The first of these relates to her thesis that such relational terms exhibit patterns of acquisition characteristic of unmarked/marked word pairs. We did not find the evidence which Clark uses to support this claim to be conclusive; neither did we, after examination of the linguistic nature of marking, find any a prior reason for supposing this to be so. We decided to investigate the hypothesis that the theory of marking is not adequate to account for the developing comprehension and use of spatial and temporal relational terms. The method chosen to investigate this was an investigation of the response styles of young children to comprehension and production tasks using these terms. These would then be compared with the response-styles of the same children to similar tasks incorporating word-pairs for which there existed more substantial evidence of marking. We considered the second line of investigation implicit in Clark's work to be potentially more fruitful; that is that children will employ specific response-strategies for comprehension and production, based on actual perceptual attributes of the objects and language encountered in the experimental situation. We were able to identify at least two examples of this in her work. Firstly, the strategy employed in comprehension of sentences conjoined by before or after, by which the actual temporal order of events is identified with the order in which the events are mentioned in the sentence. The second of these is Clark's observation of substitutions of spatial relations in response to comprehension items, where the relation which is substituted is not that coded in the instruction, but one which is more appropriate to the perceptual configuration. For example, a child asked to put a brick on a tunnel; is more likely to put it inside the tunnel. It was decided to make a fuller examination of such strategies.

In the work of Cromer and of Ferreiro and Sinclair, there was considerable evidence that the range of situations in which spatial and temporal relational terms could be used and understood, was limited by the level of cognitive development currently attained by the child. This level of development could be characterised in two ways: firstly, in general, with reference to progress towards concrete operational thinking. More specifically, it could be described in terms of the two stages of spatial and temporal decentering.

With the attainment of primary decentering, the child is in possession of the following logical ability: that is to relate his own subjective position within a configuration or a continuum to that of any one other object or event. However, such relations still remain entirely uni-directional; the child still cannot relate both objects/events simultaneously to his own subjective position or to each other. The cognitive capabilities of the primary-decentrred child are diagrammatically represented below.



The ability of the child to liberate himself completely from his own subjective viewpoint is established by secondary decentering. The secondary decentered child can relate events on a continuum or objects in a configuration to each other by reference to their own relative positions, and without recourse to a subjective anchor-point. The stage of secondary decentering is diagrammatically represented below.



Although the logical structures of primary and secondary decentering are identical in space to those in time, there are immediately obvious differences between the nature of the perceptions of space and of time. Whereas time, in the ordinary "Newtonian" sense, is uni-dimensional continuum, space extends over three dimensions. The existence of three dimensions, or axes of reference, in space, introduces a greater complexity in tasks involving spatial relational terms. The likely effect of this would be that spatial decentering would lag behind temporal decentering (horizontal decalage). On the other hand, if, as Piaget suggests, the concept of time evolves out of that of space, we would expect the introduction of an opposite effect. Because of the indeterminacy of the evidence, we found it impossible to formulate a definite hypothesis on the relative order of spatial and temporal decentering. We therefore confined ourselves to the hypothesis that, since their logical structures are identical, both should be attained at roughly the same ages.

It should be emphasised that our theorisation of the stages of primary and secondary decentering is not equivalent to Piaget's concept of "egocentrism". However, if such a concept is applicable to notions of space, it would be expected that the pre-operational child would display a tendency to utilise his own front/back axis, in placements involving the use of in front and behind, in preference to that of other objects.

As we have already noted, Johnston has noted that spatial relational terms may be classified according to whether the relationship that they express is topological or Euclidean. Since Piaget maintains that topological notions are more primitive than Euclidean ones, we would predict that comprehension of topological relational terms will precede that of Euclidean relational terms.

Hypotheses

These will be stated in a positive form.

Marking

1. An investigation of the response styles of children to comprehension items involving the terms before/after and in front/behind will reveal no significant difference between the frequency of substitution of the "unmarked" for the "marked" term and the frequency of substitution of the "marked" for the "unmarked" term.

2. An investigation of the comprehension of the following terms: bigger/smaller, not as big/not as small, less big/less small; will reveal significantly more substitution of the unmarked for the marked term than the reverse.

Strategies

An investigation of the strategies of comprehension of spatial and temporal relational terms will reveal the utilisation by children of specific perceptual attributes of the objects, configurations and linguistic input present in the experimental situation.

Decentering

1. An investigation of the comprehension of the terms before/after, in front/behind, above/below will reveal two distinct stages of primary and secondary decentering.

2. The onset of primary decentering in space and time will precede that of secondary decentering.

3. Using a test of conservation of liquid volume as a measure of the development towards concrete operational thinking, there will be a significant positive correlation between the onset of reversibility of action (renversabilite) and primary decentering. This will occur between the ages of $3\frac{1}{2}$ and $4\frac{1}{2}$ years.

4. Using a test of conservation of liquid volume as a measure of the development towards concrete operational thinking there will be a significant positive correlation between the onset of conservation (reversibility of operations) and secondary decentering. This will occur between the ages of 6 and 8 years.

Axes

An investigation of responses to items involving placement of objects in response to instructions incorporating the relational terms in front, behind will reveal a developmental sequence from the child's use of his own front/back axis to that of other objects.

Topological/Euclidean

An investigation of the relative ease of comprehension of spatial relational terms will reveal that topological relational terms will be easier than Euclidean relational terms.

Method

1. Subjects

This study, which is still continuing, was conceived as a longitudinal one. The subjects whose results are reported here were drawn from two sources. These are:

a) 64 children, one half of the total sample of children participating in the Bristol Longitudinal Study of Language Development, directed by Gordon Wells. This sample was evenly balanced according to sex and social class. 32 children were first tested at 1½ years, and 32 were first tested at 3½ years. 16 children at 3½ years received the temporal tests, the remaining 16 3½ year olds and all the children at 1½ years received the spatial tests. In addition to this, all children at age 3½ years received a test of conservation of liquids. It is intended that the development of these children, as shown on these tests, will be monitored at six-monthly intervals for a period of two years from the first occasion of testing.

b) 30 children, 11 aged 5 years, 10 aged 6 years, and 9 aged 7 years. The subjects were evenly balanced according to sex, but no control was introduced for social class. These children were tested at the local primary school at which they were in attendance. Each child was tested on 3 spatial, 4 temporal tests, a liquid conservation test, and a test of comprehension of dimensional terms.

2. The Tests

i. Temporal

a) Temporal Seriation Test

This test is designed to investigate primary decentering. The testing material consists of a series of 7 coloured cards, each of which illustrates a simple declarative sentence. Each sentence forms part of a short story about a Teddy bear.

e.g. Teddy is asleep
Teddy wakes up
Teddy gets out of bed etc.

The story is told to the child by the experimenter, who lays out the cards as each sentence is spoken, so that the cards form a left-right series. The story is retold once, with the experimenter pointing to the appropriate picture for each sentence. The cards are then shuffled on the table, and the child is required to re-order them as the experimenter reads out the story. The purpose of this is to teach the child a simple one-to-one correspondence between sentence and picture, and the left-right convention of temporal order. The child is then asked e.g. "show me what Teddy does just after he wakes up". A similar sentence is used to test comprehension of the word before.

The child is then asked to insert 3 further pictures into the series, e.g. "teddy wakes up when the alarm clock goes off". Comprehension of the terms "and then" and "just before" is also similarly tested. Success in these tasks is taken to be indicative of the attainment of primary decentering; in each case, the child is required only to take one event as reference for another, or

"subjective present", and relate the other event to it along a continuum. Children are assigned to Pass and Fail categories according to their performance on the entire test.

Each of the 6 test items has a possible score of 2 points; a total score of 9 out of the possible 12 points over the entire test is designated as the Pass criterion.

b) Test of Production of Temporal Relational Terms.

This test is similar to that used by Ferreiro and Sinclair (1971). The method by which the child is induced to produce temporal connectives is as follows: the experimenter performs a sequence of two actions, using dolls and toy animals, involving either one or two agentive participants. The child is then asked: "what happened there?" His response is noted. The child is then asked e.g. "When did the mummy open the door?" if one of the actions is the mummy doll opening the door. He is also asked when the other event occurs. In the one case in which the agent of the first action is different from the agent in the second action, the child is then asked to describe the entire sequence again, but to start by talking about the agent of the second action. This is to determine whether or not the child can free himself, in production, from the constraints imposed by the correspondence of word order with temporal order. The purpose of this test is to test the child's productive competence in the use of temporal relational terms. Results obtained in this test are compared with results gained from tests of: comprehension of the same terms, decentering, and liquid conservation. The test also provides data on the order of appearance in the child's productive repertoire of the words, before and after.

c) Test of Comprehension of Before and After. (Temporal Comprehension Test)

In this test, the experimenter reads out a series of eight sentences, each of which links two actions, to be acted out by the child using dolls and toys, by use of the words before or after. The test is designed to investigate the effect on the child's performance of the following 3 variables:

1. Number of participants in the sentence

2. Position (either initial or mid-clause) of the relational term

3. Relative ease of comprehension of before and after

In this way, concrete strategies employed during the transition from primary to secondary decentering may be elucidated. It will also provide evidence as to the validity of Eve Clark's (1971) classification of before and after as an unmarked/marked pair.

The eight sentences used in the test are as follows:

1. The boy strokes the dog before he goes upstairs.
2. The girl kisses the mummy before the dog touches the horse.
3. After mummy cleans the window, she goes downstairs.
4. After the girl crosses the bridge, thecar goes down the road.
5. Before the boy pats the dog, he kisses the girl.
6. Before the girl goes upstairs, the boy sits on the chair.
7. The boy climbs onto the horse, after he pats the dog.
8. The boy pats the dog after the girl kisses the horse.

d) Temporal seriation: three-term series

This is a test of secondary decentering. The experimenter presents three cards to the child, each depicting an event in which the major participant is the teddy-bear. The experimenter then reads out a sentence in which all the events are ordered according to a sequence determined by two temporal prepositions, either before or after.

e.g. Teddy picks some flowers before he rides the bike but after he meets the monkey.

There are four sentences in all, taking the forms.

a) X before Y but after Z

b) X after Y but before Z

c) X before Y and before Z

d) X after Y and After Z

where X,Y,Z are all events depicted on the cards. Sentence (c) can be successfully interpreted by use of an order-of mention strategy, sentence (d) by use of a reversal of this strategy, sentences (a) and (b) only by the attainment of secondary decentering.

Since in addition to the semantic complexity of the sentence the child may face problems caused by limitations in short-term memory, a control sequence is also first administered in which three events are linked by the connective "and then". In addition to this, a two stage test is administered, where the child is required to order the three cards in two separate and consecutive stages, according to two sentences which each link two of the cards by the use of before or after

e.g. Teddy makes the sandcastle after he paddles.
(Pause)
But ... before he makes the sandcastle, he eats a stick of rock.

There are four such items in all, each requiring the child to relate one event at a time to another fixed reference point. It is therefore logically equivalent to a primary decentering task.

Both these latter tests also establish whether or not the child has managed to establish correct iconic equivalences between the pictures and the spoken sentences, and is in possession of the relevant left-right representational convention. A similar test involving an acting-out technique was also piloted, in view of the difficulties involved in the use of pictorial representation. However, this test was found to impose a greater burden on short-term memory, and was therefore abandoned. Success on sentences (a) and (b) is taken to be conclusive indication of the attainment by the child of secondary temporal decentering, and the related structures of operational thinking. By this time, the child has attained full receptive competence in the use of before and after. The child is required in these sentences to relate the event which is spoken first to two other events, which relationally define its position in the temporal order. The child is therefore required to concentrate on the relational

position of this event, rather than deducing it from a focussing of attention on the event immediately following the preposition, and using this as the anchor-point, as he can do in tests (b) and (c). This means that one would expect a strategy-shift in the perceptual decoding of these terms which would occur when the child is actually in the process of acquiring decentering. This point will be expanded in the Results section.

ii. Spatial

It should be noted that the spatial tests incorporate a greater range of terms than the temporal tests. There are two reasons for this. Firstly, many temporal relations in English are expressed through tense and aspect, and therefore fall within the grammatical rather than the lexical system of the language. (Spatial relations, on the other hand, are signalled almost entirely through the use of prepositions). Secondly, as has already been mentioned, there are more dimensions in space than time, and therefore a correspondingly greater number of spatial relations to be coded. Partly because of the limited time available during any one testing session, and partly because of practical difficulties encountered in attempting to get children to respond, we have not included any production tasks in our spatial tests.

a) Comprehension of Locative Terms.

This test is administered to children of all ages covered by this experiment. It consists of a series of sentences to be acted out, with toys, by the child, all of which express spatial relations between objects by means of prepositions. The prepositions tested are: in, on, out of, under, beside, up, down, inside, outside, along, on the side of, across, over, next to, around, between, in front of, behind, above, below. The adverbs upwards and downwards are also included. This test will enable us to determine the order of acquisition of these locative prepositions. A pilot run of this test enabled us to isolate eight categories of response. These will be described in the section dealing with results.

The test will provide evidence against which to test the hypothesis that comprehension of locative terms proceeds from topological to Euclidean terms, and to test Eve Clark's marking hypothesis.

b) Locative Orientation Test.

As was pointed out earlier, the semantic field of space is more complex than that of time, since space is tri-dimensional. In particular, the prepositions in front and behind are ambiguous. Any expression incorporating these terms may be interpreted by reference to several axes. The appropriate axis is selected according to the cues perceived within the configuration by the observer. (E.g. "in front of the car" may refer to a position between the observer and the car and proximal to the car, or to a position at the front of the car.) Since Piaget characterises the thought of young children as "egocentric", this task was originally designed to test the hypothesis that children will begin by using their own front-back axis as reference, and only later use that of other objects. The procedure adopted is as follows: a reference object (toy lorry) is placed in the middle of a painted wooden road, marked with a central broken white line, so that the lorry is facing either along or across the road. The child is asked by the experimenter

to place a toy car in front of/behind the lorry. The position of the child is varied, being either perpendicular to the long axis of the road, so that his gaze bisects it, or at the end of the road, so that he faces down its long axis. Thus there are eight conditions in all. The test is diagrammed in the section on results. The position of the placement object (car) and the direction in which it faces is noted in all cases.

c) Spatial 3-term series.

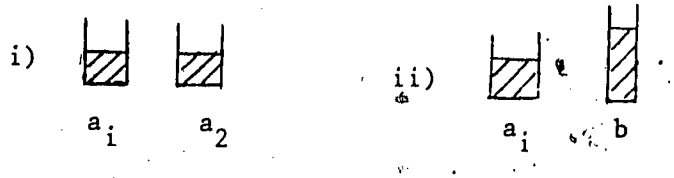
This test is designed to be directly comparable with the temporal 3-term series test. However, since there are no intrinsic spatial axes comparable to the left-right temporal order convention, we decided to use a technique of object ordering, rather than picture ordering.

In this test, the child is asked by the experimenter to place objects (a) on the road, so that e.g. "The car is in front of the lorry but behind the bus", (b) on the stairs inside a doll's house, so that e.g. "The boy is above the mummy but below the girl." The test items are therefore comparable with items (c) and (d) of the temporal 3-term series task. We did not include any items in which the same connective is used in both first and last position. Neither is a memory control introduced in this test, since it is assumed that if the child can pass the memory test in the temporal 3-term series, he is able to store three participants simultaneously in short term memory.

iii. Conservation of Liquids

This is the standard test of liquid conservation (Piaget et al 1968a) in which three containers are used, as follows:

Figure 3



After the transformation, the child is asked to judge whether the liquid in the two containers remains equal. A check test is administered, in which the child is required to pour "the same" amount of liquid into the tall cylinder as is in the standard beaker. Thus it is established whether he has the ability to compensate. A full description and discussion of this test is given later.

iv. Comprehension of Dimensional Terms.

The comprehension of the following dimensional terms was investigated: big, small, less. The method used is as follows: the child is presented with nine wooden sticks, from one to ten inches long, each of which differs in length from the next by one inch. The experimenter holds up another stick, five inches long, and asks the child to (e.g.) "give me a bigger stick than this one." The dimensional terms and combinations used were: bigger, smaller, not as big, not as small, less big, less small. The purpose of this was to determine the relative order of difficulty of the above combinations, and to investigate whether this can adequately be explained in terms of the theory of marking. For this purpose, the word not was assumed to be a simple negative marker.

RESULTS

Primary Temporal Decentering.

Each child was assigned to PASS or FAIL categories on the basis of a cut-off point in the cumulative core, as explained on P. 14.

In addition to the sample described above, 7 of the children age 3½ years were re-tested at age 4 years. Their results are included in Table 1.

Table 1 Primary Temporal Decentering.

Age (yrs.)	PASS	FAIL
3½	3	13
4	4	3
5	9	2
6	10	0
7	9	0

Of the 7 children who were re-tested at age 4 years, and who passed the test, i.e. 4 children, 3 had failed the test at age 3½ years, and 1 had passed at age 3½ years. The remaining 3 children tested at age 4 years failed on both occasions of testing.

It can be seen from table 1 that our hypothesis that primary temporal decentering will occur around the ages of 3½ - 4 years is partially confirmed. It is clear that a process of primary decentering such as we hypothesized does indeed take place, and that its onset for some children is as early as 3½ years, but for many children it is not complete until 5 years.

Primary Decentering and Reversibility of Action

It was predicted that primary decentering and reversibility of action (reversibilite) would occur at the same time. It will be seen from table 2 that no conclusive evidence was obtained to support this prediction.

Table 2

Age (years)	++ RD	+- RD	-- RD	-+ RD
3½	1	7	6	2
4	3	1	2	1

Key: R = Reversibility D = Decentering + = Present - = Absent

There is not sufficient data to establish the relationship between reversibility of action and the onset of primary decentering. It is clear that for some children neither reversibility of action nor primary decentering have been achieved by age 4 years.

The relationship between reversibility of action and primary decentering was not the most significant finding from the conservation test at this age. This will accordingly be discussed later. It may be noted, however, that these later results throw some doubt on the reliability of the standard conservation test as a measure of reversibility of action.

Primary Spatial Decentering

There is no specific test of primary Spatial Decentering. Results from the Locative Comprehension and Orientation tests will provide evidence as to the attainment of primary spatial decentering, and are reported later.

Secondary Temporal Decentering

Our results presented here are for those children aged 5 years and over. No child at age 3½ achieved success on the 3-term series test, and many failed to attempt it. Their failure may be attributed to several factors:

a) Failure of short term memory retention - over half the children at this age failed the control "and then" linked series.

b) Unfamiliarity with left-right order convention. Whereas in the primary decentering task, the order is given by the task itself, in this case the order must be created by the child.

c) Failure to spontaneously identify iconic representations of events in spoken sentences. The child is not familiar with pictorial conventions. Again, in the primary decentering task, the identification of the pictures and their labelling is first carried out by the experimenter, and is thus a given, whereas in this task the child must construct the equivalences by himself.

i. Relative order of difficulty of Temporal 3-term series sentences

The forms of the sentences were as follows:

a) X before Y but after Z

b) X after Y but before Z

c) X before Y and before Z

d) X after Y and after Z

It was predicted that, since sentence (c) can be solved by employing an order of mention strategy, it will be the easiest to solve. Sentence (d) may be solved by a simple reversal of this strategy, and should therefore be the next easiest to solve. Sentences (a) and (b) require secondary decentering, and should therefore both be of equal difficulty, and the most difficult to solve. As will be seen in Table 3, these predictions were borne out.

Table 3 Ease of Comprehension of Temporal 3-term series sentences for children aged 5 years +.

Sentence	Correct Response	Incorrect Response	
c	25	4	N = 29
d	12	17	
a	5	24	
b	7	22	

A Cochran Q-test was applied to this data, yielding a Q-value of 34.27. This result was significant, $p < .001$.

An item-against-item analysis was carried out, using the sign test. This analysis revealed that sentence (c) was significantly easier than sentences (a) and (b) ($p < .001$), and significantly easier than sentence (d) ($p < .01$). No other significant differences were found. Although there is a clear trend indicating that sentence (d) is easier than sentences (a) and (b), this is not significant because most children failed on all these items.

ii. Attainment of secondary de-centering

Examination of the results yielded the following conclusions: by age 5, most children can solve sentence (c) by means of an order-of-mention strategy, but fail on the other sentences. By age 7, most children are able to reverse this strategy, and to succeed on sentence (d). However, even the majority of the 7 year-olds have not attained secondary decentering. Over half the children who succeeded on either sentence (a) or sentence (b), did not succeed on both sentences.

iii. Secondary decentering and operational thinking.

It was predicted that, since the formal properties of transitivity and reciprocity which are required in secondary decentering, are also components of the cognitive structure necessary for the conservation of liquid volume, attainment of secondary decentering would coincide with operational thinking as displayed in a conservation of liquids test. In fact, in the majority of cases conservation appeared to precede success on the secondary decentering task. There were, however, 4 children who succeeded on a secondary decentering task but did not display conservation. (Table 4)

Table 4 Conservation and Secondary Temporal Decentering (age 5 years+)

	+ +	+ −	− +	− −	
Response Type	C.S	C.S	C.S	C.S	C = Conserving
No. of children	5	12	4	9	S = Sec. Decentering

The criterion for S, was success on either sentence (a) or (b).

iv. Strategies

It was predicted that the earliest strategy employed by the child would be one of order of mention. This would be followed by a strategy in which the order of mention can be reversed, thus giving success on sentence type (d). Intermediate between the employment of order of mention strategies, and full secondary decentering, would appear strategies which attempt to relate each relationally predicated event independently to a "concrete" reference event (i.e. to the first event spoken). Such strategies would be evidenced only in sentences (a) and (b).

This type of strategy would rely on assigning a "global" meaning to each relational term. For example, in the sentence:

> Teddy picks some flowers before he rides a bike, but after he meets the monkey

the child may correctly allocate the event spoken first to the mid-position in temporal order. Using this as a pivot, he will then go on to interpret

the other clauses as:

he rides a bike before
he meets the monkey after.

Thus the order of placement of the pictures will be:

1. Bike
2. Flowers
3. Monkey

In other words, there will be a reversal of the end-pictures, as compared with the correct order.

This strategy, then, relates two separate events, unidirectionally, to a single "pivot" event - a kind of "double primary decentering". For true secondary decentering, the child must fix the position of the central event through its simultaneous relation with two other separate events. True secondary decentering requires true reciprocal reversibility; the child must realise that an event can be simultaneously both before one event and after another event. The intermediate strategy requires the child only to recognise that a single event can have an event before it, and another event after it.

These hypotheses were substantially borne out by the results, as can be seen from Table 5.

Table 5 Strategies employed in comprehension of 3-term series.

Response Type		1	2	3	4	Correct	
Sentence	c	2	1	-	2	24	N = 29
	d	-	1	14	2	12	
	a	0	6	10	8	5	
	b	3	4	8	7	7	

Key

1 = Reference card placed in end position
2 = Reference card in middle, end cards reverse of correct order
3 = Cards in order of mention
4 = Reference card placed in initial position, followed by other cards in reverse of word order.

Where the "reference card" is in each case the one depicting the sentence spoken first. We interpret response category 2, when displayed in response to sentences (a) and (b), as instances of the "intermediate strategy" described above. Where these responses appear to sentences (c) and (d), it must be assumed that either there has been a failure of memory, or that the child does not have possession of the necessary conventions. This assumption is reinforced by the fact that those 2 children who place the "reference card" in the middle on sentences (c) and (d) are 5 and 6 years old, whereas the majority (75%) of the children who display response type 2 on sentences (a) and (b) are 7 years old.

25

An interesting response pattern is that found in category 4. As can be seen from table 5, it has a similar pattern of distribution to that of category 2. In other words, it is found predominantly in sentences (a) and (b). On the other hand, examination of the data showed its incidence in response to these sentences decreased with age, whereas, as we have said, that of category 2

increased with age. We would therefore like to suggest that this response is a precursor of the category 2 strategy. It appears that children who make category 4 responses, assign the same type of "global" meanings to before and after; but are not in fact relating the clauses to a "pivot". The child is able to establish a subjective order relationship between the words before and after, but is unable to relate either of the predicated clauses to a "pivot" event, thus the event spoken first is placed in initial position.

As predicted, the incidence of the simple order of mention strategy in response to sentences (a) and (b) decreases with age.

In conclusion, then, we would suggest the following sequence of acquisition of strategies for the solution of 3-term temporal relational problems by children who have already acquired primary temporal decentering:

1. Order of mention. (Category 3)
2. Reverse of order of mention. (Category 1 response to sentence (d).
3. Global use of before and after within subjective temporal order (Category 4).
4. Global use of before and after + use of central pivot. (Category 2)
5. Secondary Decentering.

It should be borne in mind that the strategies outlined here have been inferred from the final spatial position in which the cards were placed. It is clear that more detail about the child's responses could be discovered by noting the temporal order of placement (or picking up) of the cards. Such observations should lead to a finer analysis of strategies than that presented here. We intend to carry out such an investigation in the near future.

v. Memory Control Test.

3-term sentence with connective "and then". Every child over 5 years succeeded on this task. It is therefore clear that failure to store 3 events in short term memory cannot be the reason for failure on this task.

vi. Two stage construction of 3-term series

Although most children over 5 years succeed in constructing 3-term series of the same type as described in the secondary decentering task, provided they can construct the series in two separate and unrelated steps, there still remain a small number of children who failed in this task. It must be concluded, therefore, that even a "primary decentering" task can prove difficult for children in circumstances where they have themselves to provide the correct left-right axis, and to identify pictorially represented events. There were no consistent error patterns, and none of the children who made mistakes did so on all four of the 2-stage items presented to them.

Secondary Spatial Decentering

Since the 5, 6, 7 year old children who had the spatial 3-term series test administered to them also had the temporal 3-term series test administered to them, no extra test of short-term memory was included in this task. Since there are no clear spatial conventions with which an order of mention strategy can coincide, no sentences of similar form to the sentences (c) and (d), in the temporal task, were included in the spatial task. The four spatial relational terms used in this task were: in front, behind, above, below.

There were therefore 4 sentences in all included in the task, of the the form:

a) X in front of Y but behind Z
b) X behind Y but in front of Z
c) X above Y but below Z
d) X below Y but above Z.

Table 5. Secondary Spatial Decentering 3-term series test, age 5 years+.

Item	a	b	c	d
PASS	14	14	13	14
FAIL	16	16	17	16

There is a slight tendency for the number of correct responses to increase with age, but this was not found to be statistically significant. As can be seen from the data, there is no difference between the items in terms of difficulty - as is to be expected, since the logical structures of the items are identical.

Strategies employed.

On the whole, there were no dominant response patterns evidenced by the children who failed to give a correct response. This is not surprising, since there is no intrinsic conventional axis of spatial ordering. For this reason, if a child did use an order of mention strategy, it would be impossible to deduce this from the final configuration that he produced. However, there did not appear to be any tendency for objects to be picked up one by one, as the sentence was spoken. This seems to indicate that an order of mention strategy is not seen as appropriate by children, when they are dealing with spatial relational terms.

The only suggestive result which seemed to indicate the presence of an actual strategy was one which occurred at age 5 years. At this age, only 13 correct responses were made on the 4 items, as against 22 and 20, at ages 6 and 7 years respectively. Also at 5 years, 12 responses were produced in which the "reference" object was placed in the middle of the configuration produced, but the two other objects were placed in the reverse of their correct positions. This configuration was however produced only 3 times at age 6 years and 4 times at age 7 years.

This would seem to suggest that the "intermediate strategy" in which each relational term is linked in a uni-directional manner with the noun that follows it, is applied by children to spatial as well as temporal 3-term series.

Spatial and Temporal Secondary Decentering.

It will be remembered that no specific hypothesis was made about the order of spatial and temporal secondary decentering. It was clear from the data that for the relational terms used in the secondary decentering tasks, there was a tendency for spatial items to be easier to solve than the equivalent items using temporal terms. The only age at which this difference was statistically significant was 7 years, ($p < .02$), by which age over half the children tested were succeeding on the spatial secondary decentering task.

The reasons for this difference in difficulty may be either developmental, or due to intrinsic differences in the task-demands, or to a combination of both. A developmental explanation would be that, since temporal conceptions develop later than those in space, there may be a time-lag in the applications of the same operations at the different representational levels (vertical decalage). However it is clear that there are important differences in the task demands set by the spatial and the temporal items. Firstly, there are differences in the complexity of the linguistic input. For the spatial items, the elements linked by the relational terms are noun-phrases; whereas for the temporal task, the elements are in the form of clauses (e.g. Teddy picks some flowers.) Secondly, in the spatial task the child has only to manipulate familiar objects. In the temporal items, the child must recognise unfamiliar pictures before they can be ordered

Liquid Conservation and Secondary Spatial Decentering

Table 7. Liquid Conservation and Spatial Secondary Decentering

	+ +	+ +	- +	- -
Response Type	C S	C S	C S	C S
No. of Children	11	7	4	8

Once again, as with the temporal results, there is very little we can say about the relationship between secondary decentering and liquid conservation.

Comprehension and Production of Temporal Relational Terms

i. Temporal Production task.

In the free choice description of the squential actions (i.e. when the child is asked "what happened there?"), with one exception every child over 5 years of age used the connective "and then" to link the two events. This one exception was a child who used the word "before" to link the events. Such a result is to be expected, since the description does not require the use of a relational term to be fully grammatical and acceptable. At age 3½, approximately half the children either did not respond to the question at all, or only described one of the two events, thereby avoiding the use of any connective. The remainder used the connective "and then". It could be argued that the omission in the description is caused by a memory failure. However, as will be seen, children of this age are perfectly capable of remembering other events and relationships of equal complexity. What is more likely is that the processing mechanisms for comprehension and production are different, as will be seen in the examination of the comprehension test results.

To the questions in which the child is asked when one of the two events occurred, he must answer by using a relational term, if the response is to be acceptable to an adult. The variation in the types of responses produced by the 3½ year olds was considerable.

There were in all 6 categories:

i. Use of a spatial term in place of a temporal one (e.g. over there, in the house.)
ii. Use of a purposive expression, e.g. "to go upstairs".
iii. Use of an expression denoting manner, or an acted out imitation of the event referred to by the experimenter. (E.g. "like that", accompanied by imitation).

iv. Use of a non-relational term, which does not specify its temporal expression, e.g. "just now", "just then".

v. Use of a semi-relational term, which does not specify its temporal referent, or a relational term which stands on its own. E.g. "first," "last", "before", "after".

vi. Full relational use of a relational term.

TABLE 8 Responses to "when" questions in Temporal Production task.

Response Category		i	ii	iii	iv	v	vi	NR
Age(years)	3½	2	2	I	4	2	3	2
	5	0	0	0	0	I	8	2
	6	0	0	0	3	2	5	0
	7	0	0	0	I	2	6	0

If we compare this data with that obtained on similar tasks by Ferreiro and Sinclair (1971), certain similarities are immediately evident. All available data suggests that spontaneous production of temporal relational terms does not begin to occur until the age of 5-6 years. However, the age range of our sample was different from that investigated by Ferreiro and Sinclair. Amongst the youngest children (3½ years), we discovered non-temporal tesponses to temporal questions, as we have already mentioned. If we compare these results with those obtained in the Primary Temporal Decentering task, we find that those children who are unable to produce a temporal relational term are also those who cannot succeed in the Primary Decentering task. It is therefore clear that for a few children, a stable expression and understanding in language of a concept of time has not yet evolved at 3½ years.

The other major difference between these categories and those of Ferreiro and Sinclair, is that we found that even the older children did not produce relational terms in the free-choice situation. This may be due to the fact that Ferreiro and Sinclair were testing French-speaking children; in English "and then" is a perfectly acceptable adult response to the questions asked.

It is important finally to note that our results cannot be categorised, child by child, in the same way that Ferreiro and Sinclair treated their results. In the first place, we found more variation in the responses to the "when" questions than they did; in the second place, the free choice responses could not be broken down into definite categories. In the third place, the "inverse order" question did not yield satisfactory results - only one child out of the entire sample successfully answered this question, and there was no age or stage pattern to the responses of the others.

In addition to this, the relationship between the performance on the verbal tests and that in the liquid conservation task was found to be considerably more complex than that found by Ferreiro and Sinclair. This will be dealt with at length later on.

A comparison of these results with those obtained by Eve Clark will be made in the section of the results dealing with comprehension of relational terms and the theory of marking.

Comprehension of Locative Relational terms

In order to discover the relative ease of comprehension, and by implication the order of acquisition, of the various locative terms investigated, it is necessary to investigate the responses of the 3½ year old children. The reason for this is that by age 5 years, the vast majority of the items were correctly understood by all children. Conversely, at age 18 months, only two or three of these items were correctly understood.

TABLE 9. Relative ease of comprehension of locataives at 3½ years

Item	Topological/Euclidean	Correct responses
(Put the ball in the cup	T	13
(Take the baby out of the house	T	13
(Put the car under the bridge	T	12
(Make the lorry go along the road	T	12
(Put the lorry under the bridge	T	12
(Put the boy on the horse	T	12
(Make the girl go up the stairs	E	11
(Put the dog next to the horse	T	11
(Put the brick in front of you	E	10
(Make the aeroplane fly downwards	E	10
(Put the boy beside the horse	T	10
(Make the dog come down the stairs	E	10
(Put the mummy inside the house	T	10
(Make the boy go across the road	T	10
(Put the dog below the boy	T	10
(Put the dog at the side of the girl	E	9
(Make the dog walk around the block	T	9
(Make the aeroplane fly upwards	E	8
(Put the dog outside the house	T	8
(Make the dog jump over the horse	E	8
(Put the girl above the boy	E	7
(Make the girl go over the bridge	T	6
(Hold the aeroplane above you	E	5
(Put the bus on the side of the road	E	5
(Put the car in front of the lorry	E	5
(Put the bus behind the car	E	5
(Put the ball behind you	E	4
(Put the boy behind the table	E	4
(Put the dog in front of the table	E	3
(Put the girl in front of the house	E	3
(Make the car go in front of the lorry	E	3
(Make the car go between the lorry and the bus	T	3
(Put the ball between you and the house	T	2
(Put the car beside the road	E	2
(Put the horse between the dog and the girl	T	2
(Put the aeroplane below you	E	1
(Put the lorry behind the house	E	1
(Put the dog between the two blocks	T	1

Response patterns

The categories used to code the incorrect responses were as follows:

1) Use of an axis other than that of the reference object, to specify direction.

2) Substitution of an "unmarked" for a "marked" relation, or vice-versa.

3) Substitution of in, on or under (topological) responses.

4) Substitution of other participants than the lexical items present in the sentence, excluding the preposition itself.

5) Substitution of a relation of simple spatial proximity.

All these response types were encountered among the 3½ year-old children. For the following items, one particular error pattern was predominant, to a statistically significant degree.

TABLE 10

Item	Predominant Response type
Put the ball between you and the house.	3
Put the dog between the two blocks.	5
Put the horse between the dog and the girl.	5
Make the car go between the lorry and the bus.	5

For no other items was there any particular dominant response pattern. It is interesting that in all the items where one dominant pattern did exist, the relational term "between" was present. This term is evidently exceptionally difficult at this age. The typical response produced by the children was to bunch together all the participants mentioned in the sentence. However, it would appear that for the item "Put the ball between you and the house", the cues present in the particular child-house configuration led them to place the ball inside the house.

It is worth noting that we found it extremely difficult to classify relational terms as Topological or Euclidean; the final classifications that we arrived at are certainly open to doubt. The distinctions coded in any one spatial relational term are far more complex than can be derived simply from a topological/Euclidean classification. A more important determinant of the relative difficulty of comprehension of a term appears to be the context in which it is applied. It will be argued later that it is inadequate to see context as merely a "performance" variable.

Although, by and large, there is a trend in the results which suggests that topological relations are easier for 3½ year-old children to understand than Euclidean ones, it is by no means a definitive one. One of the most difficult items of the test involves comprehension of the term between, which does not independently specify direction and is therefore topological in meaning. Clearly other variables operate to determine the order of difficulty, including the number of participants which are necessarily coded.

Once again, it is clear that the pattern of a response is determined largely by the perceived context within which the preposition occurs. The attempt to demonstrate the existence of discrete semantic features from responses to a relational term in only one context, is for this reason questionable. This point will be returned to later.

The Theory of Marking and the Acquisition of Relational Terms.

A major part of the evidence cited by Eve Clark in support of her theory of marking is derived from her studies of the acquisition of before and after (Clark 1971). She suggests that not only the order of acquisition but also the pattern of errors made by children, in the comprehension of these terms, is homologous with that found by Donaldson and Balfour (1968) and Donaldson and Wales (1970) in their investigations of the acquisition of the relational terms more, less, same and different.

However, it is evident that major differences exist between these latter terms and the before/after word-pair. In the first place, both more and same are quite clearly the "global" or generic term of their respective word-pairs. In each case, the addition of a simple NEG-marker to the word transforms it into its respective opposite, either less or different. This is not the case with before and after (even less so with infront/behind); not before is not synonymous with after. The assignment of a positive value to before is linguistically quite arbitrary - it depends solely on the terminal semantic feature as (Prior) rather than (Subsequent).

There is a related difference in the patterns of linguistic distribution of these word-pairs; more and same can be used in sentence frames in which less and different cannot; no such syntactic difference exists for before and after. Eve Clark recognises (Clark 1973) that before and after are not strictly a marked/unmarked pair; but she still maintains that they can be assigned positive/negative values. Her only justification for this stems from her conception of perceptual semantic universals. (Before, by extension from infront, is within the visual field, after, by extension from behind, is not.)

The data which we obtained from our Temporal Comprehension Test does not support Eve Clark's hypothesis. The major factors affecting difficulty of comprehension are not to be found in any intrinsic difference between the two terms, but in the frames within which the relational term is located. (For more detail, see discussion page ff) Furthermore, these variables, taken in isolation, do not produce gross effects which are easily measurable.

Three different types of analysis were carried out on this data. These are listed below:

1. Two-way analysis of error frequency, dichotomising the data in terms of each of the 3 notional variables incorporated in the stimulus-sentences. These variables were:

   a) Items containing before vs. items containing after.
   b) Items containing 3 participant roles vs items containing 4 participant roles.
   c) Items in which temporal order is identical with linguistic order of mention, vs items in which linguistic order of mention reverses temporal order.

2. Analysis of error types for each item.
Errors were classified in the following categories:

   a) No response.
   b) Omission of earlier action in sequence.
   c) Omission of later action in sequence.
   d) Semantic reversal (substitution of before response to after item, or vice-versa.
   e) Lexical substitution (substitution of one participant by another).

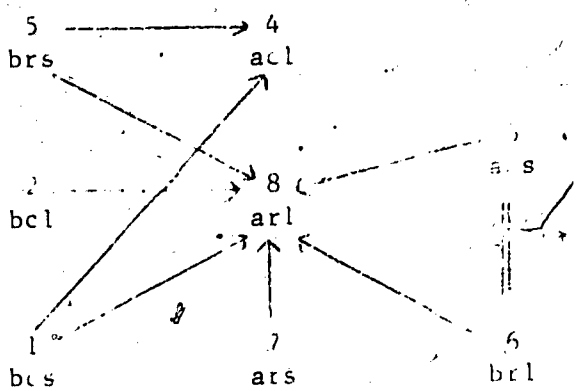
3. Item-against-item analysis, in terms of relative frequency of errors for each item.

The results that we obtained from these analyses do not substantiate Eve Clark's hypothesis. In the first place, analysis of the results for the children aged 3½ years yielded no significant differences on any of the 3 analyses. This suggests that the differential effects introduced by these variables do not begin to take effect until a relatively late age. This result will be commented on later.

The results for the children aged 5 years and over were more positive. However, no significant differences were obtained from either analyses 1 or 2. Clark's hypothesis would predict (a) that for analysis 1 items containing after would be significantly more difficult overall than items containing before. This was not the case. It would also predict (b) that for analysis 2, the predominant error type would be substitution of a before response for an after item, i.e. that for items containing after there would be a predominance of error-type d. This, again, was not the case. Neither was it the case that significantly more type d. errors were made in response to items containing after than to items containing before. In fact, mistakes were fairly evenly distributed amongst all the error types, across all sentences.

The only analysis which yielded significant results was gained from item-against-item comparisons of correct vs. incorrect responses at age 5 years+. The results for all eight items are diagrammed below

Figure 3 Relative order of difficulty of items in Temporal Comprehension test.



x —— y y is signicantly more difficult than x

x ═══ y x and y are of exactly equal difficulty

p .02 analysis by Sign Test

Code

The numbers refer not to order of difficulty, but to item number within the test. Each item is categorised according to each of the 3 variables These categories are represented below the numbers according to the following convention:

a = item containing relational term after
b = item containing relational term before
c = order of mention corresponds with temporal order
r = order of mention is reverse of temporal order
l = large number (i.e. 4) of participant roles
s = small number (i.e. 3) of participant roles

(For examples of items, see p.i.)

As can be seen from Fig. 3, item 8 is the most difficult item. This item is characterised by a large number of participants, a temporal order which reverses the order of mention, and the use of the preposition after. Thus it does appear that after is a more difficult relational term for children to understand than before. This difficulty, however, we do not attribute to after being the negative of before. While it is true that no before item is significantly more difficult than any after item, this fact taken by itself does not give a full picture of the factors affecting difficulty of comprehension. We would suggest that the reason why after, at the age of 5-7 years, is more difficult than before, is that its use and comprehension in mid-clause position require that the speaker/hearer must either reverse the actual temporal order of events in the production of a sentence such as those which we used, or reverse the perceptual order of mention of the events in the decoding of the sentence. It is significant in this respect that no such differences in difficulty were found at 3½ years. This was by no means because the items were simply too difficult - between 25% and 50% of children at this age gave correct responses on the various items. We would suggest, therefore, that the order-of-mention strategy does not fully develop until after the age of 3½ years. It is the acquisition of this strategy that produces the difference in difficulty of comprehension that is evidenced by the older children. It is not the case, as Eve Clark suggests, that the meaning of the word changes. Rather, the cognitive structures and perceptual strategies which govern and delimit the use of the word are in a process of continual development. Still less is it the case that in the early stages after means the same as before - none of our evidence points to this conclusion.*

These results call into serious question the theory that the meanings of relational terms (or any lexical item, for that matter) are acquired by addition one by one of semantic features which are identical to those constructed by the linguist as a structural description of the adult lexicon. The process by which the child learns the meaning of a word is far more complex than this. It is not adequate to envisage the child as piecing together, one by one, "bits" or features, of the adult meaning of a word, in a rigid and predetermined sequence.

The meaning of a word for a child is not merely a truncated segment of the meaning that it holds for the adult speaker. It is a meaning in its own right. Even if one wishes to speak in terms of semantic components, these will be different in a formal description of the lexicon of any individual child, from those which are derived from a description of the adult lexicon. In any case, it would seem that the basic internal relations of the lexicon are pretty well developed at an early age. Later developments involve the ability to apply these meanings in varying contexts and the gradual acquisition of the contextual rules which determine socially appropriate usages. At different stages in this process, the child will employ various strategies to achieve this end. Each of these strategies represents an approximation to the appropriate contextual rules, within the constraints imposed by his memory-span, perceptual processing skills and level of cognitive development. Since the child's knowledge of the rules will depend upon the contexts within which he has encountered the word, it is reasonable to suppose that for some words, there will be considerable individual differences with respect to the strategies employed, given that children's experiences are not uniform.

* For data relevant to marking from other relational terms, see appendix 1.

We have already pointed some of the differences between the domains of space and time. In the first place, there are a greater number of dimensions in space than in time. Consequently, there exist more lexical items referring to spatial relations, than lexical items referring to temporal relations. But in addition to this, spatial relations refer to objects rather than events. The only major perceptual cue which can be isolated from events is order, whether this be in reality or in auditory input. On the other hand, objects possess very many and diverse perceptual attributes, relating to function, orientation etc which are potential signals for the application of comprehension or production strategies This would suggest that the uniformity and regularity of the strategies encountered in the temporal items, is not likely to be duplicated in the results of the spatial test items. Spatial relations therefore, provide an opportunity to isolate individual, or idiosyncratic strategies

Because the Locative Comprehension test comprises items incorporating a very large number of different relational terms, it is almost impossible to isolate individual strategies from the results obtained in this test. However, since the locative orientation test is concerned with only two relational terms, in front and behind, deliberately introducing different perceptual contexts for their use, it is much more amenable to this type of analysis.

Locative Orientation Test

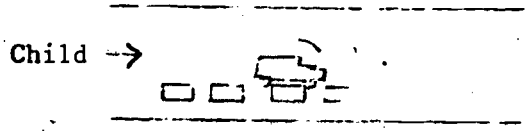
Two points need to be made before embarking on a full discussion of the results of this test Firstly it was not the case that behind items were more difficult than in front items as a general rule Secondly, it was not the case, as we had originally hypothesised, that children consistently progress from the use of their own front/back axis of reference to that of other objects

The results that we did obtain, however, were far more interesting than this. The most interesting of these were the results obtained from the youngest of the children, age 3½ years

The most outstanding feature of the responses that these children made was the individuality of each child's particular strategy Therefore, instead of presenting a table of results we shall present various instances of different strategies

A major feature distinguishing the strategies used by these children from those applied by older children and adults is that the 3½ year-old children used as their basic axis of reference either their own front/back axis, or that of the lorry No children at this age used road-usage rules, neither did any 3½ year-old use only one reference axis in response to all items.

In one particular item, almost all children used axis of self This item is diagrammed below



In this item, the child is asked to put the car in front of the lorry. As can be seen, the axis of reference of the lorry coincides with that of the child, and also with that of the road. This situation evidently produces confusion, since if all the different possible axes coincide perceptually, he is unable to make a conceptual distinction between them. In this situation, the easiest response to produce is the one in which he uses his own axis. Evidently, the ability to operate on the basis of axes other than that of self is developed through the use of situational cues. These cues will include the ability to isolate the front and back of an object, by virtue of its perceptual asymmetry; the direction in which the object will [illegible] to move, if set in motion - defined not only by the intrinsic attributes of the object, but also the conventions of road usage and traffic flow, at least in the case of the adult. (For a discussion of the nature of front/back perceptual cues, see L.J. Harris and E. Strommen, 1972.) For young children, cues will not possess the same saliency when viewed from different angles. In situations where the cues which permit the use of responses based on the axis of another object are less salient, the child will produce a response based on the dominant and more global cues which feature in the use of his own axis.

This would clearly be the case in the example given above. Since the car is facing away from the child, the front-back cues (a) are less salient than if the car is at right angles to the child's line of vision (b) do not immediately specify an axis different from his own. This would explain why for this item no child used the axis of the lorry. The most common response was in fact to put the car between the lorry and themselves; a few children placed the car next to and parallel to the lorry, suggesting an unsuccessful attempt to utilise another axis. An alternative explanation for this latter response may be as follows: if, as was the case for one or two children, placements in earlier items were made next to the lorry, on the basis of axis of self, the response to this item may have been a consistent replication of earlier responses. One would expect such children to be at a slightly earlier level of development, not yet having isolated the cues for the use of different axes.

The item immediately following the one above, preserved exactly the same configuration of child-lorry-road, but required the child to place the car behind the lorry. In all but two cases, the child replicated the response made to the previous item. In this case, too, we see that where the child is subject to conflict, he will attempt to preserve consistency in his responses.

There are many examples of such consistent, and often idiosyncratic, response strategies. One child, for example, consistently placed the car facing the lorry, in response to in front items. Evidently, her subjective meaning for in front, but not behind, included the perceptual feature (facing) This and other examples of individual strategies may be found in Appendix 2

The picture at 5 years+ was entirely different. Very few individual differences were found, and response strategies had stabilised around the "correct" usage of both the front/back axis and directional orientation of the lorry, regardless of the position of the child. A few children were using responses based upon the direction of traffic flow along the road. This was something that no child at 3½ years was capable of, and reflects an increasing knowledge of the rules of road usage. (See appendix 2)

In order to establish whether there was a consistent adult level of performance with which the performance of children could be compared, we subsequently tested 16 adults, of both sexes, all members of the Research Unit. The results were surprising. In this experiment, all subjects were asked to give two alternative responses to each item, a first and second choice. In addition to this, they were asked to state their subjective criteria for deciding the appropriate placement. The results are given in table 11.

TABLE 11 Adult Responses on Locative Orientation Test

Subjective Criteria	Subjects	Subjective Criteria	Subjects
Axis of lorry	9	Axis of lorry	6
Road usage Rules	5	Road Usage Rules	5
Axis of Self	I	Axis of Self	3
"Avoiding Crashes"	I	Use of Various Axes	I
		"Avoiding Crashes"	I

It is clear from these results that adults perceive the given configurations in different ways. The perceived field includes not only the spatial configuration but also the sum total of what he knows about the physical and socio-cultural constraints operating upon the configuration. These constraints constitute the "rules of the game". The adult can then proceed to apply logical operations to the organisation of elements specified within the perceived framework. Thus while all adults may bring the same logical operations to the situation, they do not all perceive exactly the same constraints, since they do not all share precisely the same experience. We stated earlier that the child acquires some "basic" meaning of relational terms relatively early; what comes later is the situation of these meanings within logical operations and knowledge of socio- cultural constraints.

TABLES

Table 1 Primary Temporal Decentering.

Age (years)	PASS	FAIL
3½	3	13
4	4	3
5	9	2
6	10	0
7	9	0

Table 2 Primary Temporal Decentering and Reversibility of Action

Age (years)	++ R	+- RD	-- RD	-+ RD
3½	1	7	6	2
4	3	1	2	1

Key: R = Reversibility D = Decentering + = Present - = Absent

Table 3 Ease of Comprehension of Temporal 3-term series sentences

Sentence	Correct Response	Incorrect Response	
c	25	4	N = 29
d	12	17	
a	5	24	
b	7	22	

A Cochran Q-test was applied to this data, yielding a Q-value of 34.27. This result was significant, $p < .001$.

Table 4 Conservation and Secondary Temporal Decentering (age 5 years+)

Response Type	++ C.S	+- C.S	-+ C.S	-- C.S	
No. of children	5	12	4	9	C = Conserving S = Sec. Decentering

The criterion for S, was success on either sentence (a) or (b).

Table 5 Strategies employed in comprehension of 3-term series

Response Type		I	2	3	4	Correct	
Sentence	c	2	I	-	2	24	N = 29
	d	-	I	14	2	12	
	a	0	6	10	8	5	
	b	3	4	8	7	7	

Key

I = Reference card placed in end position.
2 = Reference card in middle, end cards reverse of correct order.
3 = Cards in order of mention
4 = Reference card placed in initial position, followed by other cards in reverse of word order.

Table 6 Secondary Spatial Decentering - 3-term series test, age 5 years+.

Item	a	b	c	d
PASS	14	14	13	14
FAIL	16	16	17	16

Table 7 Liquid Conservation and Spatial Secondary Decentering

	+ +		+ -		- +		- -	
Response Type	C	S	C	S	C	S	C	S
No. of children	11		7		4		8	

Table 8 Responses to "when questions in Temporal Production task

Response Category		i	ii	iii	iv	v	vi	NR
Age (years)	3½	2	2	I	4	2	3	2
	5	0	0	0	0	I	8	2
	6	0	0	0	3	2	5	0
	7	0	0	0	I	2	6	0

Table 9 Relative ease of comprehension of locatives at 3½ years

Item	Topological/Euclidean	Correct responses
(Put the ball in the cup	8	13
(Take the baby out of the house	T	13
(Put the car under the bridge	T	12
(Make the lorry go along the road	T	12
(Put the lorry under the bridge	T	12
(Put the boy on the horse	T	12
(Make the girl go up the stairs	E	11
(Put the dog next to the horse	E	11
(Put the brick in front of you	T	10
(Make the aeroplane fly downwards	E	10
(Put the boy beside the horse	T	10
(Make the dog come down the stairs	E	10
(Put the mummy inside the house	T	10
(Make the boy go across the road	T	10
(Put the dog below the boy	E	10
(Put the dog at the side of the girl	E	9
(Make the dog walk around the block	T	9
(Make the aeroplane fly upwards	E	8
(Put the dog outside the house	T	8
(Make the dog jump over the horse	E	8
(Put the girl above the boy	E	7
(Make the girl go over the bridge	T	6
(Hold the aeroplane above you	E	5
(Put the bus on the side of the road	E	5
(Put the car in front of the lorry	E	5
(Put the bus behind the car	E	5
(Put the ball behind you	E	4
(Put the boy behind the table	E	7

(contd. overleaf)

Table 9 (contd.)

Item	Topological/Euclidean	Correct responses
(Put the dog in front of the table	E	3
(Put the girl in front of the house	E	3
(Make the car go in front of the lorry	E	3
(Make the car go between the lorry and the bus	T	2
(Put the ball between you and the house	T	2
(Put the car beside the road	E	2
(Put the horse between the dog and the girl	T	2
(Put the aeroplane below you	E	1
(Put the lorry behind the house	E	1
(Put the dog between the two blocks	T	1

Table 10 Comprehension of "between" by 3½ year olds

Item	Predominant Response Type
Put the ball between you and the house	3
Put the dog between the two blocks	5
Put the horse between the dog and the girl	5
Make the car go between the lorry and the bus	5

Table 11 Adult Responses on Locative Orietntation Test

Subjective Criteria	Subjects	Subjective Criteria	Subjects
Axis of lorry	9	Axis of lorry	6
Road usage Rules	5	Road Usage Rules	5
Axis of Self	I	Axis of Self	3
"Avoiding Crashes"	I	Use of Various Axes	I
		"Avoiding Crashes"	I

Summary of Results

The results presented thus far do not constitute the entire body of experimental evidence included in the paper. However, on the basis of the results so far, we can indicate the extent to which our initial hypotheses were borne out.

Decentering

a) Time. The results indicate that there are indeed two separate stages of primary and secondary decentering; that they emerge at roughly the same ages at which reversibility of action, and concrete operations, respectively, are attained.

b) Space. The results indicate that there exists a definite stage of secondary decentering in space, and that it marginally precedes that time. Primary decentering, the ability to relate other objects in space to one's own position, or to the position of another object in the immediate perceptual field, was clearly established by the age of 3½ years in all children tested. Thus it again appears that primary decentering in space precedes that in time.

Marking

Both our hypotheses about marking were confirmed (see appendix 1 for data relevant to Marking hypothesis 2.)

Strategies

Our investigation revealed the use of 5 different strategies, in a definite developmental sequence, by children attempting to solve Temporal 3-term series problems. 3 strategies were revealed in the decoding of spatial 3-term series problems. The strategies employed at a given age reflect both the organisation by the child of the perceptual cues present in the experimental situation, and the level of cognitive development attained by the child. In addition to this, it appears that the selection of peceptual cues is increasingly governed by the knowledge of relevant socio-cultural rules.

Axes

Our hypothesis with regard to the use of front/back axes was not confirmed.

Topological/Euclidean

Although there was some slight support for this hypothesis, there was no statistically significant trend.

What is wrong with Semantic Features?

We believe that the results that we have obtained from our work discussed so far puts into serious question the major assumption made by Eve Clark. That is, that the semantic features or components which can be derived from an analysis of the structure of the adult lexical system are precisely identical to the actual perceptual and cognitive units that the child uses to construct the meanings of words. Semantic features are, after all, merely a way of

characterising the relationships of hierarchical dominance and contrastive opposition that obtain between the lexical items which go to make up a specific semantic field in a language. To that extent, they are merely a convenient theoretical fiction, since they simply serve to represent the intensional organisation of meaning within a semantic field.

The problem of "meaning" and "reference" has always been a source of disagreement, both amongst linguists and philosophers (Lyons 1958). Recently, many of these disagreements and opinions have surfaced yet again in discussions of language acquisition. Essentially, the problem is that there exist many words in a language for which there is no immediate concrete or material referent - a word such as beautiful cannot be said to refer to any easily specified attribute. This word does, however, obviously possess meaning.

Thus philosophers and linguists have traditionally distinguished between the meaning that a word derives from its relationship with other elements of the linguistic system (its intensional meaning, or sense), and the object, or class of objects, that the word denotes (its extensional meaning, or reference). The intensional meaning of a word derives from its linguistic context of use - i.e. from the set of all possible syntagmatic and paradigmatic relationships into which it can enter with other words. The intensional meaning thus subsumes such semantic relations as synonymy, antonymy, hyponymy.

The basic assumption behind Clark's theory of the acquisition of semantic features, is that the phenomenon of over-extension of reference is to be explained by imputing to the child an incomplete and different intensional organisation of meaning from that of the adult. If a word in the lexicon of a child is assumed to contain fewer semantic features than the same word in the adult lexicon, this implies that the meaning-relations into which that word enter with other words, must of necessity be different from the relations into which the same word enters in the adult lexicon. This would appear to be a similar position to the one which Fodor (1972) criticises in his discussion of Vygotsky's theory of linguistic development. While disagreeing with Fodor's own theoretical position, we would agree with his criticisms of the logical inconsistency of this particular hypothesis.

In our view, the typical overgeneralisations reported in the literature on this topic (e.g. over-extension of the word dog to refer to cows or other animals) can be better explained by postulating an over-extension of reference than an over-extension of intensional meaning, due to a different internal organisation of the lexicon. It is significant in this respect that most reported over-extensions concern referents with similar perceptual attributes.

However, one obvious and important difference between the lexis of the child and that of the adult, is that the former contains fewer items.

Eve Clark conceives of semantic organisation as an ordered hierarchical tree of semantic features. We would prefer to conceive of it as a complex and ordered topological array of different words each of which enters into certain "sense"-relationships with other words. For each semantic field, there will be one or more "centres" of the array in which will be incorporated those words embodying the most basic, or fundamental, cognitive or perceptual distinctions.

It would therefore seem reasonable to suppose that lexical items tend to be acquired in a sequence which progresses from the centre, or centres, of the semantic field, to the periphery. Thus it would seem likely that the basic internal relations of the child's lexis, and therefore the intensional

meanings of the words he uses, are approximately homologous to that of the adult. The real differences are to be found elsewhere.

Eve Clark herself suggests that certain perceptual attributes of the objects used by the child and manipulated by him can have a considerable influence on whether or not the experimenter's instructions are carried out successfully. She was able successfully to predict from the perceptual properties of the objects which were given to the child what type of errors would be made on that item. (Eve Clark, 1972).

Nevertheless, she still explained this away by assuming that the child simply substituted different adult semantic features for the ones coded in the experimenter's instructions.

What we would like to suggest is that the child does indeed make use of certain "features" in interpreting the meaning of spatial and temporal relational terms, but that these features are more concrete and more complex than those she suggests.

In fact, these features will be actual perceptual attributes of the situation encountered by the child. For example, the major feature of events, as they are encountered either in the real world, or in their linguistic representations, is order. Similarly, if the child is required to construct certain spatial relationship between objects, he will make use of the perceptual attributes of the objects and of their relationship within the configuration. If these perceptual attributes coincide with the child's previous experience of constructing the configuration which is the referent of the experimenter's instruction, the child is likely to give a correct response. If not, the child may well construct a configuration which is suggested by the perceptual attributes present in the situation.*

As the child gets older, and his mastery of the language increases, his strict dependence on concrete perceptual features, rather than on other contextual and socio-cultural cues, diminishes. However, for very young children, below the age of 2 years, the concrete perceptual features of the situation will impose strict limitations on possible responses. This suggestion is confirmed by the observations we have made of 18-month old children, on tests of comprehension of elementary spatial relational terms. These observations are reported below.

It is clear that this approach ties in with the concept of object permanence, as put forward by Piaget. Object permanence, in its developed form, entails more than simply the existence of an object through time independent of its visibility or location, it entails the recognition that:

a) The same potential relationships (either spatial or functional) between one object and other objects or agents, exist independently of the orientation assumed by the object or its position within the configuration created by it and the other objects.

b) This potential for relationships can only be realised in certain fairly specific orientations and configurations.

If a child has not reached this developed stage of object permanence, although the semantic distinctions between such words as in and on are present in the linguistic system of the child as for the adult, and although the

* Naturally, some spatial relationships are also functional relationships. E.g. "The ball is in the box" specifies not only a spatial relationship between two objects, but also a functional relationship entailing the use of a container. "The ball is next to the box", on the other hand, carries no such functional connotations.

referents that he attaches to these words may be approximately identical to those of the adult, the range of application of the words will be narrower than that of the adult. The 3½ year-old child, having reached this stage of developed object permanence, is able to manipulate configurations in a way that the 18-month old child cannot. The testing procedure for the 18-month old children was therefore entirely different from that used with the older children. The procedure was to present the child several times with each of a small range of instructions, each of which incorporated a simple spatial preposition, (In on under up, down in front of, behind). For each presentation of each instruction, the situation confronting the child was varied. Unfortunately, this testing procedure was not systematized until quite recently, so we are unable yet to present tabulated results. What we can do, however, is outline a few typical response strategies, and attempt to explain them.

The normal testing procedure was for the experimenter to give the child the object which he would be asked to place, and then to give the instruction. Typical instructions were:

Put the ball in the cup
Put the ball on the cup
Hold the aeroplane up
Hold the aeroplane down
Put the ball in front of you
Put the ball behind you
Put the boy in front of the table
Put the girl behind the table
Put the dog under the table, etc.

The most common response strategy was simply to repeat a previous action, e.g. the child would put everything in the cup, or on the table. This response constitutes a simple play-routine, or exercise of a sensori-motor scheme. It was typical of children who either had no comprehension of the verbal input whatsoever, or who were not attending to it.

The most interesting results came from the items where the child was asked to put the ball in or on the cup. It was found that many children readily responded to the instruction "Put the ball in the cup", providing the ball was placed in their hand, and the cup was the right way up on the table in front of them. However, if the cup was inverted and the instruction repeated, two different response strategies emerged. Either the children would place the ball on top of the cup, or else they would bang it up and down on the surface of the inverted cup. Very few children were able to turn the cup round and achieve the correct result. Even if they did so, it was usually after carrying out the second response strategy mentioned above. In a condition where the cup was laid on its side on the table, with the mouth facing away from the child, similar results were found. However, when the cup was placed on its side with the mouth facing the child, a far greater number of children were able to right it and place the ball inside. When children were asked to put the ball on the cup, when the cup was right side up, no child inverted the cup. The typical response was to place the ball inside. If however the initial positioning of the cup was upside down, many children produced the correct response.

It would be possible to interpret these results as an indication that the child simply does not possess the meaning of these words. In fact, it was clear that for many children the majority of the instructions were not understood at all. But the type of responses that are outlined above suggest that the problem is not "lack of comprehension" in the abstract, but an inability to manipulate the given configuration.

We would interpret these results in the following way: The [illegible] meaning of a spatial preposition entails a certain set of configurations, which is perceptually distinct from other configurations.

Certain other more elementary orientations and configurations make up the component parts of the configuration which is coded in the experimenter's instruction. If the child is asked to make a configuration, but cannot identify the component parts which must be combined to fulfil the task demand, he may either:

a) attempt to perform the instruction without altering the configuration, and fail. (E.g. bang the ball up and down on the inverted cup).

b) Produce a different configuration, which is suggested by the already existent configuration; (e.g. Place the ball on the inverted cup).

c) Make an entirely irrelevant response, or not respond at all.

This is because he is unable to realise that he can transform one configuration into another. Thus the subjective meaning of the word for the child "over-extends" itself, not to incorporate the meanings of other words, but to include the component configurations which signal the potential to construct the referent configuration. Should the configuration encountered by the child not correspond to his experience of those component configurations, the child may re-interpret the instructions. This is not because he does not understand the meaning of the word, but because the configuration that is encountered is in fact a signifier for another, different constructed configuration, and thus activates a different sensori-motor scheme. So meaning is both "over-extended" and limited. For example, the meaning of the word *in* may include the existence of a space, bounded in all aspects except from that of the observer, and of something to fill it up with. It is these component configurations that we refer to as perceptual features - they represent the units of sensory input upon which strategies of comprehension are articulated.

Figure 4

in entails the existence of a space and an object to fill it:

initial configuration

referent configuration

on entails the existence of a flat surface and an object to put on it:

initial configuration

referent configuration

The comprehension of relational terms such as *in front* and *behind* requires more than developed object permanence, it requires operational thinking. When an adult identifies a certain configuration and uses *in front* or *behind* to describe it, he is not identifying simply a configuration or disposition of objects, but a relationship. He may use perceptual features and/or socio-cultural rules to isolate the relationship but he will use them in a consistent and logical manner. For a pre-operational child, however, the whole meaning resides in these configurations whatever they may be in his personal experience, according to the strategies he has formulated, (e.g. *in front* may be coded as: facing the reference object facing the same way as the reference object, at the front of the reference object, between himself and the reference object, or a combination of these). Figure 4 illustrates the way in which component

configurations or features, when integrated into a sensori-motor scheme, intrinsically suggest a further, more complex configuration.

Language, Cognition and Perception

As we have seen, two major determinants of the child's ability to use a relational term are (1) his experience of the socio-cultural rules that govern activity in a given situation, and (2) the level of cognitive development that he has attained.

However, as we have seen, responses typical of one level of cognitive development may be given in one situation, and responses typical of a different level in a different situation. What defines the situation for the pre-operational child is the presence or absence of certain perceptual cues which enable him to utilise a generally successful strategy. If these strategies produce incorrect responses, the child himself may be unable to recognise this, or at least to rectify it, since his level of cognitive development is not adequate to this. Perceptual features therefore constitute a sort of intermediate constructive device for the child to create the cognitive structures he must master. The major demands he must react to are either coded in, or at the very least accompanied by language. This language, therefore, will first of all assume meaning through its "association" (by this we mean operative or sensori-motor integration) with certain perceptual features. This leaves open the possibility that some childrem may utilise idiosyncratic features which consistently lead in certain situations to apparent mistakes being made. These mistakes may obscure the real level of cognitive organisation attained by the child, since he will be forced by the contradictory cues present in the situation, including those encoded in language, to apparently regress to more primitive response strategies typical of a lower level of cognitive development. Similarly and conversely, the production of a response indicative of a certain fairly high level of cognitive organisation in limited situations does not allow us to infer the existence of the cognitive structure as a whole. The response may be a manifestation not of the structure itself, but of the structuration process or strategy employed by the child to produce a specific appropriate result.

Much recent work has emphasised the interactive nature of the relationship between language and thought, stressing both the logical and ontogenetic primacy of cognition (Sinclair-de-Zwart, 1972), and the accelerative role that the use of language plays in cognitive development (Bruner 1964, Vygotsky 1962). However, if we are to extend the notion of "meaning" outwards both from Piaget's position that words (signifiers) are immediately integrated into sensori-motor scheme's or concrete operations, and from the behaviourist theory of ostensive definition, and include within the child's subjective meanings the perceptually salient attributes of the situations and objects normally encountered as the context for a new word, a more complex view emerges. Language on this basis could potentially not only facilitate cognitive development, but in certain situations could impede the activation of cognitive structures.

Like many of Piaget's classic experiments, the test of conservation of liquid volume relies upon the disjunction between the logic of the operations carried out by the child and the perceptual feedback by means of which the child judges the results of his actions. The resolution of these contradictions and the establishment of conservation depends upon the child mastering the logic of the operations regardless of the immediate situation. Until this point, the child is still "perceptually dominated". Obviously, the perceptual input will have a large bearing on whether or not the child can solve the

specific task, although we cannot say that the concept of conservation has been acquired until the child can produce his solutions on the basis of the logic of operations across all the various situations. We have already seen that the child's use of logical relational terms is dependent on the perceptual features which he has coded in language. Inhelder, in discussing the problem of conservation of length (Inhelder 1973), points out that: "During the four successive steps in the construction process exemplified in the preceding experiments (Inhelder 1973), either the apprehension of the properties of the subjects own actions, or the apprehension of the actual properties or features of the objects may be preponderant at one time." Inhelder conceives of cognitive development as a mutual interpenetration of two interwoven systems. When these two systems converge in the apprehension of any problem in the real world, the resultant formulations of the problem which each generates, may be either in harmony or in conflict. Since the language used by the experimenter plays a directive role in the formulation by the child of the problem, the relative dominance assigned to each of these systems may be affected by the meanings encoded, by the child, in the words of the experimenter's instructions.

Recently, a certain amount of controversy has been generated as a result of claims by various authors that they have found conservation behaviour in very young children. Two major explanations have been advanced to account for this phenomenon. Mehler and Bever (Mehler 1972) have suggested that failure to conserve between the ages of 4 years and 8 years is due to the loss of initial innate capacities, and their replacement by more advanced memory strategies. Bryant (1973) explains the same phenomenon as resulting from hypothesis-conflict caused by inadequate short-term memory. A full discussion of this previous work is to be found in Appendix 3.

The results that we have obtained from tests carried out with children aged 3½ years confirm that some children at this age do indeed display a variant of conservation behaviour. In fact, it should be pointed out that no child tested could at this age give conservation responses in the standard test, in which the child is asked to judge whether he has "the same to drink" after the liquid is poured from the standard beaker into the tall, narrow cylinder In fact the problem was confusing for these children; they did not appear to understand the meanings of same and different in this context. Many children when asked "are they the same?" would reply "yes", but would also reply "yes" when asked, "are they different?". These results confirm the findings of Donaldson and Wales that children at this age cannot distinguish between same and different (Donaldson and Wales 1970). However we also administered to 19 children a test of compensation. In this test the child is given the original standard beaker of orange squash. The experimenter tells the child that he is going to drink out of the tall cylinder, and that he wants to have "exactly the same to drink" as the child. The child is instructed to shout "stop." when he thinks the experimenter has poured into the cylinder "exactly the same to drink". Out of the 19 children tested, 14 showed clear compensation, while the remaining 5 equally clearly shouted stop when the level of squash in the cylinder reached that of the squash in the beaker. It seems therefore, that not only are young children well able to remember appropriate perceptual configurations, but that, in certain circumstances, they can also establish equivalences of quantity between non-identical configurations. Thus these children, while they cannot be said to be conserving, are clearly not perceptually dominated, since they can remember what the level was that an equal amount of liquid had reached after pouring, on a previous occasion. We arrived at the following hypothesis as an explanation for these results.

The word "same", as has often been pointed out, combines within itself several different meanings. In the first place it can refer to identity. That is, that when an object or substance is translated across space or time, it retains its identity - it is the same after translation as before. It is clearly this criterion which is important from the point of view of conservation.

The word "same" may, however, refer to perceptual similarity. This may be either of an absolute nature - i.e. two objects are different tokens of the same type - or of a relative nature, i.e. two objects are alike in some one or more respects, but not all. Clearly, the problem in a conservation task is that although the liquid remains "the same" - i.e. retains the essential features of identity over transformation, the transformed liquid in the cylinder is not perceptually similar to that in the beaker. If the child's subjective coding of the word "same" is in terms only of perceptual similarity, then he will claim that he and the experimenter do not have the same to drink. However, before the age of about 4 years, it appears that children are unable to consistently use the words "same" and "different" at all. When these words do emerge, they will initially be coded in terms of perceptual features, simply because the cognitive structure of the child is insufficiently powerful to support the notion of identity.

Thus for the 4-year old child, it will be by means of perceptual features that the child assigns objects and situations to categories of similarity and dissimilarity. Clearly, the predominant feature which codes liquid "sameness" is the coincidence of the levels which liquids in different containers reach. For other objects, substances and situations, presumably other perceptual features will be used to code "sameness". But the hypothesis that such features will in fact be used gains support from recent findings of Taylor and Wales (1970). They found that gross perceptual features were more salient in the classification by children of figures into categories of similarity than were other variables such as spatial orientation. (c.f. also Olver and Hornsby, 1966).

Until these features have been abstracted by the child from the situations which he encounters, he will not be able to code them in language. Neither will he be able to construct strategies ("perceptual dominance") for the solution of problems which are based on these features.

We therefore predicted that, on a re-testing of these children at 4 years, a greater proportion of them would solve the compensation problem by reliance on the perceptual feature of identical liquid level. This in fact appears to be the case. Although we have only re-tested 7 children, 4 of these gave non-compensatory identity-of-level responses, 1 child fully compensated, and 2 children gave intermediate responses. These latter "compensated a bit", but expressed unease about their solutions.

These results are however open to one objection. That is that the children are simply remembering at 3½ what level the squash, when poured into the tall beaker, "ought" to go to. By age 4, it could be that this memory has failed, and thus the children fail. We therefore devised a test which is not open to such objections. The requirements for such a test are that it should directly investigate a conservation problem and that it should entail that the child remember previous relations of equality or inequality. In fact, we deliberately chose a conservation of inequality task, since this was the only way to avoid the use of the words same and different.

The testing procedure is as follows. A large toy horse and a small toy dog are placed in front of the child, who is told: "here is the big horse, he likes a lot to drink, here is the little dog, he likes a little to drink." A standard beaker of squash is then placed in front of each animal, the horse's beaker containing more than the dog's. The squash from the dog's beaker is then poured into a tall, narrow cylinder, and the squash from the horse's beaker is poured into another standard beaker. After this operation, the level of liquid in the tall cylinder is higher than that of the liquid in the standard beaker. The child is then told, "remember, the big horse likes a lot to drink, and the little dog likes a little to drink. Now give them their drinks."

In this test, the language used by the experimenter directs the child not to the perceptual attributes of similarity or difference of the two liquids, but to their actual functional quantities. In other words, the language focusses on the actions to be carried out.

If the hypothesis of memory-failure is correct, at 4 years children should fail this test. If, on the other hand, perceptual dominance were an absolute and linguistic input had no influence whatsoever, they should also fail. We predicted, on the other hand, that since the language focusses on the functional rather than the perceptual aspects of the situation, children at both 3½ and 4 years should succeed.

Of the 9 children at 3½ to whom the test was administered, 7 succeeded. One child definitively failed the test, in that she gave the animals the wrong beakers. One child stated that he could not give the tall cylinder to the dog, as the dog would not be able to reach up and drink out of it.

Of the 8 children at age 4 years to whom the test was administered, 6 succeeded. One child clearly did not understand the test - he refused to assign the beakers to the animals. One child made two different responses, one correct and one incorrect. She spontaneously produced the words big and small, and as a result of this coding, stabilised her behaviour at an incorrect response.

This suggests the possibility that older children as a result of a linguistic recoding of the experimenter's instructions, may fail this test.

We do not maintain that these results demonstrate that children at the age of 3½ and 4 years are capable of conserving liquid volume. Piaget has correctly pointed out that conservation of inequality is not logically equivalent to conservation of equality. Full conservation, based on concrete operations, is constructed out of several different components. What these results do demonstrate is that non-conservation on the part of young children is a necessary result of the classification strategies they employ, which are based on the immediate perceptual attributes of the objects and situations that they encounter. The lexis of relational and dimensional terms reflects the abstraction by the child of these perceptual features. The linguistic input in the experimental situation must therefore be treated as a major and independent variable defining that situation for the child. A change in the lexical items used in the test may therefore shift the focus of the child's attention. This may be taken to be one example of the directive function of language in thinking as discussed by writers such as Vygotsky (19).

Conclusion

The traditional mode of explanation of cognitive development which has been developed and expounded by the Genevan school is that of a "genetic structuralism". The cognitive capacities of the developing organism, at any stage, are defined by the formal properties of the system of operations, carried out either on the real world or by means of internal representations, which logically and consistently generate the observed responses of the organism to events in the real world.

Such a structural description does not automatically constitute an adequate explanation or description of the actual process of acquisition or construction of the system as a whole. The developed system, or structure, cannot, of course, be defined merely by reference to the acquisition process - the integration of the various elements into a logical totality is a qualitative rather than an additive transformation.

But very little concrete description of the actual processes of accommodation and assimilation which charaterise the developmental mechanism has been offered by the Genevan school. An acceptance of the fundamental priority of the action-based, logico-mathematical source of knowledge of the world, does not bind one to the view that this aspect of the cognitive process is dominant in every instance in which the child, or any organism, encounters a problem in the world. It is in this sense that we would agree with Inhelder that "the (cognitive) structures are atemporal and reflect the possibilities of a total system, but to locate the formative mechanisms that can explain the transition from one stage to another we have to go beyond such structural models." (Inhelder 1973).

In other words, despite the radical disjunction between the a-priori requirements for the formal structural descriptions of the consecutive stages, the transition from one stage to another can be seen to have a dynamic and logic of its own. The transition mechanisms can be elucidated through the investigation of the systematic response-strategies which the organism employs. It would appear that there are three major determinants of these strategies. Firstly, there is of course the general level of operative intelligence, or cognitive organisation, that the child has achieved. This level of organisation delimits the extent of the "field" within which an operation (in our experiments, the use of relational terms of time and space) can be applied. Secondly, there are the perceptual attributes of the objects and situations which constitute the disparate elements on which the operations function. It is these perceptual features which define for the subject the logical possibilities within the situation. Thirdly, there are the socio-cultural rules which assign to these perceptual attributes relative degrees of saliency, and enable the subject to decide which ones are applicable.

Language does not, as many psychologists in the Genevan tradition have maintained, reflect only the first of these relatively autonomous sub-systems. It reflects the cumulative interaction between all three of them (and possibly others). Further, language may be used to emphasise one of these aspects, and de-emphasise others. It has a selective and directive function, both for the subject and for the other people who are defining the situation for him. We would not suggest that language is the source of cognitive organisations or of thought, merely that the very complexity and flexibility of language stems from its role as a communicative system which assigns differential salience to the various aspects of the situations which are its contexts.

"Intellect", or "logic", does not function in a vacuum - reason cannot exist in the absence of the objects of its knowledge. While it is valid to construct formal definitions of the properties of the "collective epistemic subject", abstracted from the objects of knowledge, actual psychological processes involve real human beings in differing social and physical contexts. It is through knowledge of these contexts that the child acquires cognitive structure, and through the identification of these contexts that the adult applies logical rules. Differential performances amongst adults stem from differences in interpretation of context, rather than failure to apply logical rules.

The development of systematic differences in the knowledge and perception of context is a matter for social, as well as purely cognitive, investigation.

In this paper we have tried to demonstrate some limited aspects of this process by reference to the development of the use of spatial and temporal relational terms, and of some other dimensional terms. We hope that this may contribute to further discussion of the concrete nature of the processes referred to above and to their investigation in other areas of cognitive and linguistic development.

APPENDIX I

The Comprehension of Marked and Unmarked Terms

A classification of words into marked/unmarked pairs may be made according to linguistic criteria (specified earlier).

It can be seen that certain pairs of relational or dimensional terms do in fact fulfil these criteria. (Big/small, more/less,). Semantically, or psychologically, these terms may be seen as clear positive/negative pairs. Something which is small is not big. Less is the negative of more.

In other cases neither the linguistic or the psychological/semantic criteria for this type of marking are fulfilled. The negation criterion (psychological/semantic) is merely a special case of the general phenomenon of marking, where an element must fall into either one of the two categories, marked or unmarked; there are no other categories. (Singular/plural, for example).

The words infront, behind, before, after, do not conform to this general rule. If one object is not in front of another, it does not mean it is behind it. Consequently, the error types that we find for these items are not those of true unmarked/marked pairs. For such pairs, one would predict that:

a) Marked item M is later acquired and more difficult to comprehend than Unmarked item U.

b) Marked item M is initially understood as being synonymous with Unmarked item U, since the only difference between them is the addition of a Neg-marker to U to produce M.

For no item in which either in front or behind was used, at any age, was there a preponderance of substitution mistakes over other types of mistakes. The results for before and after have already been given.

For all in front/behind items, at all ages, there was only one item which showed a significant difference between the difficulty of these terms when located in the same sentence frame. This was when the 3½-year old child was asked to put the ball in front of/behind you, in which the infront item was significantly easier at a level of $p < .05$. Even here, there was no tendency for children to substitute in front for behind. Cases have in fact been observed where children respond to in front items by putting the object behind them.

Now let us examine the data for the other pairs, which can more adequately be classified as unmarked/marked pairs. The items given were

bigger, smaller, not as big, not as small, less big, less small.

All the errors are ones of substitution. This merely reflects the fact that these were the only error types possible in the experimental situation.

Results

At age 3½ years.
No significant difference between bigger and smaller - both easily understood by children at this age.

Not as big significantly easier than not as small. ($p < .05$) Reflects fact that not as in this situation acts as simple Neg-marker. But small is already negatively-marked, therefore not as small is a doubly-marked item.

No significant difference between less big and less small.
Both were too difficult for almost all children at this age. Less acts as a neg-marker, but is itself the marked variant of more. Consequently less big is also doubly-marked, less small treble-marked.

For same reason, no significant difference between not as small and less small.

But not as big is significantly easier than less big. ($p < .01$) At age 5 years+.

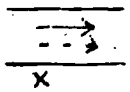
Not as big significantly easier than not as small ($p < .01$)
Less big significantly easier than less small ($p < .02$)
Not as big significantly easier than less big ($p < .001$)
Not as small significantly easier than less small ($p < .01$)

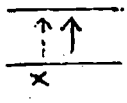
Thus, these are true unmarked/marked pairs. We can therefore see that those terms which are true unmarked/marked pairs, according to both linguistic and psychological/semantic criteria, conform to the expected error patterns for unmarked/marked pairs. Those which, on the aforementioned criteria, are not, do not conform to such error patterns.

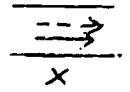
APPENDIX 2

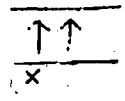
Examples of 3½-year old childrens' responses on the locative orientation test.

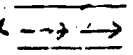
a) Parallel placement strategy

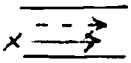
1)  in front

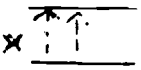
2)  in front

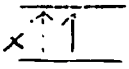
3)  behind

4)  behind

5)  in front

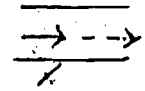
6)  behind

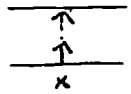
7)  in front

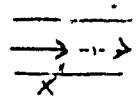
8)  behind

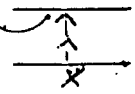
Key = ⟶ = reference object (lorry x = position of child
⇢ = placement object (car)

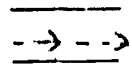
b) Consistent use of an 'infront' strategy

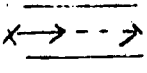
1)  in front

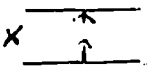
2)  in front

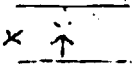
3)  behind

4)  behind

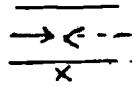
5)  in front

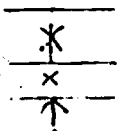
6)  behind

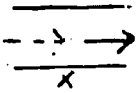
7)  in front

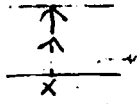
8)  behind

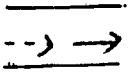
c) Use of " facing" feature for 'in front' strategy

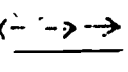
1)  in front

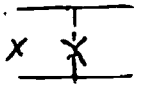
2)  in front

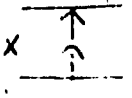
3)  behind

4)  behind

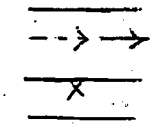
5)  in front

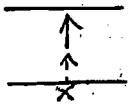
6)  behind

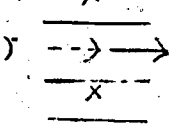
7)  in front

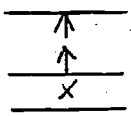
8)  behind

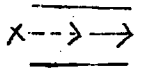
d) Consistent use of a 'behind' strategy

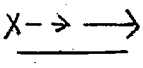
1)  in front

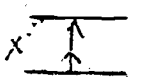
2)  in front

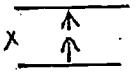
3)  behind

4)  behind

5)  in front

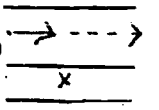
6)  behind

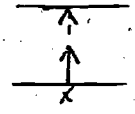
7)  in front

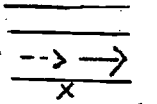
8)  behind

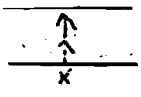
Examples of locative orientation strategies used by 6-year old children

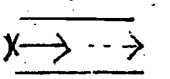
a) Consistent use of axis of lorry

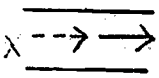
1)  in front

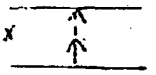
2)  in front

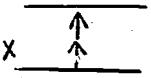
3)  behind

4)  behind

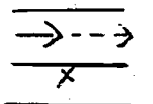
5)  in front

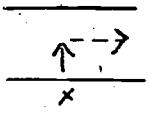
6)  behind

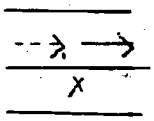
7)  in front

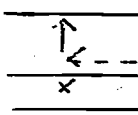
8)  behind

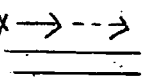
b) Cons stent use of 'road-user' strategy

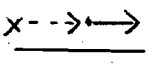
1)  in front

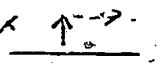
2)  in front

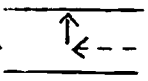
3)  behind

4)  behind

5)  in front

6)  behind

7)  in front

8)  behind

APPENDIX 3

Experiments on the Cognitive Capacities of Very Young Children

The two major recent claims to have found "operational" responses in very young children have been made by Mehler and Bever (1967), and Bryant and Trabasso (1971).

Mehler and Bever. Conducted experiments on children aged 2 years 4 months, to 4 years 7 months, to investigate conservation of inequality of number and volume, using clay and candy pellets.

Method

Children were asked to make a judgement about the equality of 2 arrays:

O O O O O

O O O O O

The array was then transformed, and two pellets added to the lower row.

O

O O O O O O O

In the case of the clay pellets, children were asked to judge which row had more. With the candy pellets, they were asked which row they wanted to keep for eating.

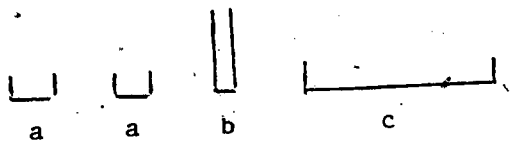
Results

Success with the clay pellets was highest between the ages of 2.4 and 2.7 and lowest between the ages of 3.8 and 3.11, rising again between 4.4 and 4.7. With candy pellets, the fall in "conservation" responses between the ages of 3.8 and 3.11 was less dramatic.

Mehler and Bever concluded that "rules that allow them (children) to be successful at a younger age can be tapped if motivation is sufficiently strong."

Verification Experiments

These involved the use of the pellets in conservation of inequality in volume.



Experiment 1. Identity was established in the usual way, using 10 candy pellets per beaker (a). The children were asked to put one (extra) pellet into one of beakers (b) or (c), after one of the beakers (a) had had its contents transferred into it. The children were asked to choose:

i) which beaker had more pellets
ii) which beaker they wished to keep for eating.

In both conditions, up to age 3.4, children chose the beaker with more pellets. After this age, they appeared to base their choice on shape (i.e. they preferred the tall beaker).

Experiment 2. The same beakers were used, but this time no extra pellets were added. Here, the children were asked which beakerful they wanted to keep for eating. Between the ages of 2.6 - 3.0 they chose to keep either container with equal probability. When asked whether there were the same number or more in either beaker, 10 out of 22 children replied "equal" or words to that effect. On the other hand, 8 c of 10 children aged 3.6 - 4.5 chose the tall beaker, and said it contained more pellets.

Several criticisms have been levelled against this series of experi ts notably by Beilin (1968) and Piaget (1968).

1. Both Beilin and Piaget pointed out that conservation of inequality is not the same as conservation of equality. It was in the former that Mehler and Bever's most conclusive results were obtained.

2. Beilin maintained that because of this, Mehler and Bever conflated two different transformations, addition and relocation. When he tested these separately, the results did not conform to those of M & B. Not one child succeeded in conservation of equality. It should however be noted that in this instance he required verbal responses, involving the use of same/different, more/less.

Beilin noted children may understand more in one of two possible ways: either (a) relationally, or (b) "more of", thus corresponding to either relocation or addition. He did not, however, draw any conclusions from this statement.

Piaget suggested that M & B's subjects had not reached the stage of evaluation by length, and therefore used more primitive topological evaluations based on "heaping" or "crowding".

He attempted to replicate M & B's experiment with rows of pellets, but added the following condigion:

O O O O. O

O O . O O

Piaget noted that the terms used in the experiment were of considerab importance. The young children were not always able to understand more and less consistently, but a lot and a little and not a lot gave rise to more consistent answers.

Piaget noted differences in interpretation of more in the young subjects, but also noted that their answers were totally inconsistent if they were asked several times during the same experiment. (It is worth noting here that we too noted inconsistency in judgements of same and different at age 3½ years in the conservation of liquids test.)

4. Piaget makes the further point that since M & B made "no transformations of equal collections" they have no justification in describing their findings as conservation.

Piaget also mentions that young children do not understand same and different, and are thus not confused, whereas older children begin to do so, and are subject to conflict:

"It is worth noting that non-conservation therefore indicates an effort to dissociate variables; very young children and severely mentally retarded subjects pay no attention to these variables, whereas older, normal children pass through a stage of non-conservation as they reorganise relations which they cannot yet grasp in full."

Our own summing up and criticisms of these experiments will be dealt with later. It is necessary first to discuss M & B's theoretical position, since it plays a major part in their explanation of their findings.

Mehler (1972) expresses this position as a "theory of impoverishment of rich initial dispositions". He draws a comparison between this view and Chomsky's proposals that there exists an innate linguistic ability. Mehler maintains that it is unreasonable to suppose that the child constructs increasingly rich strategies ex nihilo, and counters this view with the suggestion that children begin with initial rich, global capacities, which are gradually lost as a result of reliance on later, narrower, more specific strategies. He further suggests that the "beliefs of 2-year olds may be based to a great extent on a phenomenal mnemonic capacity."

He cites the 1967 experiments as evidence that very young children can perform extremely well in global situations involving unstructured events, simply by virtue of their high capacity to register these events in memory. Memory traces thus develop from global to more analytic systems, which enable the child to rely less on "sheer memory" and more on rules and regularities. This departure from reliance on memory occurs, according to Mehler, at around the age of 3½ years, and gives rise to a total change in performances, whereby the child relies more on what he sees than what he believes. He cites the different performances in the tasks involving clay and candy pellets as evidence that high motivation preserves reliance on the part of the child on what he believes rather than what he sees.

Piaget, commenting on Mehler's innatist hypothesis, wrote:

"As the great biologist Dobzhansky has said, though predetermination is impossible to disprove, it is on the contrary, and I would add, precisely for that reason, completely useless."

Bryant (1971) and Bryant and Trabasso (1971)

These experimenters also claim to have discovered conservation behaviour in very young children. In 1969, Bryant showed that while 5-year olds were able to distinguish horizontal, vertical and oblique lines in simultaneous presentation, they were not as successful in successive presentations. He went on to suggest that Piaget's (1971) demonstration that children below the age of 8 years cannot make transitive inferences from perceptual input (i.e given A > B B > C, they cannot infer A > C) may have been influenced by the fact that the arrays were never presented simultaneously. In other words, Bryant claimed that their failure to make transitive inferences may have been due to memory failure.

Bryant and Trabasso (1971), therefore, trained 4- 5- and 6-year old children on a series of direct comparisons of lengths of sticks. I.e. children were trained in the comparisons A > C, B > C, C > D, D > E. The training on the various pairs was conducted in random order.

They then tested the children's ability to make transitive inferences, e.g. A > C, etc. It should be pointed out that the only conclusive demonstration of the existence of the transitive inference is on the pair B > D. Only in this case has each of the rods been both larger and smaller in the initial comparison. It is, therefore, the only pair which cannot be solved by focussingon the absolute length of one of the rods in the pair.

Successful performance on this task was observed at all ages although the B > D pair was consistenly more difficult than the others. B & T argued that "Lower performance in the critical B > D pairs is not due to a failure to make inferences but to a failure of retention of the information contained in the initial comparisons".

From this conclusion Bryant went on the challenge Piaget's assertion that young children do not understand invariance. An adult, he calimed, solves a conservation problem by the following method:

$$A = B \quad \& \quad B = B' \qquad B = B'.$$

A young child may understand this, but (because of limitations of short term memory) may be unable to co-ordinate the two judgements involved in the task. This stance led Bryant to generate what he called the Hypothesis-Conflict Theory. Piaget had always claimed that the organisation of conservation data was a higher-order problem. In his view, a young child is unable to free himself from the data (i.e. his own perceptual viewpoint) and is thus unable to solve the invariance problem. According to Bryant, a young child may know that quantities of liquid have remained the same through tansformation in a conservation of liquids task, but is confronted with two conflicting hypotheses - same or different - and does not know which to abandon. Lack of conservation may thus be seen as a failure to resolve conflict.

In order to test his theory, Bryant (1971) conducted the following experiment. He presented children age 4 years with an array of two unequal rows of counters.

O O O O O O

O O O O O O O O

Children correctly judged that these two rows were unequal. The counters were then placed in identical glass beakers, so that they occupied apparently equal volumes. The children were now able to judge which beaker contained counters (a perceptual judgement would have led the children to say that the numbers were now the same.)

If we examine Bryant's argument, it is apparent that it does not necessarily account for the child's success. He claimed that, since the child established invariance with counters and formulated a hypothesis he was not confused when the counters were poured, thus retaining his initial hypothesis. However, if we examine experiments on which the same children fail we can see that Bryant's argument falls down. The child in a conservation experiment establishes a definite hypothesis of invariance, (both beakers same). When he pours therefore, no hypothesis in conflict should appear. And yet on this experiment the child fails!

Youniss and Furth (1973) have made several criticisms of Bryant's work.

1) They maintain that Bryant did not properly manipulate the memory variable. Bryant replied that in later experiments he did indeed do so. (Bryant 1973).

2) They calim that much of the inference work showed inferences which were sub-logical rather than logical. In reply, Bryant denied this. It should be noted however, that A > C taken from the information A > B B > C requires only uni-directional representation. B > D on the other hand, requires bi-directional representation and is therefore the only inference which is truly logical, (i.e. both B and D are bigger and smaller at the same time). It is clear from our own evidence that the A C comparison could be seen to coincide with primary decentering, and the B D with secondary decentering. Perhaps Bryant's most important remark is that while younger children were successful on passive inference tasks, they failed on similar "active" ones , which required to construct the array themselves. Our own decentering tasks are active. Bryant suggests that children "gradually acquire effective strategies for putting inferential ability into practice. His (the child's) task, at any rate, above the age of 4 years, is not to quire the inferential mechanism, but to learn when and where and with what materials to use these mechanisms."

It is interesting to note Bryant's mention of strategies in the light of possible alternative explanations of his and of Mehler and Bever's results. If we consider the possibility that, as we have suggested in the main body of the paper, children do indeed develop different strategies, each of which results from the interaction of the child's developing logical abilities and his interpretation of the concepts and percepts coded in the experimental instructions, then we may have an alternative explanation.

We have suggested that before the age of about 4 years a child is unable to fully integrate the linguistic input with the perceptual features he abstracts from experimental situations. We would suggest that "perceptual dominance" is a specific stage in the child's developing cognitive apparatus, and that until this stage is reached, no strategies based on perceptual features will emerge.

If we examine both Bryant's and Mehler and Bever's work, we can see that their results could be explained in this way.

Mehler and Bever found that when candy pellets were used in both types of experiment, even 4-year olds were able to "conserve". If we look at these results in terms of the difference of the language used, rather than any difference in motivation, it can be seen that the children succeeded when they were asked which they wanted to keep for eating, and failed when asked which had more. In other words, we would maintain that the child's understanding of the term more was what confused him. When the beakers of pellets were equal, the younger children chose either beaker with equal frequency. They also said the the beakers were equal or not equal with equal frequency. We have already noted that in our experiments the 3½-year olds were equally willing to change their minds about judgements of same or different. Again, in M & B's experiment, 8 out of 10 4 year olds chose the tall beaker when asked which had more. As we noted, both Beilin and Piaget stressed the importance of the words used in the experiments.

We would specify these remarks in the following terms: children between the ages of about 4 and 6/7 years code relational terms according gross perceptual features, which represent the criterial definitions of these terms. If a child under 4 years has not constructed this coding, he may well appear to give a conservatio-type response, since he has completely failed to understand the judgement he has to make. When, (as in our compensation task), he is asked to make the squash 'the same' (as it was before) he has not yet coded same perceptually and is thus free to produce, by using memory, the levels of squash as he saw them before. By about age 4, he has begun to code similarity in terms of coincidence of level, so that when he is faced with the two different beakers he judges them not to be the same. It is not simply that the child cannot solve the conservation problem because of memory-failure, but rather because the language he uses interacts with his logical ability in such a way as to apparently transform the problem with which he is confronted. Thus what appears to be a regression, is in fact a further development of the linguistic and the logical systems he uses.

The above remarks can, on the whole, be taken to apply also to Bryant's work. However, there still remains the problem of the BD inference, on which several children made correct responses to a level significantly greater than chance. Clearly, this task is different from conservation tasks in that there is no conflict between perceptual input and logical task-demand. In addition to this, we have found that the terms 'bigger' and 'smaller' are well understood by children at the age of 4 years. It is possible that under these relatively undemanding conditions, transitive inferences can be made by 4 year olds; this does not, however, invalidate the essential point that the active application of concrete operational, logical rules does not occur until a later age.

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