INTRODUCTION

Sinclair-de Zwart (1973) claims that the syntactic structure "SVO" could be learned from the structure of sensory-motor schemes. This working paper is a preliminary attempt to examine this claim in explicit detail. Please note that this paper assumes some knowledge of Piaget's theoretical approach.

A STRUCTURAL DESCRIPTION OF SENSORY-MOTOR SCHEMES

Piaget describes a sensory-motor scheme as "that which is generalizable in a given action" (Piaget, 1963). To this description, we can add that sensory-motor schemes are behavioural patterns which the child knows and can control in some way. As the child's sensory-motor schemes become more complex, his knowledge and control become more complex. Behaviour, knowledge, and control are aspects of a single cognitive phenomenon in Piaget's theory.

In what sense does this cognitive phenomenon have structure? The answer will depend on what aspect of the phenomenon we choose to describe, and on the form of our description. In The Origins of Intelligence in Children, Piaget concentrates on a description of a child's behaviour and control. This is a verbal description. It should also be possible to design a description of sensory-motor schemes as knowledge. Such a description would be particularly useful if it were a formal description, comparable to a formal linguistic description of the child's language as knowledge.

For the past several years, I have been working on a formal system for the description of a child's language as knowledge. This formalism is particularly adaptable to the descrip-
tion of sensory-motor schemes because it uses constituent categories which correspond to categories of knowledge in Piaget's theory. The main constituent categories are $e =$ entity, $a =$ action, $cx =$ context, and $att =$ attribute. The categories $e$ and $a$ are particularly relevant to this paper. In Piaget's terms, they are objects ($e$) and the sensory-motor behaviour which discovers them ($a$). The category $cx$ will also be used in this paper. For the purposes of this paper, $cx$ can be understood to refer to the perceived context in which sensory-motor behaviour occurs.

How can the child's developing knowledge be described by the formalism? We can begin by assigning the symbol $a$ to a child's knowledge of his primitive actions, his first reflexes (Stage I, 0 - 1 month). As each reflex becomes differentiated, during the first acquired adaptions, we can describe a growth of knowledge as follows.

\[
(1) \quad a \rightarrow \left\{ \begin{array}{c}
     a_1 \\
     a_2 \\
     a_3 \\
     \vdots \\
     \vdots 
\end{array} \right\}
\]

If $a$ symbolizes the child's knowledge of the sucking reflex, then $a_1$ might symbolize his knowledge of how to suck a nipple, $a_2$ his knowledge of how to suck a pacifier, $a_3$ his knowledge of how to suck a blanket, etc. The symbol $\rightarrow$, borrowed from historical linguistics, can be interpreted as "becomes over time." The curly brackets indicate "$a_1$ or $a_2$ or $a_3 \ldots$" as in phonology. The three dots indicate an indeterminate set.

This differentiation leads to control. At first (Stage II, 1 - 4 months), the child can only prolong an action. He does not have control over its initiation. Gradually, however (Stage III, 4 - 8 months), he develops the capacity to initiate the differentiated actions in their appropriate contexts, the contexts which gave rise to the differentiation in the
first place. For example, when the child puts a pacifier, which originally forced him into a special kind of forward-in-the-mouth sucking, into his mouth, he will now initiate the special kind of sucking of his own accord. In terms of the formalism, (2) now receives a more complex interpretation.

\[
(2) \quad \left\{ \begin{array}{c}
a_1 \\
a_2 \\
a_3 \\
\vdots \\
\end{array} \right. 
\]

That is, \(a_1\), \(a_2\), and \(a_3\) are now interpreted as particular kinds of sucking which the child initiates of his own accord.

Subsequently, as the child's control grows, he begins to detach the differentiated actions from the specific contexts which gave rise to them (Stage IV, 8 - 12 months). For example, the special forward-in-the-mouth sucking might be used to separate the pieces of a toy. At this point, we can no longer describe knowledge of the differentiated actions of the child as in (2). In (2), \(a_2\) symbolizes knowledge of an action bound to a context. In our example, the pacifier in the child's mouth was the context. Now, the child has knowledge of the same action out of context. If we symbolize this action as \(a_2\), we must symbolize different contexts separately. Thus we arrive at the following formulation.

\[
(3) \quad a_2 \quad \left\{ \begin{array}{c}
\text{cx}_1 \ (a_2) \\
\text{cx}_2 \ (a_2) \\
\text{cx}_3 \ (a_2) \\
\vdots \\
\end{array} \right. 
\]
We can simplify the righthand side of (3) as follows.

\[
\begin{pmatrix}
  cx_1 \\
  cx_2 \\
  cx_3 \\
  \vdots \\
  \vdots
\end{pmatrix}
\]

\[
(a_2)
\]

\(cx_1\) might symbolize knowledge of the pacifier in the child's mouth, \(cx_2\) might symbolize knowledge of the detachable toy in the child's mouth, \(cx_2\) might symbolize knowledge of a particular piece of material in the child's mouth, etc. \(a_2\) is enclosed in brackets simply to indicate that contexts are not necessarily related to the action in spatial or temporal sequence; the action can be seen as being embraced by its contexts.

Having separated knowledge of an act from knowledge of contexts, the child begins to initiate experimental acts to test various contexts (Stage V, 12 - 18 months). In terms of the formalism:

\[
\begin{pmatrix}
  cx_1 \\
  cx_2 \\
  cx_3 \\
  \vdots \\
  \vdots
\end{pmatrix}
\]

\[
(a_2)
\]

\[
\Rightarrow
\]

\[
\begin{pmatrix}
  a_1 \\
  a_2 \\
  a_3 \\
  \vdots
\end{pmatrix}
\]

If \(cx_1\) symbolizes knowledge of the pacifier in the child's mouth, \(a_1\) might symbolize knowledge of pushing-with-thumb and \(a_3\) might symbolize knowledge of spitting-out.

As the child combines contexts and actions in various ways, contexts become more differentiated for him. Ultimately (Stage VI, 18 months on), he becomes aware of entities in space and time. These entities (which Piaget calls \(\text{objets}\)) include the child himself; that is, the child becomes aware of himself as an entity in space and time. Also, the child
becomes aware of causality.

We can describe the differentiation of the child's knowledge of contexts as follows.

\[(6) \quad ax_1 > e_1 e_2 e_3\]

The formalism can be interpreted as follows: knowledge of contexts is differentiated to become knowledge of entities in space and time.

As knowledge, the child's sensory-motor schemes can now be described as follows.

\[(7)\]
The formalism is becoming complicated. This is because, with
the differentiation of \( ox \), a multiplicity of semantic relationship
ships between elements becomes possible. Knowledge of a partic-
ular kind of forward-in-the-mouth sucking in conjunction with
knowledge of the pacifier in the mouth can be described by the
simple conjunction of the elements \( ox_1 \) and \( a_2 \). However, with
the elaboration of \( ox_1 \) into entities related to each other and
to an action spatially, temporally, and causally, knowledge of
schemes must specify the various possible semantic relationships between entities and actions and between entities. For example, the child's scheme for hitting a block with a hammer will contain the same elements as his scheme for hitting a hammer with a block, but these elements must be related differently. If $e_1$ symbolizes the block, $e_2$ symbolizes the hammer, $e_3$ symbolizes the child, $a_1$ symbolizes a particular hitting action, arc 1 symbolizes an agent-action relationship, arc 2 symbolizes an instrument-action relationship, arc 3 symbolizes a patient-action relationship, arc $\beta$ symbolizes and agent-instrument relationship, arc $\gamma$ symbolizes an instrument-patient relationship, and arc $\alpha$ symbolizes an agent-patient relationship, specific knowledge of the two schemes can be described as follows.

(8) The child hits the block with the hammer.

(9) The child hits the hammer with the block.
It is at this point (Stage VI) that the child becomes fully capable of what Piaget calls "representation". For Piaget, representation is more than the child's knowledge of sensory-motor schemes as performed by the child. It is the mental enactment of new sensory-motor schemes, independent of performance. This kind of mental creativity is fully possible now that the child has knowledge of semantic relationships within a context. Given this knowledge of semantic relationships within a context, which is the result of the differentiation of knowledge of contexts into knowledge of entities, the child can mentally arrange entities and actions into new sets of relationships.

In representing an event to himself, the child needs only the knowledge described in (7). The es and as in (7) can now be matched to mental images, a process described in Piaget (1962).

However, at this point the child also begins to use what Piaget (1962) calls a "socialized" form of representation, verbal language. That use of this form of representation requires additional knowledge is suggested by the term "socialized". However, Sinclair-de Zwart (1973) maintains that part of the structure of this form of representation, "SVO" structure, could be learned from the structure of sensory-motor schemes. This means that knowledge of a unit of syntax could follow from sensory-motor schemes, as knowledge. In examining this claim, we must specify what is meant by "could follow from." Having described sensory-motor schemes as knowledge, we must now describe the child's knowledge of the syntactic unit "SVO" in order to understand in what sense the latter "could follow from" the former.

CHILDREN'S KNOWLEDGE OF THE SYNTACTIC STRUCTURE "SVO"

The following utterances are representative examples of early "SVO" utterances from my own data.
These utterances are taken from the spontaneous speech of four children during Roger Brown's Stage I. (There are eight hours of data, made up of two-hour sessions recorded at six-week intervals, for each child.) Thus, they are among the children's earliest "SVO" utterances.

How can we describe the knowledge which these utterances reflect? Assuming that surface syntactic regularities are known to the children, we can describe this knowledge as follows.

continued on next page
Here, $e_1$, $e_2$, $e_3$, etc., symbolize knowledge of referents for entities, $a_1$, $a_2$, $a_3$, etc., symbolize knowledge of referents for actions, $\text{arc } \{\{2\}\}$ symbolizes knowledge of a set of possible semantic relationships between $es$ and $as$, $\text{arc } \{\{5\}\}$ symbolizes knowledge of another set of possible semantic relationships between $es$ and $as$, $\text{arc } \{\{4\}\}$ symbolizes a set of possible semantic relationships between $es$, and I, II, and III symbolize knowledge of temporal precedence relationships associated with the three sets of possible semantic relationships. The precedence relationships fix the related elements, $e_1$, $\{\{a_1\}\}$, $e_2$, in the temporal order corresponding to the left-right order in which they appear on the page.
The formalism can be interpreted as follows: knowledge of sets of possible semantic relationships between types of referents is associated with knowledge of temporal precedence relationships.

In addition, we can characterize the sets of semantic relationships as follows.

(a) \{ ... \} Relationships between referents for actions and referents for entities which perform the actions.

(b) \{ ... \} Relationships between referents for actions and referents for entities that are affected (that in (10)) or affected (house in (13)) by the action.

(c) \{ ... \} Relationships between referents for entities which perform actions and referents for entities which are affected or affected by actions.

WHAT FOLLOWS?

Comparing (7) with (17), we can see that the delineation of elements in (7) might be a necessary condition for the delineation of elements in (17). In (7), the elements e and a symbolize knowledge of entities and actions, while in (17), the elements e and a symbolize knowledge of verbal referents for entities and actions. It might be that the former must precede the latter. In this sense, (17) could follow from (7), and the syntactic structure "SVO" could be learned from the structure of sensory-motor schemes.

In differentiating entities within contexts, (7) creates semantic relationships between es and as and between es. In (17), semantic relationships between es and as and between es
occur also. Thus, the semantic relationships in (17) might be learned from the semantic relationships in (7). In this sense, also, (17) could follow from (7).

We can term these two aspects of (17) which could follow from (7) the delineation of elements and the delineation of semantic relationships. These two aspects of the child's knowledge of language are not necessarily language-specific. They could be learned from sensory-motor schemes, and might therefore be acquired through sensory-motor development rather than through some language-specific mechanism. These aspects of (17) are, then, formal specifications of the claim in Sinclair-de-Zwart (1973) which we have been considering.

However, there are two aspects of (17) which could not follow from (7), since they differentiate (17) from (7) in unpredictable ways. First, the use of verbal referents in (17) could not be predicted from (7) (although, as explained above, given that (17) uses verbal referents, the kinds of referents used, their delineation, could be predicted from (7)). Second, the grouping of semantic relationships into temporally ordered sets in (17) could not be predicted from (7). In (7), the semantic relationships 1, 2, 3... can occur freely between es and as. The only constraints on semantic relationships are semantic constraints. For example, relationships between es and as are different from relationships between es. This difference is symbolized in the formalism by the use of different symbols for relationships between es and as (numbers) than for relationships between es (Greek letters). In (17), however, temporal constraints apply. The semantic relationships 1, 2, 3... n always occur between es which are first in temporal order, while semantic relationships n + 1, n + 2, n + 3... always occur between es which are last in temporal order and as.

We can term these aspects of (17) which could not follow from (7) verbal reference and temporal grouping. We can say that these aspects of (17) are specific to (17). That is, they are formal specifications of language specific knowledge which children must acquire.
CONCLUSION

In this paper, I have presented an explicit account of the claim in Sinclair-de Zwart (1973) that the syntactic structure "SVO" could be learned from the structure of sensory-motor schemes. I have shown, in terms of an explicit formalism, various ways in which this claim is and is not true. Most of the processes described in this paper are described in some form in Sinclair-de Zwart (1973). However, the formalism used in this paper has described these processes explicitly, clearly distinguishing the acquisition of sensory-motor schemes from the acquisition of language specific knowledge of the syntactic structure "SVO".

REFERENCES