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The Development of Rulebound Strategies for Manipulating Seriated Cups: A Parallel Between Action and Grammar[1]

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Systematic observation of American children from 11 to 36 months of age playing with seriated nesting cups established the existence of a developmental sequence of rulebound or consistent strategies for combining the cups. The three action strategies seem formally homologous to certain grammatical constructions, and the manipulative strategies are acquired in the same developmental order as the corresponding grammatical structures. These strategies might therefore constitute a manifestation of some underlying structural capacities critical for language acquisition. The development of seriation described by Piaget for children from 4 to 8 years of age working with other materials was replicated in this much younger age range using nesting cups. These stages in the growth of a concept of ordinal quantity turn out to be empirically and theoretically related to the rulebound strategies upon which the study focused.

This study sought to document the existence of consistent strategies in the naturally occurring manipulative play of 1-, 2-, and 3-year-old children. Systematic observation of American children from 11 to 36 months of age playing with seriated nesting cups tested the existence of a developmental sequence of rulebound, that is, consistent, strategies for combining the cups. A related objective was to investigate the question of formal homology between strategies for cup construction and certain grammatical constructions.

In linguistics, Chomsky has been dubious about the value of analogies between grammar and any other system of mental organization, although he leaves open the possibility that "the lack of analogy testifies to our ignorance of other aspects of mental function, rather than to the absolute uniqueness of linguistic structure" (1968, pp. 77–78). In contrast, the Genevan epistemology and psycholinguistics of Piaget (1963) and

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Sinclair (1969) postulate a general isomorphism between language and other forms of cognition. In American psychology, Bruner (1968) has been more specific in raising the possibility of grammar-like programs for action starting early in infancy. Yet no empirical evidence concerning direct formal parallel between action and grammar thus far exists. Observation of one of our children (Lauren Greenfield) playing with seriated cups at home led to the notion that these materials might reveal just such a sequence of manipulative strategies, with its corresponding sequence of grammatical development. The present study constitutes a systematic test of that notion.

PROCEDURE

Sixty-four children aged 11 months to 36 months were tested. Four males and four females at each of the following ages are included in the sample: 11, 12, 16, 20, 24, 28, 32, and 36 months.

Children sat at a table either in a small chair or on the mother's lap. The experimenter sat opposite the child and presented five cups measuring from 3.3 to 7.7 cm in diameter across the bottom; the cups increased in diameter by 1.1-cm steps. After placing the cups in front of the child, the experimenter proceeded to nest the cups by means of the strategy hypothesized to be the most advanced, the subassembly strategy shown in Fig. 2.

Although this strategy can be used to create nonseriated structures (the second alternative depicted in Fig. 2 under Strategy 3), the demonstration started with the smallest cup and proceeded to the next largest, yielding a seriated structure (the first alternative depicted in Fig. 2 under Strategy 3). Because Fig. 2 is schematic, it shows the minimum number of cups necessary to constitute Strategy 3 (defined in detail at the beginning of the Results section); the demonstration, however, utilized all five cups, thus ending with a five-cup seriated structure.

The experimenter ensured that the child was looking at him before he proceeded with the demonstration, but no direct instruction to imitate the experimenter was given. It was found at the outset that children would not necessarily combine the cups if they were simply asked to play with them. The demonstration thus served as an impetus to combine the cups without in fact determining the specific strategy, as the results indicate. The reason for using the most advanced strategy as a model was to maximize the child's performance, thus revealing something about his underlying capacity for manipulating the cups.

After the demonstration, the cups were placed one by one in front of the child in the pattern shown in Fig. 1. The array was presented in two positions (Fig. 1, a and b), one a left-right and front-back

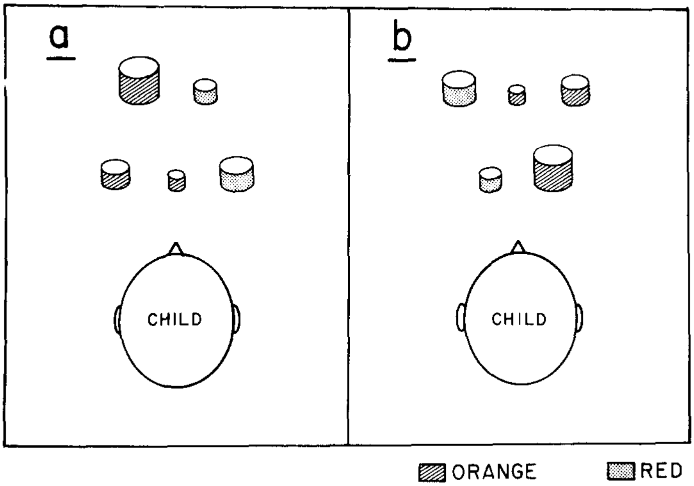

FIG. 1. Cup arrays.

inversion of the other. Presentation of the two positions was counterbalanced both within and across children. Thus, preference for the smallest or the largest cup could be distinguished from position preference and chance selection. At the time of the experiment, the only nesting cups available included cups of various colors; whether or not the use of cups of two different colors influenced the children's behavior could, however, be empirically tested.

Each child who completed the experiment had four trials with each array shown in Fig. 1. The first trial, or "free" trial, in each set of four trials allowed the child to choose his first cup. The child was then told, "Now *you* play with the cups, all of the cups," while the experimenter gave general encouragement, but no specific instructions. The second trial was similar but the smallest cup was removed from the array and handed to the child before he was instructed to play with all the cups as in the first trial. Thus, he started the trial with the smallest cup in hand. On the third trial with a given array, the child was given the middle-sized cup with which to start and, again, given instructions to play with all the cups. The fourth trial with an array was the same, but the child was handed the largest cup at the outset.

If at any time a child completed a seriated structure comprising all five cups, he was given a green cup, 5.8 cm in diameter, between the third and fourth cups in the series, and asked to "Put it where it belongs." Regardless of his success in placing the green cup appropriately, it was removed before the next trial began and presented again only if a five-cup seriated structure was again produced. The purpose of introducing this sixth cup was to relate the development of strategy to the development of operational seriation as defined by Piaget (1965).

The reason the research design involved varying the starting cup was to test the existence of an internal program which would cause a strategy to appear across a range of conditions, some of which made a given strategy simpler or more probable than did others. For example, if a child were going to seriate the five cups, putting the smallest cup in his hand at the outset would make Strategy 3 relatively more probable; whereas putting the largest cup in his hand at the outset would make Strategy 2 relatively more probable.

For each child, behavior was coded into 10 categories for the first two final structures in each trial. Additional structures in a given trial were coded according to only one category—strategy. Interscorer reliability ranged from 94.7% to 98.2%. A final structure was defined as the largest size obtained by a cup edifice before being dismantled or terminated by the child. A single strategy was associated with each final structure. Thus, final structure, rather than trial, was the coding unit; and the strategies constitute mutually exclusive categories with respect to a given final structure. Several final structures could, however, be constructed and scored within a given trial.

The criterion for a scorable trial was that at least two cups be put together, either inside each other or on top of each other. The cups could be either upright or inverted. A child could make one final structure, dismantle it, and make a new structure within a single trial, but a new trial was not begun until at least one structure had been made. Several subjects, therefore, completed only part of the eight-trial sequence.

The nine scoring categories used to obtain the results reported in this paper were: (1) overall strategy (Fig. 2); (2) the number of cups in a final structure; (3) size and contiguity as consistent selection criteria; (4) fate of the first cup when the experimenter chose that cup; (5) characteristics of the first cup on free trials; (6) characteristics of the first recipient cup; (7) characteristics of the first acting cup; (8) systematic use of color in selecting the sequence of cups comprising a final structure; (9) consistent choice of cups ipsilateral to child's moving hand.

RESULTS

Description of Strategies

Three distinct strategies were identified. They are illustrated in Fig. 2. In the first, a single cup is placed in or on a second cup. Most often it

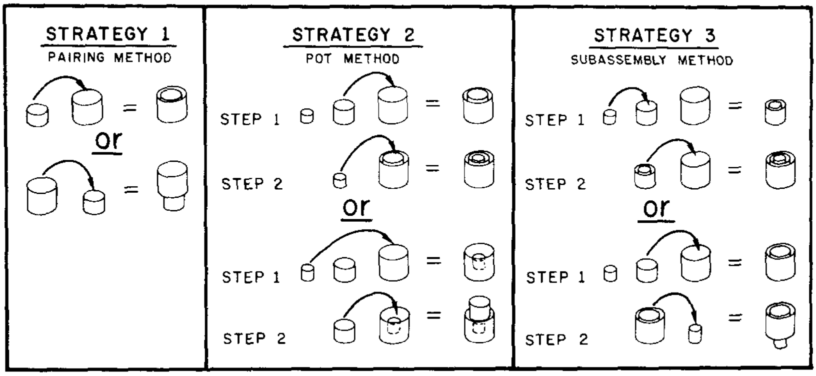

FIG. 2. Strategies for combining seriated cups.

is immediately withdrawn from this cup; sometimes the child goes on to place it in or on a second cup. The structures resulting from this strategy consist of one pair or successive pairs of cups. This strategy, like the other two, can form either a seriated or nonseriated structure, as shown in Fig. 2. Thus, all three rulebound strategies are theoretically independent of seriation. The empirical data will reveal the actual interrelationship between strategy and seriation.

Each strategy consists of a series of moves in which the child's hand moves an acting cup into or onto a stationary cup that functions as the recipient or object of this action. In this particular strategy, the child takes one cup in hand and this is the sole moving or "acting" cup involved in the strategy. A single move, moreover, completes a two-cup structure. As in the rest of the paper, "strategy" refers to the child's method, "structure" to the resultant edifice of cups.

In the second strategy, the pot method illustrated in Fig. 2, two or more cups are placed in or on another cup. Thus, a single structure consisting of three or more cups is formed. This strategy can yield an ordered series or a "pile" as Fig. 2 shows. In this strategy, the child successively holds a number of cups which move into or onto a single stationary cup. This stationary cup thus functions as a pot, holding the mobile cups. With respect to the stationary cup, each moving or acting cup bears the same relationship of actor to acted upon.

Clearly, the first move in making such a structure conforms to the definition of Strategy 1. The strategy producing the *final* structure is the only one coded, however. Strategies therefore describe certain formal properties of *complete sequences* of cup combinations rather than *individual moves.* In Strategy 1, a final structure is completed in a single move, as shown in the illustration (Fig. 2). Although two is the minimum number of different cups defining Strategy 1, the same moving cup may be removed from its first object and placed in or on another stationary cup. In this way, all the cups in the experiment (or *n* cups is an *n*-cup experiment) could be involved in a single instance of Strategy 1, although the final structure would be a series of two-cup edifices formed sequentially with a single acting cup. Similarly, the figures illustrating both Strategy 2 and Strategy 3 show the minimum number of moves and, therefore, the minimum number of cups necessary to make a structure that conforms to the respective definition of each strategy. These strategies are capable of being used to build a five- or six-cup structure in the present experiment or, potentially, an *n*-cup structure when *n* cups are available to the child.

The third strategy is distinguished by the fact that a previously constructed structure consisting of two or more cups is moved *as a unit* into or onto another cup or cup structure. This strategy, applied to the cups, has a number of variants. Figure 2 illustrates a "pure" form in which a two-cup unit is placed in or on a third cup. If the child continued to employ this strategy to build a larger structure, the resulting three-cup unit would be placed in or on a fourth cup, and so on. Again, this may yield either a seriated or "piled" final structure. In terms of individual cups, the distinctive feature of this strategy is that the stationary cup that is acted upon in the first move becomes the acting cup in the second move. Thus, one or more cups has a double role: it makes the transition from being acted upon to acting. In terms of the multicup units or subassemblies, the defining feature is that each multicup unit functions as a single moving or acting cup. A variant form of this strategy occurs when a child combines two previously assembled two-cup units.

Consistency of Strategic Behavior

The consistency of each individual's strategic behavior was defined in terms of his dominant or most frequent strategy. A child's dominant strategy accounted on the average for 80% of his structures; the mean number of structures per child was eight. The range was from one to 29 structures per child.

Manipulative methods intermediate between Strategy 1 and 2, or Strategy 2 and 3 appeared once per child, on the average. These methods were the dominant form of a strategy for four chlidren in all. For purposes of analysis, an intermediate method was counted an occurrence of the less advanced of the two strategies.

For the average child whose prevailing method was Strategy 1, pairing, 88% of his or her structures were formed by this method. For children who most often used Strategy 2, the pot method, this strategy was employed to construct 80% of all structures on the average. For children whose dominant strategy was 3, the subassembly, it occurred 72% of the time on the average. Is this consistency statistically reliable? A conservative way of answering this question is (1) to assert that a psychologically dominant strategy ought to be used by a child more than 50% of the time and (2) to test this hypothesis. Fifty-four of the 64 children tested did in fact apply their dominant strategy more than half the time. A sign test indicates that the probability of this ratio occurring by chance is less than .0001 (2-tail test).

The consistency with which a single strategy is employed by a given child demonstrates that these strategies function as internal "rules" governing the child's play over a range of concrete situations. Dominant strategy was not, in fact, affected by the configuration of cups presented to the child. Fifty-five children completed trials with both array *a* and array *b*; all but one of these 55 used their dominant strategy with both arrays. Similarly, dominant strategy was consistent across conditions: it was little affected by what cup a child was given at the outset of a trial or by whether the child selected the first cup himself. Of the total 64 children, 53 manifested their dominant strategy under every starting condition they met; ten manifested their dominant strategy under all but one starting condition; only one child failed to manifest his dominant strategy under two of the four possible starting conditions.

The total frequency of the various strategies was quite well distributed over the various conditions, as Table 1 shows. A series of x^2 tests failed to reveal any statistically significant association between starting condition and strategy.

The use of color as a cue will be discussed later; at this point it should be noted, however, that consistent choice of cups of a single color would not differentially bias the results toward one strategy or another; any of the three strategies could be as easily carried out with cups of the same color as with cups of different colors.

We are in no way saying that these strategic "rules" are consciously

TABLE 1
Number of Children Using Each Strategy under Each Condition

	Starting cup			
	Large	Medium	Small	Free
Strategy 1	27	22	24	22
Strategy 2	37	44	46	45
Strategy 3	10	9	15	12

formulable by the child himself. Yet the term "rule" seems preferable to the term "habit" because the dominant strategy manifests itself in the child's very first approach to the task in 56 out of 64 cases. The dominant strategy was, therefore, not something learned over a number of trials, nor was the appearance of the dominant strategy on the first trial related to previous experience with similar toys (assessed by questions to the parent). Because "rule" connotes a relatively greater degree of preadaptation of behavior than does "habit," it seems a more appropriate term in the present context.

Development of Strategies

Looking at the three strategies from a developmental point of view, we see from Fig. 3 that there is a definite developmental sequence to their appearance. The consistency data presented earlier indicate that this graph presents a fair picture of each individual's behavior as well as group profiles. Strategy 1 (one or more two-cup combinations involving but one moving cup) is the dominant strategy for seven out of eight children at 11 months of age. Strategy 2, the pot strategy, reaches its peak at 20 months when it, too, becomes the dominant strategy for seven out of eight children. Methods intermediate between Strategies 1 and 2 reach their height a bit earlier, at 16 months. These intermediate strategies involved the construction of two coexisting pairs of cups or of one pair and one three-cup structure. In two cases of 16-month-old

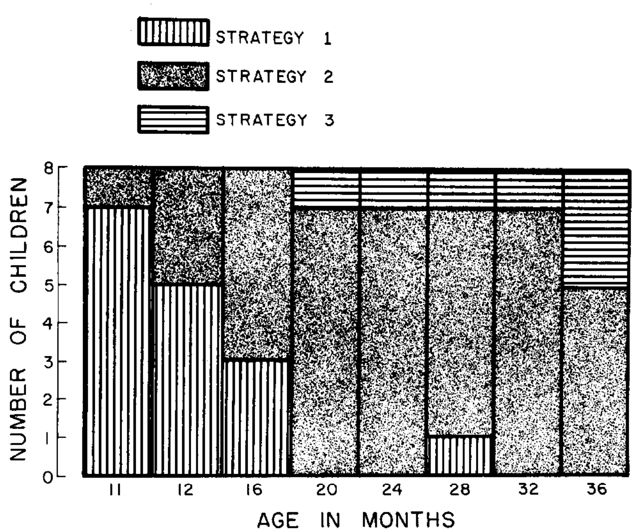

FIG. 3. Frequency of dominant cup strategies at different ages.

children, these intermediate forms were the dominant way of actualizing the pairing strategy. Strategy 3, the subassembly method, reaches its height among the oldest children; it is the dominant strategy for three out of eight 36-month-old children. At 36 months of age, seven out of eight children use this strategy at least once. This proportion is in sharp contrast to the 11-month-old children who never achieved the subassembly strategy. The middle groups, 20 and 24 months of age, fall between the oldest and youngest in this respect: three out of eight in each group attained a subassembly strategy at least once. Strategies intermediate between 2 and 3 reached their height at 28 months; these methods, using both pot and subassembly techniques at different points in construction, were dominant for two of the 28-month-olds classified as using the pot method for their dominant technique. Thus, the timing of intermediate methods confirms our conclusion concerning the ordinal sequence of strategies in development.

This developmental sequence also explains the slight decline in consistency from Strategy 1 to Strategy 2 to Strategy 3: older children have the simpler methods as part of their manipulative competence; whereas younger children have not yet attained the more complex strategies.

The asymmetrical combination of two cups occurring in Strategy 1 represents a neat advance over the preceding stage in which the baby's two hands are limited to symmetrical manipulation. At that stage, two objects can be banged together at the midline, but differentiated interaction is impossible. Thus, nesting or stacking cups is precluded, for in these activities the two objects being combined necessarily have differentiated roles. When differentiated hand-use does appear at about 11 months, it seems that once a cup has become the acting or moving cup by virtue of being picked up by the child, he treats it as an extension of his hand. This relationship of cup and hand is particularly apparent when the child puts one cup into a second and immediately withdraws that cup without ever letting go. This form of the strategy was used by all 11-month-olds and seven out of eight 12-month-olds.

An extremely common phenomenon among the 11-month-old children is the transfer of a single moving cup from one stationary cup to another without ever letting go of the original cup. This behavior is no more probable than the pot method on *a priori* grounds; yet seven 11-month-olds manifest it. In contrast, only one child in this group uses the pot strategy. Thus, we see that the 11-month-old children in fact make extra moves to avoid switching acting cups. Therefore, the preponderance of the two-cup strategy among the youngest children cannot be attributed to their more random behavior.

Treatment of the moving cup as an extension of the hand is demonstrated by trials in which the experimenter starts by handing the child the largest cup. The child holds the largest cup in his hand, yet there is no way that the largest can be the first acting cup if the child is to seriate two cups. As we will see in a moment, even the youngest children do in fact seriate when they combine two cups. Therefore, if the youngest child is capable of putting one cup down and picking up another one, he ought to do so. On the first trial that starts with the large cup, two-thirds of a group of eighteen 11-, 12- and 16-month-olds failed to put down the large cup, but rather used it as the first acting cup. Among the next oldest groups of children—20, 24, 28, and 32 months of age—this occurs in only 11 out of 30 children (37%). Finally, only one out of eight 36-month-old children (12.5%) uses the largest cup as the first actor. These group differences are statistically reliable according to a x^2 test ($x^2(2) = 13.06$, $p < .005$, 1-tail test). Clearly treatment of the moving cup as an extension of the acting hand decreases with age, allowing strategies which demand multiple acting cups or a change in function from acting to acted upon to develop.

Development of Seriation

Although the strategies we have described are conceptually independent of seriation, they have an empirical relationship to seriation and, in fact, constitute basic competencies necessary to its development. These strategies turn out to be closely related to the development of ordered size concepts.

Size, however, is but one possible criterion for cup selection. Color and contiguity to the child are two others relevant in the present experiment. Note that, like size, these criteria are theoretically independent of strategy: any strategy can be carried out using any (or no) criterion of selection.

Structures were analyzed according to the consistency with which successive cup choices for a structure conformed to the various criteria. Selection for a given structure would be based on color if every cup chosen by the child were of the same color or if all the cups of one color were selected before any cups of the other color. Selection for a given structure would be based on size if all the cups ended up in serial order. Selection for a given structure would be based on contiguity to the child if he never reached behind a nearer cup to use a more distant cup. Selection for a given structure could also be based on a different kind of contiguity if the child never reached across his own midline to use a cup. Selection of cups for a given structure can theoretically conform to any of these criteria alone or in any combination. Selection of cups is guided by none of these criteria when the child shifts the basis for his choice in the midst of making a given structure.

The results show that color is not prominent as a selection criterion in any age group no matter what strategy is used. The modal combination of criteria for selecting cups among the 11- and 12-month-old children is size and position on the same side as the acting hand. Looking at the relation between selection criteria and strategy, size and ipsilateral side are the modal criteria used with Strategy 1. In other words, the youngest children, who almost always use Strategy 1, typically choose pairs of seriated cups from among those on the same side of the table as their moving hand.

Among the 16–24-month-olds, the modal combination of selection criteria is contiguity alone. Looking at the relation between selection criteria and strategy, we see that contiguity alone is also the modal criterion for the pot strategy, which predominates in these groups. These children are consistent in not reaching behind a cup to use a more distant cup, although they are not bounded by the midline.

For the 28-, 32-, and 36-month-olds, size alone is the modal combination of criteria guiding their selection of cups. This criterion is very closely associated with Strategy 3, the subassembly method. Thus, when the subassembly method is used, it yields a totally seriated structure 91% of the time.

The 11-, 12-, and 16-month-old children operate as though size were a binary concept rather than a continuum possessing infinite gradation. It seems as though one cup is treated as "biggest" while all others belong to the category "little." This is manifest in the large number of children who place some smaller cup into the largest as a first move. Seven out of eight 11-month-olds, seven out of eight 12-month-olds, and seven out of eight 16-month-olds employ this strategy at least once. When two-cup structures are being built, this concept of ordination yields a seriated structure; a smaller cup is inside a larger one. Thus, ten out of eighteen 11- and 12-month-old children form consistently seriated structures. As soon as the pot strategy appears, however, and structures contain three or more elements, this concept of ordination breaks down; if the next largest cup has not been placed in the largest cup, all further additions may be out of order, yielding a pile rather than a nest. At 16 months, a binary concept of size is conjoined to the pot strategy, yielding the nadir of seriated structures and the height of piling; only one child in eight builds consistently seriated structures.

Following the breakdown of the binary concept of size comes a second stage of seriation. This stage is characterized by an ability to seriate all five cups, but an inability to insert the sixth cup presented after the five-cup series has been formed.

Behavior representing this stage is most freqent at 28 and 32 months of age. In these two groups many children seriate all five cups, but six of the ten children who are given a sixth cup to insert in the middle of the series fail at this task. In terms of strategy, four of the six who fail are restricted to the pot strategy, whereas all four who succeed are able to nest by the subassembly method.

In the third stage, the child succeeds at inserting the additional element. Thus, by 36 months of age, five of the six children who seriate the original five cups also succeed in inserting a sixth intermediate element. All these children are able to use the subassembly strategy. At this point, the child must have a systematic strategy of seriation. Such a method implies the operation of reversibility, as Inhelder and Piaget (1969) point out, for in order to place a new element in a series it must be related both forwards and backwards in the series—larger than the element on one side, smaller than the element on the other. Constructing a series from scratch, in contrast, demands only a single relation; consistent choice of either the smallest remaining cup or the largest remaining cup suffices to form a series.

In a similar but more general way, the subassembly strategy requires that all the intermediate cups have two different relationships to the two cups on either side of them in the structure; each is first the object of the action as a two-cup unit is formed, and then becomes the acting cup when a three-cup structure is constructed. This is also the kind of reversibility where a single element enters into two opposing relationships. Although seriation is just as feasible by the pot method, the method requires but a single role for each cup: the pot is always stationary and is acted upon by all the other cups which function as moving or acting cups. The subassembly strategy appears necessary to the ability to insert a sixth intermediate cup into the series. Thus, the use of a method in which a single element both is acted upon by a second element and also acts upon yet a third element, may be basic to operational seriation: the ability to place an element so that it is both larger than one thing and smaller than another.

DISCUSSION

Are the three strategies for cup construction formally parallel to any grammatical construction? Here is the argument for an affirmative reply to this question:

Each time one cup acts upon another to form a structure there is a relation of actor–action–acted upon, a relation most simply realized in sentence structure as subject–verb–object. In this conception, cups are the units equivalent to noun phrases in a sentence. Thus, in Strategy 1, the pairing method, the basic strategy can be represented as in Fig. 4.

The equivalent sentence in the middle line of the figure is one possible

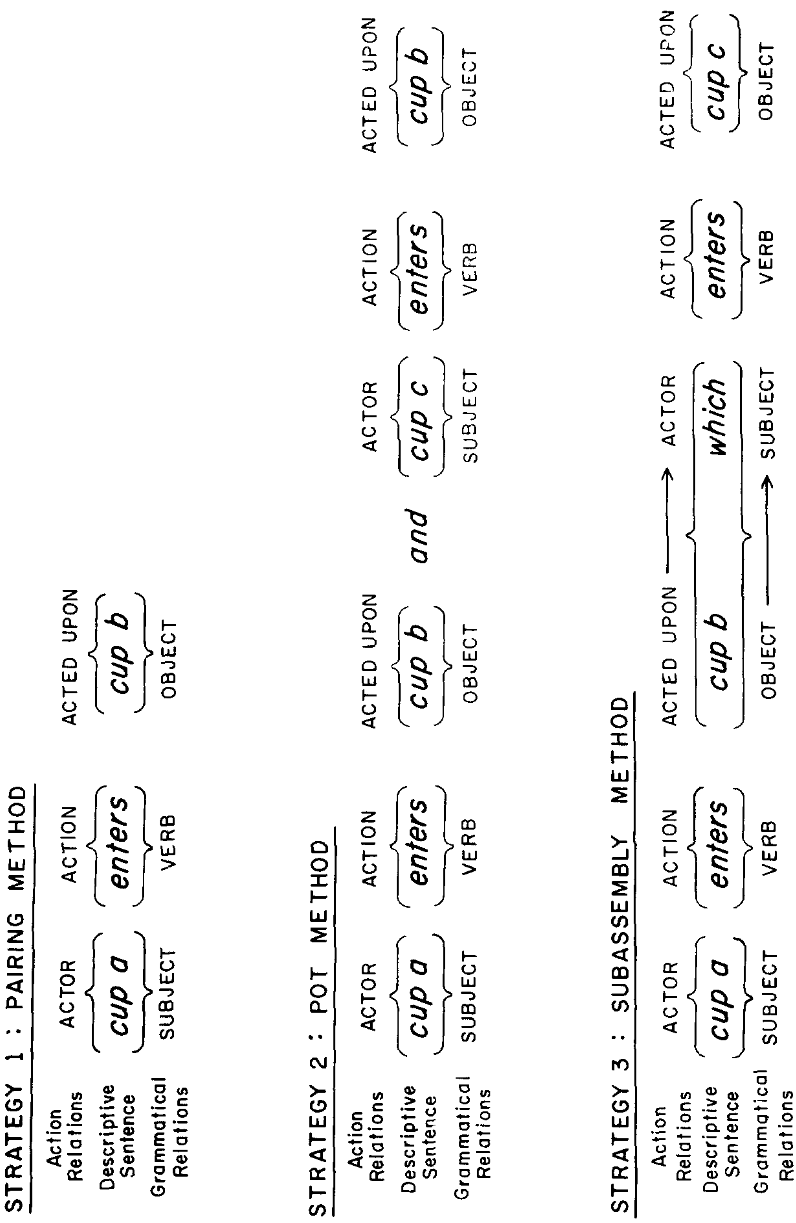

FIG. 4. Formal correspondence between manipulative strategies and sentence types.

illustration of the action relations on the top line, along with the grammatical relations of an analogous sentence on the bottom line—a so-called simple sentence.

For Strategy 2, the pot method, the basic strategy and corresponding grammatical relations are shown in Fig. 4. This strategy comprises multiple actor–action–acted upon sequences, each involving a different acting cup. The element that is acted upon represents a single locus which, of course, contains an additional cup after each successive move. A convention governing the parallels between language and action represented in Fig. 4 is that grammatical relations must appear in the same temporal order as the corresponding action relations. Because subjects of the "descriptive sentence" for the pot method in Fig. 4 are related to the verb in the same way, they have no ordered relationship among them, but are logically interchangeable. The same holds for the logical structure of the manipulative strategy. It is therefore of considerable interest to the notion of a language-action parallel that it is only in connection with this particular strategy that acting cups are in fact commonly used in an unordered way, yielding a "pile."

In Strategy 3, the subassembly method shown in Fig. 4, the first cup that is acted upon (b) becomes the actor in relation to cup c, just as the first object in the sentence becomes the subject of the following clause. Although the first acting cup (a) is included in the second acting unit (a and b), the child lets go of cup a and then picks up and moves cup b in the second move. It is for this reason that the transition of cup b from acted upon to actor is stressed in Fig. 4. In the case of seriated cups, the separate acts are linked when the same cup that is the object of action in the first combination becomes the initiator of action in the second. In the case of sentences, the object of the first, main clause, becomes the subject of the second, relative clause.

We have seen that the cup strategies develop in this sequence, but do the corresponding sentence types follow the same developmental order? Certainly simple sentences appear first (McCarthy, 1954). One source of evidence on the relative ordering of the other two types of grammatical construction is provided by data from two of the children participating in Brown's longitudinal study of speech development. The conjunction of two sentences by *and* was frequent in the corpus of both children before relative clauses were a regular feature of their speech (Brown, 1962–1967). Smith (1970) found that conjunction preceded relative clauses in the spontaneous speech of 18 three- to four-year-olds. An imitation experiment with the same children confirmed this sequence. They were much more frequently able to repeat the sentence "Sam and Harry built the house" than "The boy who was running fell down." Although the first sentence contains a compound subject, the base structure is the same as that depicted for the pot method in Fig. 4. Smith's example of a relative clause is simpler than that depicted for the subassembly method in Fig. 4 in that the underlying simple sentences contain no direct objects. Slobin and Welsh's (1968) imitation data also show that conjoined sentences appear before relative clauses. Thus, the available evidence suggests parallels between manipulation and grammar not only in form, but also in developmental sequence.

This analysis relates to a structural analogy between the development of action and grammar structures; the descriptive sentences in Fig. 4 are not supposed to be in the child's head. The importance of the action–grammar analogy lies in the possibility that the same human capacities may be responsible for both types of structure. A further study is in progress to test out the direct relation between the structure of linguistic commands about the cups and cup manipulation itself. Pilot work showed that linguistic commands to make different types of cup structures could not be comprehended and followed before adolescence; and so the final study used college students as subjects. The results will indicate whether there is a direct correspondence between semantic and action relations and whether this correspondence relates to the surface structures represented in Fig. 4 or to the corresponding base structures.

It is necessary to bear in mind two additional points. The first is that both strategies and structures, and therefore grammatical parallels, are limited by the physical nature of the nesting cups. One would expect other strategies and structures to manifest themselves with other materials, but one would expect their emergence to follow the developmental order of the corresponding grammatical constructions. Similar research with other types of material will speak to this point.

The experiment of Huttenlocker, Eisenberg, and Straus (1968) indicates that when a child manually displaces an object there is a psychological reality to the correspondence between that moving object and the logical and grammatical subjects of a sentence. The present study has extended this conception to the development of a sequence of related actions in naturally occurring manipulative play.

Among the younger children the cup that is grasped in the hand becomes the first acting cup. A quite striking parallel is found in the grammatical development of some English speaking children (Brown, 1962–1967; Bloom, 1970): at first, animate nouns serve as sentence subjects, inanimate nouns as objects. The same phenomenon has also been reported for children learning to speak Hebrew (Schlesinger, 1968) and Finnish (Bowerman, 1968). Relating this stage in grammatical development to the nesting cup situation, we may say that by connection with the child's hand a cup becomes "animate" and therefore an actor, analogous to the animate subject in a sentence. Gradually, this deterministic factor loses its power in sentence construction, just as identification with the hand ceases to be the main factor in choosing an acting cup. In both cases, factors intrinsic to the structure itself take on increasing importance.

The second point to bear in mind is that the strategies belong to the child, not to the cups. We are therefore describing the first emergence of the ability to make one object act on another object; that is the beginning of tool use. In this context, the early identification of cup with hand mirrors de Laguna's (1963) observation that the evolution of tools begins with the tool as an extension of the hand and proceeds to the tool as an entity, whose use is governed by its own independent properties, just as a particular cup's function in a structure comes to be governed by its size properties rather than by its spatial relationship to the child.

The generality of the first strategy is confirmed by our observations of Lauren Greenfield at 12 months taking one of a gradated series of rings and repeatedly putting it on and taking it off its pole base. At the same time, she applied the identical strategy to a form-board puzzle containing, among other things, two round pieces and holes of the same size. In this situation, she would take a round piece, put it in one of the round holes, take it out, and put it in the other one, never going on to handle a second piece.

Similarly, the generality of the pot strategy is reinforced by Piaget's (1954) observations concerning his own young children's discovery of "the relation of contents to container." At about 15 months of age, his children put solid objects in a hollow object, a more literal pot than in the present experiment.

Furthermore, Piaget's description of his daughter Jacqueline's behavior upon encountering nesting boxes for the first time at 16 months of age fits our description of the pot strategy, although Piaget did not recognize it as such.

The development of ordered size concepts, that is, of seriation, described for this task in the age range from one to three years, is parallel to that reported by Piaget (1965) for older children with a more difficult seriation problem. In that study children were asked verbally to arrange ten rods differing by .8 cm from "shortest" to "longest." One mark of the Stage 1 behavior manifested by four-year-olds was a binary division of the sticks into "big" and "little," corresponding to the behavior manifested by one-year-old children in the present study. Similarly, Piaget and Sjeminska (Inhelder & Piaget, 1969) identified a second stage, starting at age six in some children, of nonoperational seriation in which a series can be constructed but in which additional intermediate elements cannot then be inserted. A parallel second stage appeared in the present study around age two. Finally, Piaget identified a third and final stage of seriation characterized by an ability to insert new elements in an already formed series. Some six-year-olds attain this level. We also observed this last stage, and in our data connected it to the ability to relate an element both forwards and backwards in a series. Apparently the same sequence of development can be repeated with different tasks at different ages. Piaget (1950) himself has spoken of the recurrence of sequences of development at different points in time. The age for a particular task seems to depend upon how much is required by a given task in the way of information processing, number of separate acts to be coordinated, manipulatory skills, and language skills. A parallel conclusion has been reached by Bower (1967) and Aronson and Tronick (1971) with respect to quite different capacities.

The subassembly strategy did not dominate the behavior of a majority of the 36-month-old children, yet at 40 months, children were too bored to participate in the experiment. The role of the model may account for this anomaly. The use of the theoretically most difficult strategy in the demonstration was based on the notion first put forth by Piaget (1962) that imitative behavior reflects the capacities of the imitator as much as the characteristics of the model. In the case of this study, the model was mainly preserved as a generalized goal state: to put the cups inside each other. There is evidence that the model was used by the youngest children mainly to get this nesting activity going, whereas it was used by the older children as a basis for *terminating* activity as well. For them, the final stage of the demonstration appeared to function as a precise goal and signal for termination. Thus, the experimenter had to intervene to terminate trials for all twelve 11- and 12-month-old children for whom data on this point were available. In contrast, at the other end of the developmental continuum, all six of the 36-month-old children on whom there was data did, in fact, spontaneously initiate termination themselves by giving an appropriate signal to the experimenter. The oldest children, seemingly capable of the subassembly strategy, may not have used it consistently because the pot strategy also could be a means to the same end of complete seriation. Instructions that emphasized following the method shown in the demonstration as well as attaining the end state could possibly increase consistent use of the subassembly strategy in the oldest group. But the fact that there were no specific instructions makes the presence of such a high degree of structure in the children's play and the homology of this structure with that of language all the more compelling.

After this study was complete, we learned that Woodward in England was approaching nesting cup behavior in preschool children from the point of view of rule-guided behavior. In her procedure she first presents the child with a set of 12 cups already nested together and then tells the child to get all the cups together again. Woodward's report confirms our idea that children using different strategies preserve the generalized goal of getting cups inside each other. She reports behavioral phenomena corresponding to Strategies 1 and 2, as well as behavioral consistency; but her classification of strategies is more from the point of view of seriation. The seeming absence of Strategy 3, the subassembly method, tends to confirm our ideas of the role of the model, for children in Woodward's study were shown and told the goal to be attained—12 cups in a nest—yet were given no visible clue as to the means to be used.

The possibility of a single competence underlying certain forms of action and grammar made evidence as to the universality of the action forms desirable. For this reason, a nesting cup procedure was used with 30 children living in Zinacantan, a Mayan communitv in Southern Mexico. Observation of these children, ranging from 9 months to 5 years of age, revealed the same sequence of strategies, although detailed results of the study must await a later paper. Note that the strategies appeared even though these children were totally unfamiliar with seriated cups or any other type of manipulative toy. When one considers that the language environment of these children was Tzotzil, a Mayan language totally unrelated to European languages, the possibility of universal innate competencies basic both to language and other forms of behavior becomes a very real one. Indeed, the existence of action structures formally similar to grammatical structures may provide a cognitive base for language learning itself. A known action pattern could provide a strategy for decoding a linguistic description of that action. This hypothesis is in accord with theories of language acquisition recently put forth by McNamara (1970) and Greenfield and Bruner (1970).

There is a general correlation of language development (as assessed by a few questions to the mother) and nesting cup strategy. But this would be expected if only because both are developing with age. It is also true that cups can be combined before words: a two-cup structure invariably precedes the two-word utterance. But rather than think of linguistic capacities as causing cup strategies or *vice versa*, and looking for a temporal relationship to prove it, we prefer to consider both as behavioral manifestations of underlying internal forms of organization which have many other concrete applications as well. This idea is in accord with recent theoretical contributions of Bever (1970) and Schlesinger (1968). The precise developmental timing of different manifestations of the same capacity would not then be absolute but would depend upon relative amounts of experience in different domains, as well as upon the different information processing skills involved in the various manifestations of the single structure.

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