

## **Miniature Linguistic Systems as Tests of the Use of Universal Operating Principles in Second-Language Learning by Children and Adults**

**Brian MacWhinney<sup>2</sup>**

*Accepted December 7, 1982*

*This study examined four universal operating principles for first language acquisition proposed by Slobin (1973) and MacWhinney (1978). The applicability of these principles to second-language acquisition was tested by teaching children and adults a miniature linguistic system. The results suggested that the four principles played a major role in the learning of the system by 5- to 7-year-olds but not by adults. Modifications were made in the standard miniature linguistic system technique in order to maximize linguistic naturalness and referentiality. The result was a complex system that could still be taught even to 5-year-olds in the space of a few hours.*

### **INTRODUCTION**

Slobin (1973) has proposed that, when children are learning their first language, they often rely on certain basic and universal strategies, which he called "universal operating principles." According to Slobin, these principles serve to guide children in their processing of linguistic data and

This work was supported by Grant 1R01MH3116001A1 from the Personality and Cognition Research Committee of the National Institute of Mental Health.

'My thanks to Pamela Zell for her assistance in conducting the teaching of the child subjects and to Elizabeth Bates for comments on an earlier draft. Special thanks also to the personnel and students of the Maria Montessori School of Denver for their thorough and friendly cooperation in this study, and to the Van Dellen Christian Elementary School of Denver for their assistance in the pilot phase of the research.

-Department of Psychology, Carnegie-Mellon University, Pittsburgh, Pennsylvania.

to facilitate their formulation of hypotheses regarding these data. These operating principles can also be viewed as important components of the general language-learning ability that Chomsky (1965) has called the Language Acquisition Device. However, given that most of the evidence for these principles has come from naturalistic studies of first-language acquisition, it is not clear to what extent one should expect to find evidence for the use of similar operating principles in second-language acquisition. For example, if one were to believe that there is a critical period (Lenneberg, 1967) for the acquisition of language, one might also expect to find that at least some of these basic operating principles would not be used as extensively by adult second-language learners as by children learning a second language.

In the present study, children and adults are taught a miniature linguistic system (MLS) that is designed to examine the role of four of these universal operating principles in second-language learning. As McLaughlin (1981) and Slobin (1971) have persuasively argued, studies involving the teaching of miniature linguistic systems are, by definition, studies of second-language acquisition. In all such studies, subjects can and probably do rely on the structure of their native language in acquiring the experimental language. Thus, learning in an MLS experiment is, in a sense, a microencapsulation of normal second-language learning. Given the fact that such learning can rely quite heavily on transfer from the first language, any evidence for the use of universal operating principles in miniature linguistic system learning can be taken as evidence for the pervasiveness of these principles.

The present study focuses on four particular operating principles taken out of the larger set of principles discussed by Slobin (1973) and by MacWhinney (1978). The first principle is Operating Principle D in Slobin (1973, p. 199) and Claim 9 in MacWhinney (1978, p. 20). This principle holds that children choose to "avoid the interruption of linguistic units." In regard to lexical acquisition, this means that children will first attempt to acquire those lexical items that are continuous. If an item is discontinuous, the child will acquire one of its continuous pieces. For example, in English, children might first acquire the morpheme *be* + *-ing* as simply *-ing* (Brown, 1973). Thus, given a continuous item along with a similar discontinuous item, this first operating principle would predict that the continuous item would be acquired before the discontinuous item.

The second principle to be examined is Operating Principle A in Slobin (1973, p. 191). This principle holds that children "pay attention to the ends of words." In regard to lexical acquisition, this means that

children will tend to preserve final syllables in the words they learn. Thus, given a word with both a prefix and a suffix, one would expect the suffix to be acquired earlier than the prefix. For example, in Swazi, the locative affix is a discontinuous morpheme involving both the prefix *e-* and the suffix *-ini*. Kunene (1979, p. 87) reports that Swazi children use the suffix before the prefix, although both ways co-occur in adult speech. Kuczaj (1979) and Danemann and Case (1981) have conducted experimental tests of this same principle using miniature linguistic systems. The results of both of these studies indicate that English-speaking children do, in fact, "pay attention to the ends of words."

The third principle appears as Claim 2 (affix-checking) in MacWhinney (1978, p. 20); it is also described in an earlier article by Slobin (1971, p. 220). This principle holds that during the output stage of speech production, children will monitor the words they produce in order to see if they have all the markings that they are supposed to have. Thus, if a form appears to have a marking, the monitoring procedure will be satisfied and no further marking will be attached. As a result, children will be less likely to attach an affix to forms that already appear to contain that affix. For example, in English, children will seldom produce *bented* because *bent* appears to already contain the past tense morpheme. Examining his own diary data, Kuczaj (1977) found reason to doubt the generality of this principle. However Linell (1979) and Menn and Mac-Whinney (in press) have presented data indicating that the process of affix-checking is of fairly universal importance for both inflectional and derivational morphology.

The fourth principle appears as Operating Principle F in Slobin (1973, p. 205) and Claim 11 in MacWhinney (1978, p. 20). This principle holds that the child will attempt to "avoid exceptions." In regard to lexical acquisition, this means that a child will attempt to acquire a single form to express a single function. Furthermore, once one form has been learned, the child should resist acquisition of a second, synonymous form. In other words, when the alternation between two forms cannot be predicted by any combination of phonological or semantic conditions, acquisition of the second form of the pair should be slow and prone to error.

By way of summary, the four specific hypotheses that derive from the application of these operating principles to lexical acquisition are as follows:

Hypothesis I: Continuous items will be acquired before discontinuous items.

Hypothesis 2: Suffixes will be acquired before prefixes.

Hypothesis 3: Children will be less likely to attach an affix to forms that already appear to contain that affix.

Hypothesis 4: Once a form has been learned, the child will resist acquisition of a synonymous form.

In order to test the applicability of these four hypotheses to the context of second-language learning, a miniature linguistic system was constructed that contained specific contrasts between (1) continuous morphemes and discontinuous morphemes, (2) prefixes and suffixes, (3) pseudomarked forms and unmarked forms, and (4) consistent forms and inconsistent forms. By including all four contrasts in the design of a single experiment, it becomes possible to examine the relative power or salience of the separate operating principles. At the same time, the resulting system comes closer to looking like a fragment of natural language. However, the result is also a system that is at least as complex as many that have proven to be challenging to adults in the past. In order to facilitate the learning of this complex system by children, it was necessary to correct two weaknesses in prior implementations of the MLS technique. (For a good review of the MLS literature see Esper, 1973.)

First, it was necessary to increase the *linguistic naturalness* of the task. Consider the MLS task as it was used by Esper (1925). In that task, subjects learned a set of syllables to name shapes and another set of syllables to name colors. These syllables were then joined into a unit that functioned intonationally as a compound word. As a study in concept identification or problem solving, learning of such an MLS is a perfectly reasonable task. However, as an experimental model of language acquisition, Esper's MLS has certain problems. In particular, the semantic/morphological shape of the compound words to be learned in this system is basically unnatural. It is unnatural because languages almost never attach color words to shape words to form compounds or derived words (Tahny, 1977). Although we occasionally find "frozen forms" (Newport & Bellugi, 1978) like *greenhouse* or *blackbird*, we almost never find a productive process that turns the concept "red square" into the single word "redsquare." Similar problems arise in the MLSs used by Wolfle (1933), Malouf and Dodd (1972), Moeser and Bergman (1972, 1973), and others. However, by paying attention to the kinds of lexical and phonological structures that can be found in natural language (Greenberg, 1978a, 1978b), it should be possible to design miniature linguistic systems that constitute reasonable analogues to those aspects of natural language the researcher wishes to investigate. In the present experiment, the

words to be learned were nouns with locative affixes. Noun-plus-affix structures such as these constitute single words in languages as diverse as Hungarian, Atsugewi, and Quechua. For example, in Hungarian, the phrase "in the park" is *parkban* with *-ban* serving as a suffix meaning "in." Thus, it is clear that learning of noun-plus-locative-suffix units is not a linguistically "unnatural" task. Moreover, the fact that languages so frequently attach locative specifiers to nouns has led Talmy (1977) to suggest that the attachment of locative markers to nouns represents a cognitively natural association.

Second, the present experiment modifies previous implementations of the MLS technique by maximizing the richness of the *communicative context* in which the MLS is acquired. Moeser and Bregman have shown that even adults find it hard to learn a complex MLS when they are not given access to the meaning of the words. And even when given full semantic cues, preschoolers had a hard time learning the very simple MLSs used by Moeser and Bregman (1973) and Braine (1963). In order to overcome these problems, the lexical items in the present MLS were taught within the context of a series of communicative interactional routines or games that were designed to enhance the referential content of the items and thereby facilitate the overall acquisition of the MLS.

## **METHOD**

### *Subjects*

There were two groups of subjects—children and adults. The children were 16 students at the Maria Montessori School of Denver. Their ages varied from 5 years 2 months to 7 years 5 months, with an even distribution of subjects across that range. The adults were 16 students in introductory psychology at the University of Denver. All subjects were native speakers of English. Although the children in the Montessori school received intensive instruction in Spanish, they were all clearly English-dominant. None of the subjects suffered from any form of language disability or abnormality.

### *Stimuli*

Two counterbalanced systems were devised, each composed of the same eight object names and the same four locative affixes. However, the pairing of the names to referents was different in the two systems. Tables 1 and II summarize the two systems.

Table I. System 1 in the Experiment

Set A					
		"arch"	"dock"	"pot"	"tower"
	Base:	<i>lor</i>	<i>pugone</i>	<i>nizz</i>	<i>irife</i>
"on"	<i>-one</i>	lorone	pugone	nizzone	trifone
"in"	<i>-sib</i>	lorsib	pugonesib	nizzsib	trifesib
"behind"	<i>ra- -em</i>	relorem	rapugonem	ranizzem	ratrifem
"in front"	<i>-itch</i>	loritch	pugitch	nizzitch	trifitch
Set B					
		"cube"	"puff"	"box"	"hive"
	Base:	<i>nak</i>	<i>breen</i>	<i>pu</i>	<i>wug</i>
"on"	<i>-one</i>	nakone	brink	puone	wugone
"in"	<i>-ate</i>	nakate	breenate	puate	wugate
"behind"	<i>ra- -em</i>	ranakem	rabreenem	rapuem	rawugem
"in front"	<i>-itch</i>	nakitch	breenitch	puitch	wugitch

Table II. System 2 in the Experiment

Set A					
		"arch"	"dock"	"pot"	"tower"
	Base:	<i>pugone</i>	<i>lor</i>	<i>irife</i>	<i>nizz</i>
"on"	<i>ra- -em</i>	rapugonem	ralorem	ratrifem	ranizzem
"in"	<i>-itch</i>	pugonitch	loritch	trifitch	nizzitch
"behind"	<i>-one</i>	pugone	lorone	trifone	nizzone
"in from"	<i>-ate</i>	pugoneate	lorate	trifeate	nizzate
Set B					
		"cube"	"puff"	"box"	"hive"
	Base:	<i>breen</i>	<i>nak</i>	<i>wug</i>	<i>pu</i>
"on"	<i>ra- -em</i>	rabreenem	ranakem	rawugem	rapuem
"in"	<i>-itch</i>	breenitch	nukitch	wugitch	puitch
"behind"	<i>-one</i>	brink	nakone	wugone	puone
"in from"	<i>-sib</i>	breensib	naksib	wugsib	pusib

## Universal Operating Principles

Hypothesis 1 is to be tested by the comparison of the discontinuous morpheme *ra-* *-em* with the control affix *-itch*. Hypothesis 2 is to be tested by the comparison of the prefix *ra-* with the suffix *-em*. Hypothesis 3 is to be tested by the comparison of the pseudomarked form *pugone* (for *pugonone*) with the irregular form *brink* (for *breenone*). Finally, Hypothesis 4 is to be tested by the comparison of the learning of *-sib* or *-ate* when one suffix or the other is learned first.

### *Procedure*

System 1 was taught to eight children and eight adults; System 2 was taught to the other eight children and eight adults. Within each system, half of the subjects learned Set A first and half learned Set B first. The four orders were therefore System 1AB, System 1 BA, System 2 AB, and System 2 BA. Each order had four children and four adults. The mean ages for the four groups of children were all between 6 years 2 months

and 6 years 4 months.

For the adults, the experiment involved six phases: (1) presentation of the names of the 4 objects in the first set, (2) naming of the 16 place/object combinations in the first set, (3) testing on the first set, (4) presentation of the names of the 4 objects in the second set, (5) naming of the 16 place/object combinations in the second set, and (6) testing on all 32 items. Within each of these six phases the order of these various items was varied across subjects.

For the children, the experiment involved these same six phases along with two additional steps. After phase 2 and again after phase 5, the children were encouraged to take part in a series of three teaching games. These games were (1) families, (2) hotels, and (3) a primitive form of "chess." The purpose of each game was to encourage the child to make use of the names for the 16 locations in each set. The games all involved placement of toy animals in the various locations. The animals included four exemplars, each with somewhat different coloring, of each of these eight types of animals: frogs, dinosaurs, lions, monkeys, bears, dragons, trolls, and robots. In the "families" game, the children were introduced to the four members of each animal family. For example, the four dragons were called Puff, Harry, Feather, and Diane. The child was then told that the dragons (or the frogs or some other animal family) wanted to visit one of the four "hotels." For example, the dragons may have been

interested in visiting the "nak." Thus, Puff might want to go *naksib*, Harry might want to go *renakem*, Feather might want to go *nakone*, and Diane might want to go *nakitch*. Once located in their positions, some of the animals may have wanted to change places, and so on. Throughout this game, the child was encouraged to move the animals to the correct place and also to tell the experimenter about other places to locate the animals.

Once the child had gained some proficiency at playing "hotels," the experimenter suggested that the animals would like to play another game. The child was given half the animals and the experimenter took the other half. Both players placed their animals while naming the places. Then the child was encouraged to take "his" animals and occupy any one of the positions having animals that belonged to the experimenter. If the child could give the name of the position, he could "knock" the experimenter's animal off the board. Of course, the rules of the game were interpreted quite liberally in order to ensure that the child always won by a good margin.

For both the children and the adults, the final phase of the experiment was a test on all 32 locations. The data to be reported refer to the subjects' performance of this final test. For the adults the experiment lasted about 30 minutes. For the very youngest children the procedure required from four to six 1-hour sessions. The older children were able to complete the test in 2 to 3 hours.

## RESULTS

First, the results will be discussed in relation to the four hypotheses deriving from the four operating principles. The analysis in each case will be based on the relative number of errors produced for the various forms. Errors are defined as failures to generate the morphological forms given in Tables I and II. Minor phonological deviations from these "standard" forms were not regarded as errors.

The first hypothesis can be tested by comparing errors on the discontinuous morpheme *ra- -em* with errors on the control suffix *-itch*. The discontinuous morpheme was particularly difficult for the children. They made 30 errors on *ra- -em* as opposed to only 4 on *-itch*. The adults, on the other hand, made 15 on *ra- -em* and 8 on *-itch*. The difference between the continuous and discontinuous morphemes was significant for



the children ( $p < 10^{-7}$ , binomial probabilities) but not for the adults. Thus, Hypothesis 1 is supported for the children but not for the adults.

The second hypothesis can be tested by comparing the prefixed and the suffixed part of the discontinuous morpheme *ra-* *-em*. The children made 25 errors on the prefixed section *ra-* and only 4 on the suffixed section *-em*. This difference was highly significant ( $p < 10^{-6}$ ). The adults made only 2 errors on *ra-* and only 6 on *-em*. Thus, Hypothesis 2 is supported for the children but not for the adults. In fact, for the adults, the actual direction of the effect is opposite to that predicted by Hypothesis 2.

The third hypothesis can be tested by comparing the errors on the partially irregular *formpugone* with the errors on the fully irregular form *brink*. Overgeneralizations here include production of *pugonone* for *pugone* and *breenone* for *brink*. The children made 9 errors on the fully irregular form and only 2 on the partially irregular form ( $p < .05$ ). Adults made 1 error on the fully irregular form and 2 on the partially irregular form. Thus, Hypothesis 3 is supported for the children, but not for the adults.

The fourth hypothesis can be tested by examining the errors on the affix that was not consistent across the two sets. Both children and adults made far more errors on the inconsistent *-sibl-ate* suffix than on the consistent *-itch* suffix. Children made 30 errors on *-sibl-ate* and only 4 on *-itch* ( $p < 10^{-8}$ ), and adults made 16 errors on *-sibl-ate* and only 8 on *-itch* ( $p < .01$ ). The children made 8 errors on the first-learned form and 22 errors on the second-learned form. This difference is significant ( $p < .0001$ ). However, the adults made 8 errors on first-learned forms and 8 on second-learned forms. Thus, Hypothesis 4 is supported for the children but not for the adults.

## DISCUSSION

The central results of this study are easily summarized: Each of the four hypotheses was supported for 5- to 7-year-old English-speaking children but not for English-speaking adults, only in the case of Hypothesis 3 was it possible that the true effect of the affix-checking operating principle for adults might be obscured by a floor effect. However, affix-checking was also the weakest operating principle in the children, and it is not surprising to find that it had little effect on adults in this experimental context.

To the degree that acquisition of an MLS mirrors acquisition of a second language, these results show that English-speaking child second-language-learners do, in fact, (1) avoid interruptions, (2) pay attention to the ends of words, (3) check for affixes, and (4) avoid learning exceptions. At the same time, adults learning a second language make less use of these operating principles.

There are at least two reasonable explanations for the lesser use of these operating principles in adults. One explanation holds that these principles are time-limited components of the Language Acquisition Device. Whatever the truth of this position, it may also be the case that the operating principles are available to adults but that they have also acquired other skills that allow them to override the operating principles. For example, adults may note that some of the words in the experiment have prefixes. At that point they decide to pay attention to both the beginnings and the ends of words. Thus, the results for the adults do not prove that these operating principles have been totally discarded. Rather, it may be the case that adults have acquired a large set of more elaborate and powerful principles whose operation overrides and masks the functioning of these four hypothesized universals.

The other set of results from this study are essentially methodological. There are three such results. First, a system was designed that permitted the measurement of the effect of several learning principles for the single set of data. In this context, the principles that lead learners to avoid interruptions and pay attention to the ends of words were found to be somewhat stronger than the principles of affix-checking and exception avoidance. The second methodological innovation focused on the use of a linguistically and cognitively natural word structure. The form used was the noun-plus-locative-suffix structure found in languages like Hungarian and Quechua. The third methodological innovation involved the use of games, families of animals, hotels, and other playful techniques designed to maximize the referential richness of the communicative context in which the MLS is acquired.

By modifying the standard miniature linguistic system task in these ways, it became possible to teach complex systems even to 5-year-olds in a period of four 1-hour sessions. This can be compared with the period of several days needed for some less complex systems (Wetherby, Note 1). Of course, these modifications have not eliminated all of the problems involved in the MLS technique. For example, one would like to see the technique expanded to the point at which whole utterances could be taught in an MLS. However, such extensions can build profitably on the modifications introduced in the present study.

## Reference Notes

Wetherby, B. Reinforcement in a miniature linguistic system. Paper presented to the Biennial Meeting of the Society for Research in Child Development, San Francisco, 1979.

Meeting of the Society for Research in Child Development. San Francisco, 1979.

## REFERENCES

- Braine, M. On learning the grammatical order of words. *Psychological Review*. 1963. 70. 323-348.
- Brown. R. *A first language*. Cambridge: Harvard University Press. 1973.
- Chomsky. N. *Aspects of the theory of syntax*. New York: Harpar & Row. 1965.
- Danemann. M., & Case. R. Syntactic form, semantic complexity, and short term memory as factors influencing children's ability to acquire new linguistic structures. *Developmental Psychology*. 1981, 17, 367-378.
- Esper. E. A technique for the experimental investigation of associative interference in artificial linguistic material. *Language Monographs of the Linguistic Society of America*, 1925. (Whole No. I).
- Esper. E. *Analogy and association in linguistics and psychology*. Athens: University of Georgia Press. 1973.
- Greenberg. J. (Ed.). *Universals of human language* (Vol. 3): *Word structure*. Stanford: University Press. 1978. (a)
- Greenberg, J. (Ed.). *Universals of human language* (Vol. 4): *Syntax*. Stanford: Stanford University Press, 1978. (b)
- Kuczaj. S. The acquisition of regular and irregular past tense forms. *Journal of Verbal Learning and Verbal Behavior*, 1977. 16. 1-13.
- Kunene. E. *The acquisition of Siswati as a first language*. Doctoral dissertation. University of California at Los Angeles, 1979.
- Lenneberg. E. *The biological foundations of language*. New York: Prentice-Hall. 1967.
- Linell. P. *Psychological reality in phonology*. Cambridge: Cambridge University Press, 1979.
- MacWhinney, B. The acquisition of morphophonology. *Monographs of the Society for Research in Child Development*. 1978, -13, Nos. 1-2).
- tlvalouf. R., & Dodd, D. Role of exposure, imitation and expansion in the acquisition of an artificial grammatical rule. *Developmental Psychology*. 1972. 7(2). 195-203.
- McLaughlin, B. Second language acquisition and model linguistic systems. *Journal of Applied Psycholinguistics*. 1981. 3. 62-74.
- Menu. L., & MacWhinney, B. The repeated morph constraint: Toward an explanation. *Language* (in press).
- Moeser. S., & Bregman, A. The role of reference in the acquisition of a miniature artificial language. *Journal of Verbal Learning and Verbal Behavior*. 1972, 11. 759-769.
- Moeser. S., & Bregman, A. Imagery and language acquisition. *Journal of Verbal Learning and Verbal Behavior*. 1973. 12. 91-98.
- Newport. E. L., & Bellugi, U. Linguistic expression of category levels in a visual-gestural language: A flower is a (lower is a flower. In H. Rosen & B. Lloyd (Eds.). *Cognition and categorization*. Hillsdale. New Jersey: Erlbaum, 1978.
- Slobin. D. I. On the learning of morphological rules: A reply to Palermo and Eberhart. In D. I. Slobin (Ed.), *The ontogenesis of grammar: A crosslinguistic study*. New York: Academic Press. 1976.
- Slobin, D.I. Cognitive prerequisites for the development of grammar. In C.A. Ferguson & D. I. Slobin (Eds), *Studies of child language development*. New York: Holt, Rinehart & Winston, 1973).
- Talmy, L. Rubber-sheet cognition in language. In W. Beach. S. Fox, & S. Philosoph (Eds), *Papers from the Thirteenth Regional Meeting*. Chicago: Chicago linguistic Society, 1977.
- Wolfe, D. The relative stability of first and second syllables in an artificial language. *Language*, 1933, 9, 313-315.