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THREE-TERM CONTINGENCY PATTERNS IN MOTHER–CHILD VERBAL INTERACTIONS DURING FIRST-LANGUAGE ACQUISITION

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Selections from a large longitudinal data set of verbal interactions between a mother and her child are presented. Two sets of three-term contingency sequences that seemed to reflect maternal rewards and corrections were noted. Both the antecedents as well as the immediate consequences of maternal interventions are presented to explore training and learning processes. The observed frequencies of three-step sequences are compared to those expected based upon Markov-chain logic to substantiate the patterning of the interactions. Behavioral conceptualizations of the learning process are supported by these analyses, although their sufficiency is questioned. It is suggested that maternal rewards and corrections should be integrated with perceptual, cognitive, and social learning conceptualizations in a skill-learning approach to explain the complexity of language transmission and acquisition processes.

Key words: three-term contingency, multivariate analysis, language acquisition, reinforcement, imitation, verbal behavior, mother–child interaction

This report presents results from a research program that attempted to bridge the often conflicting arguments of cognitive and behavioral explanations of first-language acquisition and that moved thereby—against the predominant Zeitgeist—successively closer to the behavioral paradigm. It deals with verbal interactions of a mother and her child and their functions for language transmission and acquisition. This latter emphasis necessitates a focus upon training and learning. The data to be presented deal with operant aspects of those verbal interactions in an attempt to elucidate basic conceptual and methodological congruences with the majority of the reports published in this journal. In addition, phenomena for which other paradigms appear to be equally feasible or fit even more closely will be discussed.

The entire research program and the present study are fully empirical and objective, in the positivist and behaviorist tradition. Environmental verbal input, filial productions, the resulting feedback, and the structural and functional relations between them are focused upon. Certainly the research is analytic in searching for elements in the stream of behavior and for the sequential contingencies of these elements. These sequential dependencies in three-term contingency patterns will be the main emphasis of the present analysis. Skinner (1957), Day (1980), Catania (1973), Salzinger (1978), and Zuriff (1985) were consulted for the clarification and historical elucidation of the terms used here. However, the sometimes disparate evolution of radical and methodological behavioristic conceptualizations produces some fuzziness in the intension and extension of some of the terms, so their application might sometimes be ambiguous.

This present approach must be related briefly to the more common psycholinguistic analyses of this domain; the best-known approach is probably Chomsky's. It entails an almost exclusive emphasis on syntactic and other grammatical concerns, that is, upon the structure of verbal behavior, an interest shared here. Yet, Chomsky's proposed answer to the acquisition question, namely that syntactic knowledge is innate, is considered a facile labeling exercise that is completely unsupported by factual evidence and that has hindered the systematic exploration of training and learning processes. Some of Chomsky's more recent extreme pronouncements especially represent this problem. In the 1980s Chomsky began using—without any attempt at physiological/neurological substantiation—the term "language organ" (Caplan & Chomsky, 1980; Chomsky, 1975), and he appears to imply that we have an organ that "knows" how to produce language much as the stomach "knows" how to

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produce stomach acid. The product might be somewhat adapted to the surrounding circumstances, just as stomach acid is adapted to the food consumed, but basically he assumes innate linguistic knowledge and innate linguistic functions. This assumption makes any exploration of learning processes and the pertinent collection of empirical evidence appear superfluous, as abundantly demonstrated by the publications of Chomsky and his disciples.

In contrast to these presumptions, the present research program, through extensive factual analyses, has resulted in the conclusion (e.g., Moerk, 1986, 1989) that no innate linguistic knowledge is needed and language acquisition can be explained fully on the basis of learning. The present research focuses on the now classic work of Roger Brown, not only in respect to the data that Brown generously provided for reanalysis but also in regard to many basic conceptualizations. There are, however, two Brownian positions that need to be differentiated. First there was a pre-Chomsky Brown, who was a careful social scientist and emphasized learning principles and processes (Brown, 1958; Brown & Bellugi, 1964; Brown & Fraser, 1963). Thereafter, a post-Chomsky-1965 Brown argued that many of the central aspects of learning, such as corrections (Brown & Hanlon, 1970) and frequency effects (Brown, 1973), are nowhere to be found in his data. With the major learning processes declared absent, this post-Chomsky Brown is more inclined to accept innate aspects, although he is too much of a factual scientist to endorse the wild claims of Chomsky.

The present research program goes back almost 20 years (Moerk, 1972). It was strongly influenced in the beginning by the pre-Chomsky Brown and his emphasis on training and learning. It contrasts therefore with both Chomsky's position (cf. also Moerk, 1986, 1989) and also with the post-Chomsky Brown (cf. Moerk, 1980, 1983a, 1983b), even if it inherited from both a special interest in syntax. From the beginning, however (Moerk, 1972), the program borrowed eclectically from the behavioral, observational learning, system theoretical, and the functional/ecological tradition, while retaining cognitive and linguistic perspectives where they seemed most useful. With more detailed focus on interactional data, it appeared increasingly necessary to adopt learning theoretical concepts and principles in order to explain the training and learning of language skills. In this emphasis upon learning, modeling, and imitation (Moerk, 1977b; Moerk & Moerk, 1979), motivation (Moerk, 1976a), frequency of input, and rehearsals (Moerk, 1980, 1983a, 1983b), corrections (Moerk, 1976b, 1977a, 1983a, 1983b) were reported. The principle of the *concurrent method,* which was described by Schroeder and Baer (1972) as instrumental for productive generalization, was emphasized (Moerk, 1985a) as contributing to abstraction and generalization. Because all these studies focused on the structure of verbal behavior, the topography of verbal behavior and the establishment of this topography were, naturally, a central concern. For these structural aspects, concepts and terms from linguistics and philology were retained, because behaviorists had focused almost exclusively upon functional analyses (Catania, 1972, 1978).

Beginning with the first publication (Moerk, 1972), the stream of verbal behavior (as it unfolds in the interactions between mother/adult and child), the contingencies between successive utterances, and their functional relationships were central to the analyses. During the early stages of the research program, these contingencies were described impressionistically, without quantitative analysis. From 1983 on (Moerk, 1983a, 1983b, 1985a, 1985b) the analysis included Markov chain models, and the contingencies were also established quantitatively by means of transitional probabilities. The observed probabilities were compared with those expected from random sequences to test for interactional structure. Both in the emphasis on general learning principles and on contingencies between the types of behavior of the interaction partners, extensive parallels exist with the typical experimental analyses of behavior as published in *JEAB.*

Nevertheless, in the search for descriptive and explanatory adequacy, all concepts and methods are considered as tools only. None is judged to be sacred or to contain eternal truths, although some appear much more promising and progressive than others. The conceptual approach has therefore been, and still is, eclectic. To test the potential value of a conceptual tool, it is applied to the data at hand, but always with the attitude that another tool might prove more promising. In the subsequent anal-

ysis of the data, the terminology will therefore not be purely behavioral, and concepts will be borrowed from other paradigms. If behaviorists can provide alternate and even better conceptual tools, then this publication will have two positive outcomes: the establishment of communication across research programs and the achievement of more systematic conceptual tools.

Because all analyses have been based on data collected in naturalistic observations, the present data base excludes experimental manipulation. This does not mean that the degree of analytic control is low. The control derives from the single-subject paradigm that is reflected in mother–child interactions. The conceptual similarity between transitional probability and experimental approaches can be demonstrated most clearly through single-subject A-B-A-B designs. If the probability of correct behavior is high during treatment Phase B, but reaches only a level of chance occurrences during the baseline/withdrawal Phase A, then the interpretation that B causes or elicits the correct behavior is entertained in single-subject designs. Similarly in transitional probability approaches, the antecedent can be conceived as the treatment. With treatment the probability of a certain response is high(er); without this antecedent, the probability is low, remaining at a chance level. When this design is repeated hundreds or thousands of times, as in "mistake-correction sequences," the interpretation that mistakes elicit corrections can be made confidently.

Certainly all interpretations are based on principles of plausibility. The present research program does not claim to have unearthed final proofs or truths. With Popper (1962), Lakatos (1978), and Laudan (1981) "corroborations" of "conjectures" are the most that is offered, together with refutations if so suggested by the data. It is presumed that "convergent findings," obtained with diverse methodologies (experimental as well as observational) can provide firmer evidence both for the logical and ecological validity of the findings and interpretations.

Although not yet performed by the author, related experimental approaches are quite common, whether they consist of remedial interventions or experimental tests of hypotheses. The research of Whitehurst and associates (e.g., Valdez-Menchacha & Whitehurst, 1988; Whitehurst & De Baryshe, 1989) is a good example of remedial interventions. The same applies to most studies of Rondal (in Rondal, 1985). The research of Baer and associates (Guess & Baer, 1973; Stokes & Baer, 1977) and of his students Rogers-Warren and Warren (e.g., Rogers-Warren & Warren, 1980; Warren & Rogers-Warren, 1980) is well known to the *JEAB* audience. Nelson's studies with "recasts" (e.g., Nelson, 1989) follow the more typical experimental paradigm but appeared in psycholinguistic publications. They certainly emphasize control and could fully demonstrate cause–effect relations.

METHOD

The child whose verbal interactions with her mother are analyzed is the well-known "Eve," one of the 3 subjects studied by Roger Brown (e.g., Brown, 1973). Eve and her mother were observed in their home, engaging in normal activities of everyday life. Eve was 18 months old at the beginning of the observation, and she was observed for less than 1 year, up to her 28th month of age. Of the samples collected by Brown, all odd-numbered ones were selected; 2 hr of recording for each of these samples were analyzed in detail.

All the methodological details of the overall data analysis cannot be presented here. This has been done in Moerk (1983b), and only brief remarks to clarify the nature of the data are provided here. Roger Brown's research team audiorecorded the data in the home and transcribed them later. Running comments served to clarify situations. Whenever the quality of the sound track on the tape was insufficient to discern specific words or utterances, dashes were transcribed to indicate approximately the length of the incomprehensible utterance. Considering the quality of the research team and the care taken in the transcriptions, the reliability of the resulting transcripts can be considered high. They encompass basically only "observation statements."

These transcripts were coded by the author and two trained research assistants. Multiple interrater and repeat-reliability tests were performed during the entire period of coding. The reliabilities for most of the categories were in the 90% range, though for some categories a minimum of 80% reliability was accepted to retain these theoretically important categories.

Table 1

The categories of maternal teaching techniques and filial learning strategies.

Labels	Definitions
Expansion/[a] reduction	Minor syntactic elements (i.e., functors) are added/deleted while retaining other elements.
Chaining	Combines items from partner with own newly produced or repeated items.
Self-repetition	Repeats own statement almost identically.
Buildup	Adds constituents to preceding utterance; can be combined with deletions of other elements.
Breakdown	Eliminates words or constituents from preceding utterance making the subsequent one shorter.
Morpheme perseveration	Specific morphemes or morpheme categories are repeated.
Substitution	Most elements and the structure are retained, one or a few items are substituted.
Frame variation	The content is fully or partially repeated, the syntactic structure is changed. Excludes transformation.
Transformation	Syntactic structural changes that result in changes in the elocutionary force.
Vocabulary perseveration	New or rare vocabulary items are repeated.
Provides a label	Provides a noun label without any additional major content elements.
Mapping	Two or more observable nonlinguistic elements are encoded linguistically.
Asks for label	Asks for a noun label.
Requests repetition	Requests partner to repeat preceding utterance.
Item specification	Singles out one specific element of a preceding utterance that needs repetition or specification.
Reinforcement	Feedback confirming that the preceding utterance was linguistically acceptable.
Other	No recognized strategy or technique or those for which no category exists in the present system.
Uncodable	Includes simple exclamations, "yes" or "no" responses referring to the truth value of utterances, and gaps in the transcripts.

[a] A slash indicates that the specific code had a different meaning for the mother and the child. The meaning for the mother is stated before the slash and that for the child after it. The child's conversation partner was mostly her mother, but rarely the father or one of the observers joined in with a few remarks that were also coded. Sections with only the observers or the father as communication partner were excluded from the analysis because the goal was to analyze mother–child interactions.

Details of the procedures are described in Moerk (1983b, pp. 13–18). For each utterance identified, up to three techniques or strategies were recorded. The codes were recorded sequentially for all the approximately 10,000 utterances of mother and child.

For the present report, the 40 "maternal teaching techniques" and the 38 "filial learning strategies" that were defined on the basis of the recorded interactions are focused upon. The categories were generated in a two-step sequence. First, categories used in the earlier literature were culled. Brown's own work (e.g., Brown & Bellugi, 1964) and especially Weir's (1962) careful descriptions of the bedtime monologues of her son provided valuable sources. This pool of categories was then elaborated, refined, and ordered into diverse subsets in extended interactions with the available data and with the two coders. Conceptual clarity (and therewith high interrater reliability), categorical distinctiveness, and relative exhaustiveness were the major criteria for the final inclusion of a category in addition to its hypothesized theoretical importance. Moerk (1983b) provides extensive descriptions of the wide variety of categories and the solution of some of the coding difficulties. Those codes that will appear in the Results section are summarized briefly and defined in Table 1.

From these recorded codes, frequencies of single codes, diverse two-step sequences, and many three-step sequences were established and were subjected to diverse analysis. In the present report, those three-step sequences that are most relevant to the three-term contingency pattern of behavioral theory will be discussed. For each sequence, the question arises whether it is merely a random sequence or if a pattern of interaction is reflected in it. To differentiate these alternatives, both observed and expected frequencies will be presented in the tables of the Results section. Based upon Markov-chain conceptualizations, the expected frequencies are obtained by multiplying the three unconditional probabilities of the categories with each other and with the total number of triple sequences (51,766 in the case of Eve and her mother). That is, $F(\text{exp}) = (p/i)(p/j)(p/k)(N/3)$. It will be seen in the tables that the observed frequencies are generally so far above the expected ones that it is obvious that the sequences are patterned and not random. Significance levels will therefore not be given and their

computation will not be discussed here. This was done in Moerk (1983b).

Because the sequences are patterned and temporally ordered, a preliminary cause–effect interpretation is justified. The interpretation must remain preliminary because proofs are not yet provided as to the absence or the comparative unimportance of higher order transitional dependencies. That is, Item B in one of the presented three-step A-B-C sequences could, in principle, have been caused or elicited by one or more items that systematically preceded Item A. At present, interactional plausibility will be combined with quantitative evidence to substantiate the interpretations. Certainly in conversations, the response relates mostly to the preceding utterance of the partner and not to some utterance that occurred previously. It will be a task of future analyses to fully differentiate hetero- from auto-correlation or dependency.

Although the three-term relationships to be presented derive from the same extensive analyses that were presented selectively in Moerk (1983a, 1983b, 1985a, 1985b), the specific contingency patterns have not yet been reported. In the overall project, 40 categories of training and 38 categories of learning for the adult and the child, respectively, had been differentiated. All possible combinations of these 78 categories in three-term sequences result in 474,552 (78 to the third power) possible unique patterns. In the analyzed samples, 45,530 examples of three-term patterns were encountered. Only an extremely small selection of these patterns has been presented in previous studies, and they had been selected from a structural perspective. In the following analysis, the selection is based on functional perspectives and results in different sets of three-term contingency patterns.

The three-term functional relationships that were chosen for presentation are a somewhat arbitrary product of the analytical approach, just as the stimulus–response–reinforcement pattern is an artifact of the experimental design. In both cases, continuous streams of behavior are encountered and dissected into the three-unit sequences of interest. Especially in the case of language transmission and acquisition, a deviation from continuous-time analyses results in arbitrary selections of training/learning episodes, and it can lead to the loss of important evidence. Moerk (1990b) has argued for and demonstrated the value of continuous-time analyses for the recording of first massed and then increasingly spaced rehearsals, for the generalization or delimitation of stimulus and response classes, and for the demonstration of gradually increasing learning. Some indications of this continuity of processes found in continuous-time analyses will be given below. Its exhaustive presentation would, however, result in a much more extensive report.

RESULTS

Two major topics are emphasized in the three-term contingency patterns to be presented: (a) reinforcement, which is denied or at least disregarded in much of the psycholinguistic literature, and (b) maternal "expansions," which derive from an original and important observation of Brown and associates (Brown & Bellugi, 1964) but which were later neglected or incorrectly interpreted by Brown (1973). It is argued that maternal expansions, in imitating the preceding utterance of the child, indicate agreement and implicitly function as reinforcers because a master's agreement with an apprentice as to the latter's production is a positive experience for the apprentice. Expansions, by adding elements that were omitted, however, also show where the child made mistakes of omission. In this latter perspective they also fulfill a corrective function, providing the information (model) from which the child can learn the correct form. In skill-learning terminology (Moerk, 1986), the "knowledge of results" that is provided is positive, whereas the "knowledge of performance" is corrective. For each of these two topics, the child's response to the maternal feedback also will be documented.

Reinforcers and Their Consequences

In accordance with the behavioral conceptualization of the canonical three-term contingency patterns of stimulus–response–reinforcement, Table 2 presents a pattern wherein the mother produces the first utterance (stimulus), the child responds to this, and the mother provides a reward or reinforcer to this filial utterance. (The terms "mother" and "maternal" are used here because the mother was the predominant interaction partner, although the father and an experimenter infrequently participated in the conversation.)

Table 2

The three-term contingency pattern M–C–M ending with maternal reinforcement.

Mother	Child	Mother	Observed frequency	Expected frequency[a]
Vocabulary perseveration (.05)[b]	Vocabulary perseveration (.043)	Reinforcement (.029)	30	3.2
Self-repetition (.01)	Reduction (.024)	Reinforcement (.029)	20	0.4
Frame variation (.047)	Reduction (.024)	Reinforcement (.029)	19	1.7
Frame variation (.047)	Vocabulary perseveration (.043)	Reinforcement (.029)	13	3.0
Substitution (.046)	Reduction (.024)	Reinforcement (.029)	12	1.7
Substitution (.046)	Vocabulary perseveration (.043)	Reinforcement (.029)	12	3.0
Mapping (.027)	Reduction (.024)	Reinforcement (.029)	12	1.0
Substitution (.046)	Provides a label (.014)	Reinforcement (.029)	11	1.0
Morpheme perseveration (.056)	Mapping (.03)	Reinforcement (.029)	10	2.5
Asks for label (.006)	Provides a label (.014)	Reinforcement (.029)	10	0.1
Morpheme perseveration (.056)	Vocabulary perseveration (.043)	Reinforcement (.029)	10	3.6
Breakdown (.02)	Vocabulary perseveration (.043)	Reinforcement (.029)	9	1.3
Breakdown (.02)	Reduction (.024)	Reinforcement (.029)	9	0.7
Expansion (.038)	Mapping (.03)	Reinforcement (.029)	8	1.7
Frame variation (.047)	Mapping (.03)	Reinforcement (.029)	8	2.1
Substitution (.046)	Mapping (.03)	Reinforcement (.029)	8	2.1
Expansion (.038)	Reduction (.024)	Reinforcement (.029)	7	1.4
Asks for label (.006)	Vocabulary perseveration (.043)	Reinforcement (.029)	7	0.4
Item specification (.02)	Mapping (.03)	Reinforcement (.029)	7	0.9
Transformation (.037)	Reduction (.024)	Reinforcement (.029)	7	1.3
Expansion (.038)	Provides a label (.014)	Reinforcement (.029)	6	0.8
Vocabulary perseveration (.05)	Self-repetition (.016)	Reinforcement (.029)	6	1.2
Frame variation (.047)	Chaining (.006)	Reinforcement (.029)	6	0.4
Buildup (.018)	Vocabulary perseveration (.043)	Reinforcement (.029)	6	1.1
Transformation (.037)	Vocabulary perseveration (.043)	Reinforcement (.029)	6	2.4
Expansion (.038)	Vocabulary perseveration (.043)	Reinforcement (.029)	6	2.5
Self-repetition (.01)	Self-repetition (.016)	Reinforcement (.029)	5	0.2
Self-repetition (.01)	Vocabulary perseveration (.043)	Reinforcement (.029)	5	0.6
Frame variation (.047)	Provides a label (.014)	Reinforcement (.029)	5	1.0
Uncodable (.029)	Vocabulary perseveration (.04)	Reinforcement (.029)	5	1.7
Vocabulary perseveration (.05)	Mapping (.03)	Reinforcement (.029)	5	2.3

[a] Expected frequencies = $(p/j)(p/k)(p/l)(N/3)$.

[b] The numbers in parentheses are the simple or unconditional probabilities of occurrence of each specific category.

Reward and reinforcer are conceived in the sense of Thorndike (1911) and his law of effect and are operationally defined as a maternal "yes," "yeah," "right," or an equivalent response. This response class is considered to have rewarding functions because a confirming "yes," uttered by the accomplished partner of an interaction that confirms a production of the apprentice is generally judged as conveying a positive, rewarding message. It can best be conceived as conditioned reinforcement.

The patterns are presented by using the key terms introduced in Table 1. Only those patterns are presented whose occurrence reached or surpassed a frequency of five. The observed and expected frequencies of each pattern are given in the rightmost columns. The formula for the computation of the expected frequencies is given in the note to Table 1. It is obvious that most of the observed frequencies greatly surpassed those expected by chance. It is not necessary to discuss each of the listed patterns. The general dynamics, as well as the specific training/learning principles, are apparent in Table 2. Many linguistic skills are first modeled by the mother; they are more or less directly imitated by the child and rewarded by a maternal "yes" or a closely equivalent reinforcing response. In accordance with the age and early stages of Eve's language acquisition, vocabulary training is still predominant, but many grammatical exercises are also encountered, with a strong emphasis on basic syntactic training: frame variation, substitution, mapping, breakdown, transformation, and buildup. In the domain of morphology, Eve omits most

Table 3

Three-term contingency patterns encompassing the child's response to maternal reinforcement.

Child	Mother	Child	Observed frequency	Expected frequency[a]
Vocabulary perseveration (.043)	Reinforcement (.029)	Vocabulary perseveration (.043)	17	2.8
Vocabulary perseveration (.043)	Reinforcement (.029)	Buildup (.027)	12	1.7
Vocabulary perseveration (.043)	Reinforcement (.029)	Self-repetition (.016)	9	1.0
Provides a label (.014)	Reinforcement (.029)	Buildup (.027)	9	0.6
Reduction (.024)	Reinforcement (.029)	Buildup (.027)	8	0.9
Provides a label (.014)	Reinforcement (.029)	Provides a label (.014)	6	0.3
Reduction (.024)	Reinforcement (.029)	Mapping (.03)	6	1.1
Reduction (.024)	Reinforcement (.029)	Reduction (.024)	5	0.9
Reduction (.024)	Reinforcement (.029)	Other (.025)	5	0.9
Substitution (.03)	Reinforcement (.029)	Breakdown (.021)	5	0.9
Buildup (.027)	Reinforcement (.029)	Breakdown (.021)	5	0.9

[a] Expected frequencies = $(p/j)(p/k)(p/l)(N/3)$.

[b] The numbers in parentheses are the simple or unconditional probabilities of occurrence for each specific category.

minor functors ("function words") in her reductions, indicating to her mother that she is not yet ready for the training of bound morphemes. The maternal categories of morpheme perseveration and expansion therefore occur less often than in a more advanced child (e.g., Adam, the 2nd subject of Brown).

Only a partial set of interaction patterns containing reinforcers or rewards is rendered in Table 2. To provide a more comprehensive impression of the frequency of this type of reinforcement, the total number of this type of maternal rewards ($N = 474$, counted in the 20 hours observed) needs to be taken into account (cf. Moerk, 1983b, for more extensive discussions). It will be argued below that other types of reward have to be added. But even this preliminary number indicates that almost 25 instances per hour (close to one every 2 min) of "yes" and equivalent responses are provided by adults, a considerable number of instances of positive feedback.

Although highly informative, Table 2 omits the aspect that is most interesting from a behavioral language-learning perspective. The term *reinforcement* in the Skinnerian sense indicates that the probability of the filial response class should be increased. To reproduce a rather complexly structured response that obviously cannot be innate, the child necessarily had to learn it, and the response of the child to the maternal reward is therefore critical. Table 3 provides a quite restricted impression of this phenomenon. It is restricted for a reason that becomes apparent only when longer streams of interaction are studied: First, a maternal "yes" often has the function of concluding a brief interaction episode, leading to a new topic or to a nonverbal response. The effect of the preceding learning and of the reward therefore becomes apparent only after several turns of the interaction partners. It cannot be seen in short first- and second-order Markov chains. Longer patterns, or even better, continuous-time analyses are needed to capture those longer interval effects.

Despite this limitation, the data in Table 3 provide considerable indication of the effectiveness of reinforcers and for language learning. In nine of the 11 three-term patterns, Eve repeats part or all of her rewarded utterance, which can be vocabulary items or the antecedent sentence. For syntax learning, buildups are of special interest, because they indicate that the child produced a more complex sentence in adding to a previous utterance. Clark (1974) has described similar instances in which her daughter used elements from a modeled sentence together with spontaneous productions to produce complex utterances that she could not have produced by herself. Even used the same procedure interspersed with breakdowns and encodings of immediately given perceptual nonverbal information (i.e., mapping). Combining buildups with breakdowns or reductions, synthetic and analytic syntactic exercises are captured in most of the patterns (cf. Moerk, 1985a).

Table 4

Maternal corrective and accepting feedback completing three-term contingency patterns.

Mother	Child	Mother	Observed frequency	Expected frequency[a]
Vocabulary perseveration (.05)[b]	Vocabulary perseveration (.043)	Expansion (.038)	18	4.2
Morpheme perseveration (.056)	Vocabulary perseveration (.043)	Expansion (.038)	13	4.7
Item specification (.02)	Mapping (.03)	Expansion (.038)	13	1.2
Frame variation (.047)	Mapping (.03)	Expansion (.038)	12	2.8
Substitution (.046)	Reduction (.024)	Expansion (.038)	11	2.2
Asks for label (.006)	Provides a label (.014)	Expansion (.038)	11	0.5
Expansion (.038)	Mapping (.03)	Expansion (.038)	10	2.2
Expansion (.038)	Reduction (.024)	Expansion (.038)	9	4.0
Substitution (.046)	Substitution (.03)	Expansion (.038)	9	2.7
Frame variation (.047)	Vocabulary perseveration (.043)	Expansion (.038)	9	4.0
Substitution (.046)	Buildup (.027)	Expansion (.038)	8	2.4
Transformation (.037)	Mapping (.03)	Expansion (.038)	8	2.2
Item specification (.02)	Substitution (.03)	Expansion (.038)	8	1.2
Transformation (.037)	Reduction (.024)	Expansion (.038)	8	1.7
Expansion (.038)	Buildup (.027)	Expansion (.038)	8	2.0
Mapping (.027)	Reduction (.024)	Expansion (.038)	8	1.3
Requests repetition (.008)	Self-repetition (.016)	Expansion (.038)	8	0.25
Reinforcement (.029)	Buildup (.027)	Expansion (.038)	7	1.5
Requests repetition (.008)	Substitution (.03)	Expansion (.038)	7	0.5
Vocabulary perseveration (.05)	Substitution (.03)	Expansion (.038)	7	2.9
Mapping (.027)	Vocabulary perseveration (.043)	Expansion (.038)	7	2.3
Other (.027)	Other (.025)	Expansion (.038)	7	1.3
Transformation (.037)	Vocabulary perseveration (.043)	Expansion (.038)	6	3.1
Breakdown (.02)	Vocabulary perseveration (.043)	Expansion (.038)	6	1.7

[a] Expected frequencies = $(p/j)(p/k)(p/l)(N/3)$.

[b] The numbers in parentheses are the simple or unconditional probabilities of occurrence for each specific category.

Rewards Combined with Corrections and Their Impact

Maternal expansions will be the focus of the next section. These are utterances that repeat a preceding filial utterance, retaining close topographical similarity in the major constituents but adding items that were omitted by the child. They thus fulfill a double function: The imitative repetition is rewarding, but the insertion of omitted elements is simultaneously corrective and informative as to the standard form of the utterance. Study of the actual transcripts shows, however, that in the early stages the predominant aspect is the maternal agreement, that is, the rewarding aspect. For the young child, the minor and unstressed morphemes that are provided in expansions will probably often constitute only a background sound pattern and are only gradually analyzed and incorporated into her speech. The important information is again sufficiently contained in Table 4 and does not need to be repeated. Homologies in the first two elements of the patterns in Table 4 and of those in Table 2 are obvious as well, indicating the equivalence of the third element (the reward) and thereby of the entire pattern.

From the perspective of language learning, which has focused largely on the controversy of syntax acquisition, the frequent occurrences of mapping in the second position of this three-term contingency pattern are of considerable importance. Mapping refers to the child's encoding of environmental relations and events in syntactic form—a complex tact in Skinner's terminology. The mother approves and improves this filial construction by repeating and expanding it in Step 3 of the contingency pattern. Analyses in Moerk (1983b) showed that mapping followed by expansion is the third most frequent (n = 100) two-step pattern in child–mother (C–M) sequences, and mapping followed by reduction (n = 58) in mother–child (M–C) patterns is the second most frequent two-step M–C interactional structure. Both are significantly above chance in their transitional probabilities. The interactional/instructional meaning of these sequences is as follows: If the child originally encodes the environmental givens in a sentence, the mother

repeats and improves it. If the mother models the encoding of environmental configurations, the child repeats it. Mapping–reward sequences in the C–M pattern follow closely in frequency (n = 86) and structural tightness, again showing the equivalence of the maternal reinforcement categories of expansion and reward. Combinations of these patterns, such as mapping–reduction–reinforcement and expansion–mapping–reinforcement (Table 2) reflect closely related dynamics.

The frequent substitutions and several instances of buildups in the child's responses, as well as the substitutions and the breakdowns in maternal models (seen in Table 4), reflect further learning processes. It must be added that maternal substitutions, buildups, and breakdowns are common in the transcripts. All of these patterns are exercises that exhibit the internal structure of utterances or sentences. They demonstrate possibilities of combining elements, of breaking larger utterances down into rather independent constituents, or they clarify the slot-and-filler principle of syntax. These constructive syntactic exercises, which the child engages in frequently and the mother rewards and improves, account for learning of syntax a good deal more easily than Chomskyan nativists would care to admit (cf. Moerk, 1990b).

Focusing on the first element of the three-term contingency pattern that contains mapping in the middle position, another operant and training principle can be discerned. In repeated instances the mother provides a discriminative stimulus in question form, inviting the child to encode environmental givens: Requests repetition, item specification, asks for label, and probably transformation (as questions) are the clearest instances. The sequential dependencies are well established (Moerk, 1983b); that is, the maternal question is an effective stimulus for the elicitation of the child's subsequent utterance. From a learning perspective, this same maternal utterance constitutes an invitation or a challenge for the child to attempt the encoding of the environmental givens (i.e., to establish an equivalence relation between nonverbal and verbal structures). Finally, an interactional operant is simultaneously a training tool, so multiple effects are achieved through one operant.

The data in Tables 2 and 4 prejudged and biased the presentation of interactional patterns to fit closely to the best known behavioral three-term contingency pattern of stimulus–response–reinforcement. As mentioned above, the verbal interactions proceed in an almost continuing flow of turns and re-turns so that other subdivisions of the flow of verbal events are plausible and have to be considered. One focus of special interest, from the point of view of first-language acquisition, centers upon possible effects of maternal corrective feedback. Effects of general maternal input have been demonstrated in Tables 2 through 4.

Approaching the verbal interactions from a teaching/learning perspective (an informational interpretation), Table 5 provides some preliminary support for the effectiveness of corrections. The findings are of great methodological and substantive interest. First, a new pattern appears in Table 5: Several sequences terminate in a filial "uncodable." Despite initial appearances, this sequence is very meaningful. To see its meaning, a third function of maternal expansions has to be specified: Maternal expansions in their rewarding function often also have a function equivalent to a period in a sentence or a pause in a conversation; that is, they conclude a verbal exchange. An example will clarify it best:

M: "What is the child doing?"

C: "Running."

M: "She is running." (Uttered with a falling intonation to indicate agreement.)

Very similar considerations apply also to maternal feedback of "yes" or "yeah." In both cases, multifunctionality of a single utterance is encountered, and the multiple functions apply to different levels of description: the reward on the motivational and instructional level, the conclusion of an episode on the stylistic and interactional level, and the corrective function on the instructional level. The question and challenge to be raised for the behaviorist is whether all these levels can be described efficiently with the conceptual tools derived largely from nonhuman experimentation.

The more obviously instructional function of maternal expansions is frequently encountered in the data of Table 5. In most cases Eve repeats either a syntactic structure or at least a vocabulary item (i.e., the patterns represent instances of double or triple rehearsal). Often the first filial turn was already a rehearsal, as in vocabulary perseveration, substitution, buildup, breakdown, and reduction. The

Table 5

Filial responses to maternal correcting acceptance.

Child	Mother	Child	Observed frequency	Expected frequency[a]
Mapping (.031)[b]	Expansion (.038)	Mapping (.031)	13	1.9
Vocabulary perseveration (.043)	Expansion (.038)	Uncodable (.035)	12	3.0
Vocabulary perseveration (.043)	Expansion (.038)	Vocabulary perseveration (.043)	11	3.6
Mapping (.031)	Expansion (.038)	Substitution (.03)	10	1.8
Substitution (.03)	Expansion (.038)	Mapping (.031)	8	1.8
Substitution (.03)	Expansion (.038)	Uncodable (.035)	8	2.1
Buildup (.027)	Expansion (.038)	Uncodable (.035)	8	1.9
Substitution (.03)	Expansion (.038)	Substitution (.03)	7	1.8
Mapping (.031)	Expansion (.038)	Vocabulary perseveration (.043)	7	2.6
Reduction (.024)	Expansion (.038)	Other (.025)	6	1.2
Other (.025)	Expansion (.038)	Uncodable (.035)	6	1.7
Reduction (.024)	Expansion (.038)	Reduction (.024)	6	1.1
Self-repetition (.016)	Expansion (.038)	Uncodable (.035)	5	1.1
Provides a label (.014)	Expansion (.038)	Buildup (.027)	5	0.75
Breakdown (.021)	Expansion (.038)	Reduction (.024)	5	1.0
Vocabulary perseveration (.043)	Expansion (.038)	Mapping (.031)	5	2.6
Mapping (.031)	Expansion (.038)	Uncodable (.035)	5	2.1
Vocabulary perseveration (.043)	Expansion (.038)	Breakdown (.021)	5	1.8
Mapping (.031)	Expansion (.038)	Frame variation (.015)	5	0.9

[a] Expected frequencies = $(p/j)(p/k)(p/l)(N/3)$.

[b] The numbers in parentheses are the simple or unconditional probabilities of occurrence for each specific category.

mother repeats this, and frequently Eve repeats all or part of the structure again. Quite often the syntactic repetitions incorporate some change, such as substitutions, buildups, or breakdowns, wherein the child explores the internal constituent structure of the utterance. They also often incorporate information provided in the mother's Expansion. Extensive analysis of syntax learning (Moerk, 1985a, 1985b, in press) has shown that Eve's analytical or synthetic exercises in turn are based on preceding maternal models and feedback.

The contingency patterns encountered in Table 5 also support the motivating character of the maternal expansion. It induces the child to continue with identical or very similar verbal behavior, which in turn will receive positive feedback in most instances. A preliminary estimate of maternal positive feedback, including most maternal imitations and the instances of "yeah" or "yes" as exemplified in Tables 2 and 3, results in about 2,000 items in 20 hr or close to two per minute.

DISCUSSION

Only the most central concerns pertaining to first-language acquisition will be discussed briefly. First, the potential of fully empirical, behavioral, and functional analyses of verbal behavior in exploring first-language acquisition has been illustrated here. These empirical analyses demonstrate that Chomsky's (1959) assertion about the presumed lack of stimulus control in speech is factually incorrect in the case of children learning language. If Chomsky had considered even briefly the extensive evidence on imitation, he would have known this in the absence of any empirical research of his own. Transitional probabilities between maternal and filial utterances surpass those expected by chance as do their significance levels (Moerk, 1983b, pp. 67 and 69). Additional learning principles, such as input frequency (Moerk, 1980), rewards (Moerk, 1983a, 1983b), massing versus spacing (Moerk, 1990b), or corrections (Moerk, in press) can easily be demonstrated when using continuous-time and contingency-based methodologies.

Well-known evidence shows that filial utterances are mostly topographically dependent on parental models and are also influenced by parental feedback. The first aspect is partially captured in Skinner's "echoic behavior" and the establishment of an "echoic repertoire." The facts of input and feedback together seem to be captured more adequately by a social-

learning approach as developed by Bandura (e.g., 1976, 1986) and as applied to language by Whitehurst and associates (e.g., Whitehurst & De Baryshe, 1989). With the Bandurian terms of *modeling* and *imitation* and social-learning principles, additions to the strictly behavioral principle of reinforcement are suggested. Certainly no major difficulty should exist, because a conceptualization of "generalized imitation," as argued by Baer and Sherman (1964), or Skinner's "echoic response set" can be employed quite easily as an explanatory principle. It is evident from cursory reading of the transcripts that many reinforcers are provided for Eve's diverse imitations so that such a generalized tendency readily could have been learned.

The maternal verbal models provide more for the child than just the discriminative stimulus to emit a response. As seen in Table 2, they also model the topographical structure of the response that the child will produce. Because an impressive variety of linguistic information is contained in the maternal models (always in their relationships to preceding utterances that were not included in Table 2) an equally impressive range of opportunities for observational learning and for the analysis of intrautterance structure and interutterance relationships is provided. In the child's imitations, this information is reconstructed in productive trials.

Although the term *information* is not typically used in behavioral analyses, this should be mainly a terminological discrepancy. The concept of *discriminative stimulus* entails a subset of informational aspects. The present discussion emphasizes the same discriminative stimulus, but its structural as opposed to its functional aspects. Many questions of stimulus structure and perceptual learning (e.g., Gibson, 1979) are entailed in this domain. The same applies to the field of language comprehension. Few conceptual tools have been found in the behavioral literature that deal with these questions, because this literature is, obviously, concerned mostly with behavior and not with the processes of perception.

In general, Skinnerian conceptions, being derived from operant conditioning of nonverbal animals, are only minimally focused on the perceptual learning of behavioral structures and even less on the feedback cycles between two communication partners. Skinner's (1957, p. 60) description of an echoic operant as a product of random trials does not seem to reflect the facts found in mother–child interactions.

A conceptual system and a field of research exist, however, that appear ideal to bridge and integrate the perceptual learning and behavioral learning positions. This is the field of skill learning (e.g., Holding, 1981; Sage, 1984). Skills are a type of purposive behavior; they are functional, and they are trained, learned, and executed contingently in feedback patterns with the animate and inanimate environment. Because skills consist largely of acquired behavior, their investigation transcends Skinner's emphasis on "emitted behavior" and includes a strong focus on perceptual learning. Nonverbal skills, as well as language, require motivation for their acquisition and reward for their maintenance. Behavioral approaches are central to this aspect. Frequency of rehearsal, discrepancies between performance and standards, and schema abstraction (Schmidt, 1975) are important features of skill learning and skilled performance. They represent a transition to cognitive learning approaches. Skill theory, therefore, bridges the chasm between behaviorism, cognitivism, and linguistic emphases on syntactic structure. The insights derived from this field can be applied to first-language transmission and acquisition (Moerk, 1986, 1990b) in a straightforward manner. As Moerk (1990a) has argued, when seen from a broader perspective, the differences between the cognitive and behavioral paradigms are more terminological than substantive. Together with Powell and Still (1979) and Tweney (1979), a fruitful integration of various theoretical perspectives is considered necessary for the explanation of both the functions and structures of language.

With reference to skill learning, the preliminary nature of the above factual and theoretical analyses must be confronted. These analyses deal mainly with processes that could lead to lasting learning, but they have not yet demonstrated learning as it proceeds over extended periods. Summary data of frequencies and probabilities, as presented in the above tables, show neither an increase in probabilities nor changes in the verbal products. Only longitudinal data could do this. It follows that the

effectiveness of these training/learning procedures still needs to be demonstrated. This has been done in a forthcoming publication (Moerk, 1990b) and cannot be repeated here in the space available.

The present report had different goals: Because acquisition processes must occur before products, this report analyzed interactional training and learning processes that are revealed in two ways. First, the child's responses to the maternal utterances often incorporated linguistic improvements that had been modeled by the mother. Second, the fact that the transitional probabilities surpassed chance implies a preceding learning history. This is, of course, the central point of behavioral conceptions, namely, that the ties between stimulus and response classes had been reinforced.

With one cross-section through a child's developmental course, even if it is almost 1 year long, only parts of the learning process can be captured. The complex iterative relationships between functional learning (as expressed here in increased contingencies), and structural learning (linguistic skills) still require extensive elaboration. Complex multivariate and longitudinal studies must be performed to achieve this. A forthcoming publication (Moerk, 1990b) has proceeded a few steps further in this direction. The entire research program that was begun by this writer in 1972 is aimed toward the same goal.

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