Sequential Analyses, Multiple Controlling Stimuli, and Temporal Patterning in First-Language Transmission

Ernst L. Moerk
California State University, Fresno

Although inferences of causality from contingencies are problematic, as Hume argued, and are difficult to prove empirically, explanatory accounts of normal language acquisition and all remedial interventions rely on presumptions of environmental effectiveness. Careful sequential analyses of verbal behaviors can strongly corroborate dependencies by means of establishing either (a) contiguous contingencies or (b) topographical resemblances between antecedents and delayed consequences that could not be explained without assuming such dependencies. The promises, as well as the methodological and conceptual challenges, of such sequential analyses of verbal training and learning are exemplified on the basis of mother–child interactions. Concomitant variation over shorter and longer intervals, and immediate as well as lagged contingencies, are interpreted as indicators of dependency relationships. By focusing on behavioral evidence, extensive similarities or even homologies between first-language training and learning and basic behavioral principles established mostly through nonhuman research can be demonstrated. Nevertheless, expansions and innovations in the behavioral repertoire are suggested as conducive to mutual enrichment of the two fields of the experimental analysis of behavior and first-language acquisition.

This paper is a further attempt at bridge building across the apparent chasm between behavior analysis and first-language acquisition research. The discourse during which language skills are transmitted and acquired might appear to be a domain wherein contingencies are all-predominant. Questions produce answers, models are imitated, and mistakes result rather immediately in corrections. Mastery of most items is attained only after multiple trials and mands are employed functionally. One might even think that behavior-analytic concepts would be so intrinsic to first-language research and the latter would be such a central aspect of behavior analysis that any bridge building

should be unnecessary. This is obviously not the case.

Considerable methodological and conceptual divergences remain even in integrative investigations, whereas most authors in each field seem quite unacquainted with the enrichment the other has to offer. Although an attempted integration of a mentalistic-nativistic and a behaviorist learning paradigm might be risky, the concept of incommensurability of paradigms is rejected here as an outdated legacy of the Romantic belief (e.g., Herder, 1969) that languages are unique and not fully translatable. Because languages have been shown to be fully translatable, why not translate the languages of paradigms, provided that both sides show intellectual openness and cooperation. Excellent examples of such bridge building, focusing exclusively on conceptual aspects, have been presented by Novak (1996) and Schlinger (1995). The present analysis complements them from a mainly methodological perspective. Yet, not only have both sides of an argument to contribute to the bridge building; the bridge, once

Parts of this paper were presented at the annual meeting of the Association for Behavior Analysis, May 1998, as a contribution to a symposium on Conceptual and Methodological Issues in the Analysis of Verbal Behavior, organized by Sam Leigland.

Address correspondence to the author at the Institut für Allgemeine Soziologie und Wirtschaftssoziologie, Wirtschaftsuniversität Wien, Augasse 2-6, A-1090 Vienna, Austria (E-mail: ernst.moerk@wu-wien.ac.at).

established, has to be considered a two-way street on which the "goods" of the paradigms flow freely back and forth. To increase the probability that the goods of the other system are neither unknown and therefore functionally useless nor "strange" and therefore emotionally rejected or misapplied, absolute purity of terminology is not aspired to here. Yet, careful disambiguation of the major concepts from the diverse paradigms will be attempted. Also, in this endeavor further teamwork will be needed in the long run.

This clarification will first be applied to some concepts implied and employed in the title: For sequential analyses contingencies are most central, whether they are immediate or delayed ones. A temporal pattern can only be established by establishing such contingencies. The concept of *contingencies* is central in the present conceptualization, and it will be employed in all its four functions, as specified by Catania (1998): first, as the stimulus-response contingency and the response-reinforcement contingency of the three-term contingency pattern; second in two forms of stimulus-stimulus contingencies. (a) In the case of mistakes and corrections, the contingency between the two forms of an utterance makes possible a "difference by comparison analysis" (Simon, 1978) and results in the "removal of the difference," that is, in corrected behavior. (b) Within linguistic structures, regular sequences of elements result in pattern recognition. This is most obvious for word recognition but applies also to contingencies of word categories in sentences such as *I found it, I see it, I have it* (cf. Moerk, 1992). These and similar sentences, repeated often and spaced densely, result in the abstraction of the underlying pattern (cf. Moerk, 1985). Although this type of contingency will not be strongly emphasized in the present analysis, it is found in Table 4 and is central to many aspects of learning. Once the focus is changed from words to meaning

categories as units comprising patterns, such sequential dependencies might deserve reconsideration. Lashley's (1951) argument against stimulus-response chaining could be quite easily reconciled with structural arguments based on such a learning history.

As indicated, contingencies can be contiguous in time or they can be delayed. The delays of contingencies are referred to in many other fields with the terms *lags* or *lagged contingencies*, especially in Markov-chain analysis or sequential analysis (Bakeman, 1978; Bakeman & Gottman, 1986; Sackett, 1987). When a statistician or an investigator speaks of lags, he or she refers to *observable* effects that are evident only after some interval. He or she is not presuming any magic effects across historical time but unobserved processes of perception and retention that are commonly (and admittedly metaphorically) labeled *storage* in memory research. Therefore, a lag specifies (operationalizes) a minimal level of observed retention. As the conception of lags is more paradigm and procedure neutral than that of variable intervals (VI), it will be preferentially employed in the subsequent discussions. In expert-apprentice interactions, models do not always result in immediate imitations but often do so only after weeks of repetitions. This means that contingencies are often not temporally contiguous (Lattal, 1995). After acquisition, items are employed with lags of minutes, days, and weeks; this is the evidence for and effect of long-term storage. This is Bandura's (1986) contrast between *acquisition* and *performance*.

A lag is a relational concept that can be operationalized and molecularly specified through temporal measurements. It is therefore homologous to the concepts of contingency and reinforcement in that all three are relational concepts subject to clear measurement operations. As contingency and reinforcement are indications of learning, so lags are manifestations of retention. Because retention is central in lan-

guage learning, is repeatedly tested by the expert, and is the goal of many endeavors, the term *retention* will be retained in the following sections and employed in preference to the more cognitive term *memory* or the more metaphorical *storage*. *Length of retention* is reproduction after specified lags.

The multiple stimulus control of the title is more broadly referred to as multiple causation and is especially central to the newer methods of path analysis or causal analysis. In the field of language transmission, it is especially important as one example might indicate: In the case of a mand, the child might see a chocolate bar and whine or reach for it. But the mother might respond with, "What do you say? Please give me the chocolate." And the child's verbal request, "Please chocolate," imitated after the mother's model, will be dependent on both the situational discriminative stimulus (S^D) and the topography of the maternal model.

Finally, the temporal patterning of the title includes the VI mentioned above but is broader. It also entails the massing and spacing so widely explored in skill learning (e.g., Estes, 1978), as seen in Tables 1, 2, and 4; the rather fixed patterning of contingent reinforcements (a variety of fixed-interval [FI] schedules), as shown in Table 3; and the instructionally progressive shift from simpler learning contents to more complex ones that extends over months and years, as exemplified in Figure 1. As the first-language learning process extends over 20 years in the case of higher level skills, such multiple aspects of temporal patterning are central for the understanding of cumulative and incremental achievements.

The neglect of long-term considerations has led to much confusion in theories of first-language acquisition when antecedents of performances remained unrecorded. Often, researchers were prone to argue lack of sufficient input ("poverty of the stimulus") and attribute therefore great creativity to the young child. In contrast, Moerk

(1980) demonstrated in a minor reanalysis of Brown (1973) how antecedents of a production had been overlooked due to a focus on only narrow time slots in the data analysis and how conclusions about creativity were misplaced. An extreme case of methodological and conceptual confusion is reflected in the so-called projection problem, wherein Baker (1979) argued that input provided to young children should account for adult competence; otherwise, innate knowledge would have to be postulated as an explanatory factor. It should be quite obvious that Baker "forgot" that about 20 years of intensive experience in home, school, and neighborhood intervene between the early experience and the adult competence. A factor mitigating Baker's oversight might be that nobody has as yet attempted to follow the 22-year course of language acquisition longitudinally. Not even a 1-year segment or a 1-month or 1-day excerpt has been established, recording all the input and the child's responses in their temporal contingencies. Such a study would show all the mastery attempts and all the expert feedback to these attempts. While neglecting the required molecular studies (cf. Schlinger, 1992) of environmental factors that are exemplified below, researchers fell victim to the nominal fallacy of postulating a "language organ" or a "language instinct" as explanatory factors. Chomsky (1980) even arrived at his argument by eschewing all empirical research and simply arguing that "it is difficult to *imagine* [italics added] that people capable of these judgments have all had the relevant training or experience" (p. 42). His overall emphasis on speculation ("My guess would be," "I would speculate," both p. 35) might not be a model for resolving complex questions.

In the abstract and the text, the term *training*, instead of *teaching* or *instruction*, is employed to avoid confusions that are common in first-language research. In this field, teaching and instruction are often conceived as equiv-

alent to the systematic procedures in educational settings. The argument is therefore often advanced that mothers do not perform such systematic teaching and instruction; this is a correct observation from which nativists draw the incorrect conclusion that no coaching or training is taking place. The word *training* is borrowed from skill training and learning, where it is common, as encountered, for example, in the concept of personal trainer. The conceptual model employed is that of the expert-apprentice relationship in which training and learning proceed during the shared endeavor of performing a task. In the case of language, it is the task of communicating effectively, and language learning is therefore conceived functionally.

The following analyses focus exclusively on dialogues between a mother (the "expert") and her daughter (the "apprentice") in the process of first-language transmission and acquisition. The analyses explore the contingencies of training and learning features in successive conversational turns. Methodological aspects of both short-term longitudinal and extended longitudinal analyses are emphasized together with the conceptual pitfalls resulting from methodological shortcomings. First, the complexities of the dynamics in naturalistic settings are exemplified in Table 1. Then, the challenge of capturing the intensity and temporal extension of rehearsal is demonstrated in Table 2. Table 3 exhibits not only the existence of frequent rewards and reinforcements but their patterning in an almost FI schedule to be best modeled as an event series. One aspect of syntactic training in its short-term intensity and in more extended reinstatements is exemplified in Table 4. Finally, Figure 1 extends the longitudinal perspective to approximately 1 year and suggests patterning in contents of training. With these selections, temporal spans from seconds to almost a full year are introduced as methodological challenges to each and all paradigms in psychology. These challenges suggest

that even the combined efforts of several paradigms would barely suffice to handle the complexities of everyday first-language training and learning.

THE SOURCE AND NATURE OF THE DATA

The data employed to illustrate some of the methodological challenges derive from the naturalistic interactions of one child with her mother. The child is Eve, one of the three children studied by Roger Brown's group at Harvard and often reported on (e.g., Brown, 1973; Brown & Bellugi, 1964; Brown, Cazden, & Bellugi, 1968). The period during which the recordings were taken extended over 10 months, from Eve's age of 18 months to that of 27 months. Only transcriptions were available for analysis (not the audio recordings), nor were video recordings ever made. Inferences about the dynamics are therefore somewhat restricted, because prosodic aspects might provide even clearer evidence of dependencies than merely transcribed utterances. Nonvocal factors can at best be inferred from the verbal interactions and from rare comments of the observers. These gaps in the evidence are especially important regarding reinforcing feedback (to be discussed below). A broad class of reinforcers exists in these intimate interactions, including smiles, hugs, and tone of voice, in addition to the recorded verbal agreement, praise, and imitation.

EXAMPLES AND PRINCIPLES OF INTERACTION

Complexities of Naturalistic Training Interactions

An introductory example of the conceptual and methodological challenges in exploring naturalistic language transmission that await the investigator is provided in Table 1. This vastly sub-optimal episode in the language transmission and acquisition process has been intentionally chosen as a simple

Table 1

A gradual establishment of a response.

Utter- ance	Inter- vals	Child	Mother
14		Fraydiy	
15	0		I think that was "Fraser."
17	1	Fraydiy	
19	1		Are you saying "Fraser."?
20	0		Mr. Fraser?
21	0	Fraydee	
22/23	0		Yes. That's much better.
24	2	Fraydsee	
25	0		Mr. Fraser?
26	0	Yeah	
80	53	Fraser	
81/2	0		Mr. Fraser, yes.
83	1		Mr. Fraser
84	0	Fraser	
		That?	
110	25		
111			What's that?
112			That's Mr. Fraser.
114	1	Fraser water?	
115/116	0		No, I don't think Mr. Fraser wants any water.
	0		
117	4	Oh Fraser	
122	0	. . . water	
123	0	Fraser water	
124/125			Will you ask Mr. Fraser if he'd like a drink of water?
	1		
126		Fraser water	
127			I don't think so.
128	1		Mr. Fraser has coffee.
129	0		Mr. Fraser is drinking coffee.
136	6	. . . Fraser coffee	
137/138	0		Right, that's Mr. Fraser's coffee.
172	35	Fraser hat	
173	0	Oh Fraser hat	
174			What?
175	1	Oh Fraser hat	
177			What about the hat?
178	2	Fraser hat	
179	0		Oh, Mr. Fraser's hat
180	2		Mr. Fraser doesn't have a hat.
209	28	Fraser hat	
210	0		Mr. Fraser doesn't have a hat.

example. It consists of the first 30 min (estimated) of the first recording of the verbal interactions of Eve and her mother. Eve was at that time 18 months old and was quite obviously neither a voluble conversation partner nor a specially rapid learner (although the judgment of speed of learning depends, of course, on the metric employed).

Utterance 14 reflects the first occurrence of the name "Fraser" in the recording. Obviously, the source must have been either the maternal introduction ("This is Fraser") or Fraser introducing himself. Yet this model occurred at least 14 utterances before its first effect appeared in Eve's attempted repetition as Utterance 14. As topographical matching is attempted, the antecedent is a necessary prerequisite for the performance, and the matching is an irrefutable contingency though lacking in contiguity. Table 1 shows how the item "Fraser" is repeated, with varying intervals up to Utterance 209. Eve's trials are interspersed with confirmations plus corrections provided by the mother (more of those two phenomena below). This acquisition process indicates cumulative effects of repeated trials and appears therefore to be similar to the cumulative record of experimental behavior analysis.

The first major difference between the present example and the behavioristic training of a response lies in the definition of Eve's "response." There is clearly not *one type* of response, but a working up to the response the mother deems acceptable, as shown by her confirmation, "Mr. Fraser, yes Mr. Fraser," in Utterances 80 to 82. After this first level of acceptability is attained, Eve continues with variations: "Fraser water. Fraser coffee." and "Fraser hat." A second major difference lies in the multiple influences that can be discerned as the source of Eve's utterances: Fraser was drinking coffee, Eve generalized from her own experience that it might be water; resulting in "Fraser water." The mother's clarification "Mr. Fraser has coffee" and "Mr. Fraser is drinking coffee" result-

ed in "Fraser coffee." With this response, the almost exceptional case is encountered of a contingency that is temporally contiguous, as contrasted to the common lagged contingencies. Nevertheless, even this contiguous contingency is not an identical imitation of the latest preceding maternal utterance and could be explained as based on a frame: "Fraser" plus noun. This would be a fifth form of contingency, a response-response contingency but based on an abstracted frame, coming close to what linguists describe as syntax. Finally, the sources of "Fraser hat" were as baffling to the mother as they are to later investigators. Whereas the underlying frame is the same as that of "Fraser coffee," no visual stimulus of a hat was present.

This extremely simple interactional example might have demonstrated the extreme complexity of the interdependencies in first-language acquisition. The source of an utterance can lie in immediate or longer antecedent verbal models (and often both), in visual observations, or in abstracted frames. Learned phrases or underlying frames could be combined and result in seeming "generativity" ("emitted behavior"). The relationship of this type of emitted behavior, whether employed as tact or mand, to Skinner's emitted behavior deserves careful exploration. Yet, obviously, immediate causes are combined with cumulative causes and effects of past learning so that the possibilities of combinations are almost unlimited and the dynamics are much more complex and difficult to unravel than in most experiments.

The above causal analyses are still too global to reveal clearly the training and learning process. A few selected dynamics shall therefore be focused on. In the episode from Utterances 14 to 26, a feedback process with bidirectional causality is evident. As mentioned, Eve's first attempt must have been evoked by a model; the mother's guess (Utterance 15) is evoked by Eve's trial, and Eve's subsequent improvements are certainly caused by the

three models the mother provides between Utterances 15 and 20. The mother's double reinforcer and confirmation in Utterances 22 and 23 is clearly a function of Eve's improvement and Eve's "yeah" (functioning like a colon) at the end of the episode is the "cause" of the mother's discontinuation of the immediate training episode. The last strong conclusion would not be justified by the one contingency in the table but it is supported by frequent analogous contingencies in this dyad when Eve both initiated and ended an interaction episode.

The nature of the feedback phenomena results in an unsystematic transfer of the leading and lagging roles between the interaction partners. Eve's first utterance was adult-caused, but in Utterances 14, 80, 110, and 172, Eve clearly took the lead in the interaction, whereas the term *coffee* derived again from an adult verbal stimulus, as did the improvements in Eve's enunciation of the name. This fact of mutual causation also explains the problem that puzzled linguists who are not familiar with interactional data: How could the mother know which input is necessary for the child's learning at each developmental step? The answer is found in the contingencies: The mother responds contingently and mostly contiguously to the child's often slightly faulty productions, providing constructive feedback that is one level above the child's just-demonstrated performance. Neither miraculous creativity of the child nor an omniscient mother, as postulated by some, is required to explain this calibration or fine tuning.

To abbreviate the discussion of this behaviorally so simple, but nevertheless conceptually complex, example, other types of maternal responses that in turn are causes for the child's subsequent utterances are only briefly enumerated: The mother begins with accepting corrections (and not rejecting ones—a confusion that led to extensive controversies in research on first-language transmission). She repeatedly adds rewards in the form of "Yes,

that's much better, right," or as simple imitations. From Utterances 115 and 116 on, the famous "expansions" of Roger Brown (Brown & Bellugi, 1964) come into play, which obviously teach the correct grammatical form (including both syntax and morphology) of Eve's presumed intentions. Whereas the recency position in the mother's utterances of the most important items is quite obvious ("Fraser, Fraser coffee"), the intonation contours have to be interpolated from common knowledge and partly from the transcripts: "I think that was 'Fraser.' Are you saying Fraser?" with "Fraser" clearly carrying the main stress. The massed rehearsal is so obvious as not to need analysis, as are the reinstatements with intervals extending from Utterances 26 to 80, 84 to 110, and 138 to 170.

Although the lead Eve repeatedly took in the causal relationship was emphasized above, an overall survey of Table 1 shows that Eve introduced only the word *hat* completely spontaneously. All the other utterances were in one way or another stimulus dependent—an extreme contrast to Chomsky's (1980) assertion of stimulus independence of speech. This dependence applies to the name *Fraser* as well as to the name-noun combinations, which the mother expands mostly into subject-object constructions by adding a verb and other minor elements. In turn, the common, but not universal, optimal level of discrepancy (Hunt, 1965) between the child's and the mother's utterances is also caused by or based on the child's immediately preceding utterance, which aids the mother's awareness of the child's changing capacities (Rondal, 1979). The child's nonresponsiveness to complex elements, or her partial failure when trying to respond after utterances that are too complex (to be shown in Table 4), are even clearer indicators for the mother. Multiple causation applies therefore equally to the mother and to the child.

The brief section of discourse of Table 1, extending only over some 30

min in the early stages of learning and from the earliest stages of recording, when past input had to be neglected because it was unknown, showed multiple complexities: Cumulative, multi-causal learning through feedback processes took place. Similar training and learning proceed over decades, and the methodological and conceptual challenges increase exponentially for this temporally protracted process. In contrast to Table 1, Tables 2 and 3 accord more with common approaches of research reports by focusing on one outstanding aspect each: rehearsal and reward, respectively. *Reward* in the present context could be more fittingly labeled *acceptance*, *agreement*, or *praise*; in many instances it is presented as imitation. If the mother imitates the basic elements of the child's preceding utterance, this imitation implies that the expert accepts the performance of the apprentice. Imitation in these circumstances leads, therefore, to increased production of the child's improved utterance. Often imitation and a direct acceptance, "yes," are combined, proving the equivalences.

Temporal Patterns in Rehearsals

Rehearsal phenomena in language acquisition should be explored, both as universal phenomena and in their differential use of various dyads, social classes, and cultures. Especially considering the enormous differences between social classes in input frequencies, as demonstrated by Hart and Risley (1995), relations between rehearsal and acquisition seem highly plausible. Yet, with the ideology generally hostile to learning phenomena, even basic principles are still unknown in naturalistic first-language learning research, whereas remedial training endeavors are more alert to this question. Table 2 presents some of these phenomena.

The earliest verbal exchanges in Table 2, exchanges that provide indirect evidence for the nonverbal phenomena accompanying them, show that Eve encountered (seemingly for the first time)

nuts and inquired about the label. She immediately generalized from the peeling of bananas to the peeling of nuts, and was corrected by her mother. With this correction, the training sequence of "cracking nuts" begins and ends about 500 items, or four pages in the transcript, later. The interaction is an almost ideal instance of massed training being followed by spaced rehearsals and by long-interval reinstatements (Campbell & Jaynes, 1966). Such training episodes are well explored in all skill training and learning (e.g., Estes, 1978). Massed versus spaced practice is also a common concern of behavioral approaches (Catania, 1998), although the terms *massing* and *spacing* need careful definition and will probably change in their meaning with diverse organisms, ages, and stages in the learning process. In the case of Table 2, seven repetitions by Eve of "crack nuts" within 38 utterances were supported by six maternal repetitions of the same phrase, added by a few instances of "nuts" without the verb "crack." This is a considerable density of rehearsal, whether labeled *massed* or not.

As Estes (1978) argued, an immature or cognitively unsophisticated organism might require more densely massed input in the early stages of learning in order not to forget the item to be acquired. In contrast, for a more effective learner, few repetitions might suffice for relatively long-term acquisition. Diverse degrees of massing could therefore be valuable indicators of learning *capacities*, of mastery level, and of adaptation of instruction to the needs of diverse children (supplementing or replacing IQ tests, which measure acquired knowledge).

After the initial massing, a brief break of about 10 utterances is followed by another massed episode from Utterances 52 to 70. Thereafter, the intervals become longer and the rehearsal episodes shorter. Interestingly, the mother is more consistent in her rehearsal than Eve is, a fact that accords well with Kail and Hagen's (1982)

Table 2

The introduction of two new vocabulary items: crack and nut.

Utterance	Child's Utterance	Mother's Utterance
1	That?	
2		Those are nuts.
3	peel nut	
4		You want to peel the nut?
5		Well, I'm cracking the nuts.
6	(crack) nut	
7		No. You don't know how to crack the nuts.
10	(crack) nut(s) [2×]	
11		You can't crack the nuts.
12		I'm cracking the nuts.
14		I'm cracking the nuts.
18		Would you like to have a nut? There.
19	There. crack nut.	
22		Why don't you see if the tinker toy would crack the nut.
27		Go crack it with the tinker toy.
33	(()) crack nut.	
36	Eve crack nut.	
37	crack nut.	
38		Eve's cracking the nut?
52	crack nut.	
53	(I) crack nut.	
54		Did you, did you crack the nut?
Repeated utterances	60, 62, 64, 69, 92, 98, 101, 170, 173, 175, 188, 191, 279, 282; 2pp/3pp/4pp later.	56, 57, 61, 63, 65, 68, 70, 93, 102, 171, 1972, 174, 176, 178, 180, 189, 190, 225, 240, 241, 256, 272, 273, 275, 276, 280, 283, 286, 287; 2pp/3pp/4pp later.

findings that young children below the level of elementary school generally do not rehearse vocally or subvocally when asked to remember texts. Therefore the adult needs to provide the necessary rehearsal or occasions for rehearsal. Finally, full pages of text may intervene before the phrase is reinstated; yet these reinstatements serve retention and, if produced by Eve, are evidence of retention that will be registered by the mother. When Eve takes the lead in reintroducing the phrase, as in Utterance 52, this is the clearest indicator of retention. As discussed in

the introductory section, *retention* is operationalized as production after a lag.

Methodologically, the discussed rehearsals represent an event series with gradually increasing intervals between events. If presented graphically, it would be obvious that the pattern reflects a dampened oscillation of rehearsal intensity. Every cumulative record established in learning trials is an analogue to the first section of this dampened oscillation, the massed stage. Reinstatements seem to be equivalent to maintenance rehearsal

Table 3

Intermittent rewards in verbal interactions.

Ut- ter- ance	Per- son	Str- a- tegy Tech- nique	Utter- ance	Per- son	Str- a- tegy Tech- nique
2171	1	80	2211	1	2151
2172	1	5124	2212	3	0205
2173	3	02	2213	1	256102
2174	1	50	2214	3	22
2175	3	2527	2215	1	81
2176	1	28	2216	1	02
2177	3	50	2217	1	5325
2178	1	80	2218	3	5023
2179	1	0229	2219	1	5323
2180	1	252724	2220	3	2920
2181	3	50	2221	1	80
2182	1	80	2222	1	0229
2183	3	5023	2223	3	99
2184	1	2553	2224	1	02
2185	3	02	2225	1	80
2186	1	5425	2226	1	5320
2187	3	51	2227	3	29
2188	1	0129	2228	1	80
2189	1	80	2229	1	5325
2190	1	245128	2230	3	50
2191	3	0222	2231	1	6102
2192	3	29	2232	3	2920
2193	1	6125	2233	1	5323
2194	3	02	2234	3	50
2195	1	6123			
2196	3	00			
2197	1	242825			
2198	3	0225			
2199	1	512752			
2200	1	00			
2201	1	2553			
2202	3	50			
2203	1	612740			
2204	1	5325			
2205	3	5029			
2206	1	80			
2207	1	6127			
2208	3	02			
2209	1	80			
2210	1	02			

Note. Techniques: 01—identical imitation; 02—expanding imitation; 80—rewarding/confirming feedback. Person: 1—mother; 3—child.

(Craik & Lockhart, 1972) in behavioral research. These reinstatements might be most important for retention, as the rapid forgetting after cramming for exams and the decline in most skills without continued exercise suggest. The well-known phenomenon of the loss of skills even by adult speakers in their mother tongue, if they move to a foreign country and do not use their first language, is also evidence of the need for long-interval reinstatements. The vocabulary loss in children learning their first language (the "mortality" of words) suggests lack of reinstatements and has important implications for training approaches, namely, to assure that a minimum of reinstatements are maintained even after progression to new tasks. Finally, every second-language learner is only too painfully familiar with this loss of already-mastered features without spaced rehearsals. All these practical and theoretical considerations indicate how important the phenomena are, as exemplified in Table 2.

Consistent Intermittent Rewards

Having illustrated the initially rejected and now neglected phenomenon of rehearsal, the controversial topic of reward or differential reinforcement can also be considered on the basis of event-series conceptions. As to the history of the controversy, Brown (1973) argued in his classic work that there was no evidence for differential reinforcement of syntactically correct and incorrect utterances. This denial was then unquestioningly generalized to all reinforcement. The contrary evidence provided by Moerk (1978) was met with almost complete neglect. Because the preconception against reinforcement has been effective for a quarter century, the concept of reinforcement might deserve a new hearing, considering the impressive evidence that supports it.

Table 3 consists of a randomly chosen segment of verbal interactions, presented in the form of codes only, be-

tween Eve and her mother. Very few of these codes are of interest for the present discussion. Those that are have been underlined in Table 3 and are explained in the key to the table. The reader interested in the other codes for the categories of teaching and learning behaviors is referred to Moerk (1983b), where the details of the methodology have been described. Although the label "mother" is used for Code 1 under "person," it has to be clarified that in rare instances utterances of the father or an observer were included under "mother" in order not to disrupt the dynamics of the interactions. With overwhelming predominance, however, it was the mother who interacted with Eve.

The overall sequence of the utterances, from Utterances 2171 to 2234, is arranged in a left and right field in Table 3 for ease of presentation. In each field, the utterance numbers appear in the leftmost column, followed by the codes for the person speaking, and then by the codes for strategies and techniques. Those of special interest are Code 80, reflecting straight reward or acceptance (e.g., "yes," "right," or some very similar utterance); and Code 02 plus Code 01, which stand for expanded and identical imitations, respectively. Relating these underlined codes to the utterance numbers on the left side, the phenomenon of intermittent reinforcement is quite obvious. The reinforcement is provided with a slightly varying interval schedule. The predominant intervals of the 80 codes range between 4 and 6; if the imitations are added as equivalent reinforcements, the intervals extend quite consistently over about four utterances only. These interactions strongly suggest that verbal exchanges in first-language acquisition closely reflect general laws of learning: Reinforcement for verbal behavior is consistently provided. Considering the silence in the first-language research literature on this topic, one could wonder about the invisibility of the obvious.

An exception to the regularity of re-

inforcement, apparent between Utterances 2189 and 2206, deserves a brief comment as an invitation for applied research. The verbatim transcripts indicate that a communication breakdown had occurred and that a repair sequence had become necessary. A brief glance at the code strings in Table 3 also shows that, on average, they are longer in the section between 2189 and 2206 than in the preceding and subsequent segments. Also two codes of 00, that is, "uncodable," occur. The longer strings reflect the repair work, and while this work was proceeding, reinforcements were delayed. The two codes of 00 often reflect a communication breakdown (i.e., turns not conveying any information), which logically should not be reinforced. Such stretches of nonreinforcement might not only be an important discriminative message for the children, they might also, if too frequent and too long, interfere with the motivation and enjoyment of the verbal interactions, resulting in "extinction" and "expressive language delay." If these, still preliminary, hypotheses are supported, detailed contingency analyses might provide important indicators in cases of interactional and language deficits across social classes or even within families.

Massing and Spacing in Teaching Sentence Constituents

Although cause-effect relations, rehearsals, and even reinforcements have been demonstrated in Tables 1 to 3, the counterargument could be raised that these teaching and learning processes were only shown in the context of vocabulary acquisition, including that of a proper name. Nobody has questioned that vocabulary has to be learned. Because the critical arguments in linguistic theory center on syntax training, the presented evidence could therefore easily be dismissed as unimportant for the "learnability" (Wexler, 1981) question. Table 4 and Figure 1 therefore focus on syntactic aspects. Table 4 again pro-

Table 4

Intensive teaching episodes.

S	H	Utter- ance	Speaker	Text			
7	1	2296	M/O	There's one	in	the	kitchen
		2297	M/O	There's one	on	the	counter
		2306	M/O	You have animal crackers	in	the	kitchen
7	1	2576	M/O	You have animal crackers	on	the	table
		2576	M/O	She doesn't know			
		2576	M/O	how to drink	out of	a	glass
7	1	2632	M/O	Oh, you want some	out of	the	bottle
		2692	M/O	Fraser's going to drink			
		2692	M/O	his coffee	out of	a	cup
7	1	2741	C	Baby S. drink	out		bottle
		2868	C	Baby S. drink	out		milk bottle
		2871	M/O	Babies drink	from		bottles
7	1	2872	M/O	Big people drink	from		cups
		2873	M/O	I drink my milk	from	a	cup
		2874	M/O	I drink my beer	from	a	cup too
7	1	2875	C	I drink	out ...		
		2876	C	grape juice	out (from)		cup
		2877	C	... Fraser			
7	1	2878	C	he drink coffee	out		cup
		2880	M/O	And Mommy drinks coffee	out of	a	cup too
		2881	M/O	When you are big			
7	1	2882	M/O	you drink	out of	a	cup
		2882	M/O	Look at that big girl drink	out of	a	cup
8	1	154	M/O	She can't drink	out of	a	cup
		155	C	She drink	out o'		cup
		156	C	Baby S. drink	out a		cup
8	1	157	M/O	Baby S. can't drink	out of	a	cup
		158	C	Baby S. drink	out a		bottle
		159	M/O	She drinks	out of	a	bottle sometimes
8	4	2261	C	(One)	by		Papa stool
		2262	M/O	Is there one	by		Papa's stool?

Note. M/O = mother or other; C = child.

vides verbatim evidence, but is now focused on the training and learning of a sentence constituent, the prepositional phrase (PPh).

Surveying Table 4 from top to bottom, familiar principles are again encountered, together with several new phenomena. First the massing of the PPhs *in the kitchen*, *on the counter*, *on the table* is quite immediately visible. The reader less alert to prosodic phenomena is reminded of the prosodic pattern supporting this construction. All surface forms of the PPh in Sample 7, Hour 1 (S7, H1) are based on two

trochees, each consisting of a stressed followed by an unstressed syllable. In the next examples, such as *out of a glass*, the pattern is quite similar although less regular, with final unstressed elements sometimes elided.

As the utterance numbers for the subsequent examples show, the densely massed rehearsals are soon combined with spaced ones, exemplifying again the important practice of massing and spacing in the domain of skill learning. The same utterance numbers also indicate the long lags that can occur between the model and the filial

production. For example, the model "out of the bottle" was presented by the mother in Utterance 2632, whereas Eve employed an adapted construction about 100 utterances later (2741) "Baby S. drink out bottle." Then again in 2868, Eve takes over the lead and produces spontaneously "Baby S. drink out milk bottle." With such long lags and without careful sequential analysis, the models that occurred almost 200 utterances before a specific construction could easily be missed.

From a behavioral perspective, these forms of maternal modeling and filial learning of the PPh are not surprising. Schroeder and Baer (1972) emphasized multiple exemplars in the concurrent method, combining invariants of underlying structure with minor changes in surface form, in order to train generalizations (see also Razran, 1961). Invariants over transformations are also the most central aspect of Gibson's (1979) perceptual learning theory. Eve's psychologically naive mother is therefore employing theoretical principles that are widely established in psychological research. Focusing on these invariants over transformations together with the massing indicated in Table 4, a more general consideration is in order. For English it is evident, and for other tongues it is similar, that only two basic syntactic structures exist: the copula sentence and the subject-verb-(object) sentence. (The parentheses around the "object" indicate that the object is missing in sentences with intransitive verbs.) With only two major structures, speakers cannot avoid massing them in conversation. Yet with changing contents, they can neither avoid the transformations in content being superimposed on the massed invariants of structure. In accordance with the findings of Razran (1961) as well as Schroeder and Baer (1972), common conversations are therefore almost optimal for producing generalizations. Moerk (1985) has shown how such interactions can contribute to abstractions of the underlying structures.

Because only very few investigators

Fig. 1. Long-term temporal patterns in syntactic analyses.

might (as yet) be tempted to postulate innate maternal knowledge about how to teach syntax, a question arises: Which contingencies resulted in such sophistication? The answer is simple, as Utterances 2871 to 2882 in Sample 7 and Utterances 154 to 159 in Sample 8 make clear: The mother produces repeated presentations of the same or very similar messages in order to clarify for her child practical aspects—who drinks out of what. And with this intense help, including some corrections, Eve seems to understand the explanation, at least momentarily, as shown by her spontaneously formulating the rule for her own behavior. Everyday necessities will guarantee future reinstatement if Eve should forget.

Long-Term Temporal Patterns in Syntax Training

Having demonstrated immediate and lagged contingencies (lagged only as *observed* in their effects) by means of microanalyses and, therewith, concomitant variation between training endeavors and learning success, an example of long-term concomitant variation shall be provided in Figure 1 from a macroanalytic perspective. Figure 1 covers a time span of 10 months, from the beginning of data collection, when Eve was 18 months old, to its

end, at Eve's age of 27 months. The parallel profiles reflect obviously two time series so that Figure 1 presents a bivariate time series of maternal and filial behaviors. In the endeavor to complement the earlier tables and to indicate syntactic teaching, "break-down sequences" were chosen for presentation. These are defined as repetitions of utterances wherein the subsequent utterances are shorter than the antecedent ones while still dealing with the same context. That is, elements of a preceding, more complex sentence are omitted. Therefore the sequence represents an analytical exercise, breaking a whole down into smaller parts. Moerk (1983b) explains the entire categorization scheme that was employed to capture as completely as possible the teaching techniques of the mother and the learning strategies of the child. This more complete analysis demonstrates fascinating combinations of analytical, synthetic, and abstracting strategies (see also Moerk, 1985) that can be modeled as superimposed bivariate time series with interdependent periods.

Returning to Figure 1, concomitant variation of maternal and filial frequencies is clearly evident, with the exception of the last two samples. However, this concomitant variation is largely not so much simultaneous but lagged by one step (two samples, as shown on the horizontal axis of Figure 1). The mother leads by increasing her training frequencies, and Eve, although beginning to increase her frequencies in the same sample, exhibits the full impact of the mother's lead only in the subsequent samples and maintains it briefly thereafter. Such a lead-lag relationship applies to maternal increases in frequency (in Samples 3 to 7 and 11 to 15), which Eve maintains into Samples 9 and 17 to 19, respectively. The same lead-lag relationship applies for the steep decrease in frequencies between Samples 7 and 9 for the mother and between Samples 9 and 11 for the child. How Eve responded to the second maternal decrease in Samples 17

and 19 was not recorded, but other data suggest that she would probably also have responded with a decrease and a shift to other strategies. The lagged increase is concordant with a learning perspective: If the mother models a rather new technique of handling sentences, the child would need some time to catch on and perform the same analytic activities. The same lagged sequence has been found with several other techniques and strategies, providing broader evidence for this interpretation.

The decreases in support, as seen in Samples 7 and 9 as well as in Samples 17 and 19, also fit into broader conceptual domains: Rogoff and Gardner (1984) and Moerk (1992) reported that mothers seem to test the competencies of their children by sometimes withdrawing their intensive support or their "scaffolding" (Bruner, 1983) for a brief period. The child's reaction to this withdrawal of support is then a cause for the mother's subsequent behavior. If the child's behavior declines steeply in this respect, as seen between Samples 9 and 11, the mother resumes her support again, as seen between Samples 11 and 15. In contrast, if the child can maintain her performance despite strongly diminished maternal support, as in Samples 17 and 19, the mother takes this as a sign of mastery and proceeds to new training contents (not shown). Although this interpretation is certainly somewhat premature, it is also supported by much research on everyday nonverbal skill training (Rogoff & Gardner, 1984): Parents keep quite close track of the competencies of their children (Rondal, 1979) and do not continue providing support that is not needed anymore for the accomplishment of specific tasks.

When considering Figure 1, two precautions have to be emphasized. First, 10 data points are, of course, by far insufficient to securely define a cyclical time series—a time series in the frequency domain. The form of the series could be strongly influenced by random fluctuations. Longer analyses

dealing with more instructional contents will have to be performed to increase the confidence in the pattern. The second precaution follows from the preceding one: Although all interpretations are at best hypotheses, any interpretation of evidence of questionable generality is doubly insecure. Therefore the data presented in Figure 1 and the methodology exemplified through them have to be taken only as guides for the application of sequential analyses. These precautions can be counterbalanced with a note of assurance, because Figure 1 is only one example of a wide range of similar patterns presented by Moerk (1983b, 1992). These support the interpretation of rather consistent and fine-tuned training and learning in mother-child interactions. The converging strands of evidence reveal the consistency of the interaction patterns and the justification of the preliminary interpretations. Because the present emphasis is not on the finality of a specific interpretation but on the potential of sequential methodologies, the degree of corroboration of any hypothesis is relatively secondary. Yet even tentative results show that bivariate time-series analyses are useful for the analysis of behavioral contingencies and for conceptualizing the teaching and learning processes transpiring between interacting partners. In multivariate time-series analyses, it can be shown that a maternal shift to a new training technique and content results in a similar pattern of filial increase in the subsequent period. Moerk (1992) could plausibly show such long-term processes by means of 16 bivariate time series when techniques and contents were repeatedly replaced by new ones. In the early stages of these more complex analyses of verbal behavior, analyses that should extend over many years, analytical potentials and not secure truths are important.

CONCLUSIONS

Compared to the complexity of the real-life phenomena, the examples pre-

sented above are simplifications. The verbal stimuli that children encounter are enormously rich, reaching the hundreds of thousands of sentences within a few months, as estimated by Moerk (1983a) from the actual transcripts of two of Brown's subjects, Adam and Eve. The training processes extend over about two decades, until adult competence is attained. Multiple causation is the rule, and the diverse influences precede the effects, mostly at varying intervals. Both verbal and non-verbal stimuli influence filial productions, as exemplified mainly in Table 1. Observable effects in the form of mastery might lag not only over seconds or minutes, but they might—and need to in the case of long-term learning—lag over weeks. Long lags are also necessary because more complex linguistic constructions (skills) will need to be worked up to by combining subroutines, integrating corrections, and other means. Markov-chain analyses would cover these phenomena and equivalent ones in behavior-analytic research.

In contrast to antilearnability (Wexler, 1981) and antiteachability assertions, the presented evidence shows that behavioral learning principles are applicable to language transmission and acquisition. Yet, more mutual cross-fertilization between behavior analysis and first-language learning is desirable. Only a few of the main challenges can be indicated: First of all, the length of the learning process, that is about 20 years, provides challenges for both behavior analysts and first-language investigators. Behavior analysts catch the continuity of training with their cumulative record but focus on much briefer stretches of training. First-language researchers have, in principle, covered long periods, but they did this in brief cross-sectional recordings at various ages and missed the continuity of training and learning, for which event- and time-series analyses are the methods of choice. A second challenge for behavior analysts is that verbal responses cannot be "emitted"

(in Skinner's sense of the term), but must be acquired through observational learning before they can come under control of reinforcement. As Johnson and Layng (1992) argue forcefully, "reinforcement does not establish new skills; rather it maintains behavior through a program that establishes or sharpen the skills. . . . Reinforcement can only select occasion-behavior relations or stimulus control [of] topographies that have occurred; it cannot make them occur" (p. 1486). The behavioral concepts of *shaping* and *successive approximations* (cf. Catania, 1992) seem to reflect strategies similar to what was shown in Table 1: In both shaping and the phenomena in Table 1, for example, new environmental influences are added and change previously acquired responses. Differences between the shaping of emitted responses and that of verbal behavior need, however, to be explored. In first-language acquisition the shaping occurs often by means of corrections (cf. Moerk, 1994, 1996) and quite minimally through lack of reinforcement or even punishment. Corrective feedback relies on comparisons between the child's and the expert's productions, or as Simon (1978) expressed it, differences are established by comparison and then reduced or eliminated; similarity seems to have a reinforcing function (Mower, 1958). Reduction of differences through comparison is a central training and learning strategy in all skill transmission, that is, it is an important strategy in the training of behaviors and might be an interesting conceptual challenge for behavior analysts. Also, because behavior analysts are especially skeptical about the concept of memory (e.g., Schlinger, 1992), it would be fascinating to see their analyses of expertise, whether general expertise (Chi, Glaser, & Farr, 1988) or language expertise (Moerk, 1992), without recourse to memory and storage of acquired information. The near synonymy between lags to production, retention, memory, and storage, suggested

in the introduction, deserves evaluation by experts in behavioral analysis.

Cross-fertilization, equally promising in theory and method, could also be achieved in remedial approaches. Even the brief and simple examples presented in this essay entailed sophisticated training approaches, as far as rehearsals and reinforcements were concerned, that can be efficiently described by means of behavior-analytic concepts. Comparisons between dyads, social classes, and cultural groups that explore concomitant variations between contingencies and learning outcomes, such as that between low adult responsiveness and slow language acquisition (cf. Hart & Risley, 1995; Moerk, in press, chap. 6) have, however, mainly been performed by psycholinguists. Although followers of both paradigms engage in remedial interventions, evaluations of the optimal combinations of tool sets from these paradigms are rare indeed (Warren & Kaiser, 1986). The optimal proportional contributions of each might also vary with level of performance and severity of handicap.

It can be concluded that most well-known learning phenomena are easily discernible in first-language acquisition, once appropriate sequential methods are employed. Differences in domains certainly exist: mainly the contingency learning of animals and humans versus learning of strikingly new behavioral topographies. Also, the amount of information stored, what is generally called knowledge of a language, seems to require some innovative additions to the well-established behavioral repertoire. Yet, only refinements and possibly expansions, not replacements, of concepts appear to be called for. Finally, psycholinguists would greatly profit from abandoning their denial of those learning phenomena that are so well supported in all skill, that is, behavioral learning. Because both behavior analysts and language researchers focus centrally on contingencies, they could cooperate in

adapting Markov-chain analyses more optimally to their shared domain.

REFERENCES

- Bakeman, R. (1978). Untangling streams of behavior: Sequential analyses of observation data. In G. P. Sackett (Ed.), *Observing behavior* (Vol. 2, pp. 63-78). Baltimore, MD: University Park Press.
- Bakeman, R., & Gottman, J. M. (1986). *Observing interaction. An introduction to sequential analysis*. Cambridge, England: Cambridge University Press.
- Baker, C. L. (1979). Syntactic theory and the projection problem. *Linguistic Inquiry*, 10, 533-581.
- Bandura, A. (1986). *Social foundations of thought and action*. Englewood Cliffs, NJ: Prentice Hall.
- Brown, R. (1973). *A first language: The early stages*. Cambridge, MA: Harvard University Press.
- Brown, R., & Bellugi, U. (1964). Three processes in the child's acquisition of syntax. *Harvard Educational Review*, 34, 133-151.
- Brown, R., Cazden, C., & Bellugi, U. (1968). The child's grammar from I to III. In J. P. Hill (Ed.), *Minnesota symposium on child psychology* (Vol. 2, pp. 28-73). Minneapolis: University of Minnesota Press.
- Bruner, J. (1983). *Child's talk. Learning to use language*. New York: Norton.
- Campbell, B. A., & Jaynes, J. (1966). Reinstatement. *Psychological Review*, 73, 478-480.
- Catania, A. C. (1992). *Learning* (3rd ed.). Englewood Cliffs, NJ: Prentice Hall.
- Catania, A. C. (1998). *Learning* (4th ed.). Upper Saddle River, NJ: Prentice Hall.
- Chi, M. T. H., Glaser, R., & Farr, M. J. (Eds.). (1988). *The nature of expertise*. Hillsdale, NJ: Erlbaum.
- Chomsky, N. (1980). On cognitive structures and their development: A reply to Piaget. In M. Piatelli-Palmerini (Ed.), *Language and learning: The debate between Jean Piaget and Noam Chomsky* (pp. 35-52). Cambridge, MA: Cambridge University Press.
- Craik, F. I. M., & Lockhart, R. S. (1972). Levels of processing: A framework for memory research. *Journal of Verbal Learning and Verbal Behavior*, 11, 671-684.
- Estes, W. K. (1978). On the organization and core concepts of learning theory and cognitive psychology. In W. K. Estes (Ed.), *Handbook of learning and cognitive processes* (Vol. 6, pp. 235-292). Hillsdale, NJ: Erlbaum.
- Gibson, J. J. (1979). *The ecological approach to visual perception*. Boston: Houghton Mifflin.
- Hart, B., & Risley, T. R. (1995). *Meaningful differences in the everyday experience of young American children*. Baltimore, MD: Paul H. Brookes.
- Herder, J. G. (1969). *J. G. Herder on social and political culture*. London: Cambridge University Press.
- Hunt, J. M. (1965). Intrinsic motivation and its role in psychological development. In D. Levine (Ed.), *Nebraska symposium on motivation* (pp.189-282). Lincoln: University of Nebraska Press.
- Johnson, K. R., & Layng, T. V. J. (1992). Breaking the structural barrier. Literacy and numeracy with fluency. *American Psychologist*, 47, 1475-1490.
- Kail, R., & Hagen, J. W. (1982). Memory in childhood. In B. B. Wolman (Ed.), *Handbook of developmental psychology* (pp. 350-366). Englewood Cliffs, NJ: Prentice Hall.
- Lashley, K. S. (1951). The problem of serial order in behavior. In L. A. Jeffress (Ed.), *Cerebral mechanisms in behavior* (pp. 112-136). New York: Wiley.
- Lattal, K. A. (1995). Contingency and behavior analysis. *The Behavior Analyst*, 18, 209-224.
- Moerk, E. L. (1978). Determiners and consequences of verbal behaviors of young children and their mothers. *Developmental Psychology*, 14, 537-545.
- Moerk, E. L. (1980). Relationships between parental input frequencies and children's language acquisition: A reanalysis of Brown's data. *Journal of Child Language*, 7, 105-118.
- Moerk, E. L. (1983a). A behavioral analysis of controversial topics in first language acquisition: Reinforcements, corrections, modeling, input frequencies, and the three-term contingency pattern. *Journal of Psycholinguistic Research*, 12, 129-155.
- Moerk, E. L. (1983b). *The mother of Eve as a first language teacher*. Norwood, NJ: Ablex.
- Moerk, E. L. (1985). Analytic, synthetic, abstracting, and word-class defining aspects of verbal mother-child interactions. *Journal of Psycholinguistic Research*, 14, 263-287.
- Moerk, E. L. (1992). *A first language taught and learned*. Baltimore, MD: Paul H. Brookes.
- Moerk, E. L. (1994). Corrections in first language acquisition: Theoretical controversies and factual evidence. *International Journal of Psycholinguistics*, 2, 43-72.
- Moerk, E. L. (1996). Input and learning processes in first language acquisition. In H. W. Reese (Ed.), *Advances in child devel-*

- opment and behavior (Vol. 26, pp. 182–228). San Diego: Academic Press.
- Moerk, E. L. (in press). *The guided acquisition of first language skills*. Greenwich, CT: Ablex.
- Mowrer, O. H. (1958). Hearing and speaking: An analysis of language learning. *Journal of Speech and Hearing Disorders*, 23, 143–152.
- Novak, G. (1996). *Developmental psychology: Dynamical systems and behavior analysis*. Reno, NV: Context Press.
- Razran, G. (1961). The observable unconscious and the inferable conscious in current Soviet psychophysiology: Interoceptive conditioning, semantic conditioning, and the orienting reflex. *Psychological Review*, 68, 81–147.
- Rogoff, B., & Gardner, W. (1984). Adult guidance of cognitive development. In B. Rogoff & J. Lave (Eds.), *Everyday cognition: Its development in social context* (pp. 95–116). Cambridge, MA: Harvard University Press.
- Rondal, J. A. (1979). “Maman est au courant”: Une etude des connaissances maternelles quant aux aspects formels du langage du jeune enfant. *Enfance*, 2, 95–105.
- Sackett, G. P. (1987). Analysis of sequential interaction data: Some issues, recent developments, and a causal inference model. In J. D. Osofsky (Ed.), *Handbook of infant development* (pp. 855–878). New York: Wiley.
- Schlinger, H. D. (1992). Theory in behavior analysis. An application to child development. *American Psychologist*, 47, 1396–1410.
- Schlinger, H. D. (1995). *A behavior analytic view of child development*. New York: Plenum.
- Schroeder, G. L., & Baer, D. M. (1972). Effects of concurrent and serial training on generalized vocal imitation in retarded children. *Developmental Psychology*, 11, 763–768.
- Simon, H. A. (1978). Information processing theory of human problem solving. In N. S. Endler, L. R. Boulter, & H. Osse (Eds.), *Contemporary issues in developmental psychology* (pp. 437–444). New York: Holt, Rinehart & Winston.
- Warren, S. F., & Kaiser, A. P. (1986). Incidental language teaching: A critical review. *Journal of Speech and Hearing Disorders*, 51, 291–299.
- Wexler, K. (1981). Some issues in the theory of learnability. In C. L. Baker & J. J. McCarthy (Eds.), *The logical problem of language acquisition* (pp. 30–52). Cambridge, MA: MIT Press.