The Evolution of Verbal Behavior in Children

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There is growing evidence of a developmental trajectory for key verbal capabilities. The evidence comes from research guided by Skinner's (1957) theory of verbal behavior and the accomplishment of schools based entirely on scientific practices. The broad verbal developmental fractures include: listener, speaker, speaker-listener exchanges with others, speaker as own listener (self-talk conversational units and naming), reader, writer, writer as own reader, and advanced verbal mediation. Many of the capabilities, and their subcomponents identified in the research, are higher order operants or relational frames. Our research first identified missing verbal capabilities in children, which, in turn, led to the identification and induction of pre and co-requisite repertoires. Once the missing verbal capabilities were induced in children who had been missing them, the children subsequently acquired repertoires that had not been possible for us to teach previously. We speculate on the relation of these capabilities or fractures in verbal function to linguistic, neuroscientific, cognitive and anthropological suppositions concerned with the evolution of language function in the individual's lifespan, as well as, the evolution of verbal function in the species.

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Complex language is one of the unique repertoires of the human species. Others include teaching and certain "types of imitation" (Premack, 2004), although these too may be pre or co-requisites for certain functional uses of language. Over the last 40 years linguists have contributed theories and evidence about the structure of language (Chomsky, 1959; Chomsky & Place, 2000, MacCorquodale, 1970; Pinker, 1999). Neuroscientists have identified neurological correlates associated with some aspects of language (Deacon, 1979; Holden, 2004). Behavior analysts have focused on the source of and controlling variables for the function of language as behavior per se (Catania, Mathews, & Shimoff, 1990; Greer & Ross, 2004; Michael, 1984; Skinner, 1957).

More recently, scholars have come to view human language as a product of evolution; "Linguists and neuroscientists armed with new types of data are moving beyond the nonevolutionary paradigm once suggested by Noam Chomsky and tackling the origins of speech head-on." (Culottes & Brooks-Hanson, 2004, p. 1315). This work focuses on the evolution of both non-oral motor and oral components of speech (Deacon, 1997; Holden, 2004), although some arguments are characterized necessarily more by theory than data.

Despite the evidence that primates and pigeons can be taught certain features of verbal behavior (Epstein, Lanza, & Skinner, 1980; Premack & Premack; 2003; Savage-Rum Baugh, Rumbaugh, & Boysen, 1978), the speaker as own listener repertoire makes complex verbal behavior possible and this may be what is most unique about human verbal functions (Barnes-Holmes, Barnes-Holmes, & Cullinan, 2001; Lodhi & Greer, 1989; Horne & Lowe, 1996). Some suggest that oral communication evolved from clicking sounds to speech sounds, and they site the extant clicking languages (Pennisi, 2004). It is likely that sign language and gesture predated both vocal forms; but it is the evolution of the spoken and auditory components of language that are seen as critical to the evolution of language. Some of these include changes in the anatomy of the jaw—modern humans have more flexible jaws than did Neanderthals. Also, the location of the larynx relative to the trachea is different for humans, and this anatomical feature made it possible for the modern human to emit a wider range of speech sounds (Deacon, 1997). The combination of these anatomical changes together with the identification of separate, but proximate, sites in the brain for speaking, listening, and imitation seem part of what made spoken language possible (Deacon, 1997). The presence of these anatomical and physiological properties made it possible for the evolution of verbal functions through the process of cultural selection (Catania, 2001). The functional effects of speech sounds acquired by their consequences are provided within the verbal community. This latter focus is what constitutes the subject matter of the study of verbal behavior.

The new foci on language, as an evolved anatomical and physiological capacity, does not necessarily suggest the existence of a universal grammar; nor, in fact, does it eliminate the possibility of an evolved universal grammar. Some of the linguistic neuropsychological searches for an evolved universal grammar now follows the PET and MRI trails for discovering blood flow associated with the speech and hearing centers in the brain (Holden, 2004). Interesting and as important as this work may be, little of that work, if any, is devoted to the function of language as behavior per se. Nor is it concerned with the biological or cultural evolution of verbal function in our species or in the lifespan of the individual, although anthropological linguists point to functions as the initial source. Only the research associated with Skinner's (1957) theory of verbal behavior as behavior per se, and expansions of the theory by contemporary behavior analysts, provides the means for analyzing how cul-

tural selection gave rise to the function of language (Greer, 2002; Greer & Ross, in press; Hayes, Barnes-Holmes, & Roche, 2000; Lowe, Horne, Harris, & Randle, 2002). Currently, the linguistic, neuropsychological work, and the behavior analytic foci remain separate sciences, though they need not remain so (Catania, 1998).

From Theory to Research

Although Skinner's work is often described as a theory, there is now a body of research supporting and expanding the theory. While a large portion of the literature on verbal behavior has been theoretical, we have identified over 88 experiments devoted to testing the theory, not including the significant body of related work in relational frame theory that includes at least an equal number of studies (Hayes et al., 2000). In our program of research in verbal behavior, we have completed approximately 44 experiments and a number of replications. Our particular research program was occasioned by our efforts to develop schools that provide all of the components of education based solely on teaching and schooling as a scientific endeavor. While the existing work in the entire corpus of behavior analysis provided a strong foundation for a science of schooling, much was still missing. Cognitive psychology offered a plethora of theories and findings, and when they were germane to our efforts, these findings proved to be operationally synonymous to those identified in behavior analysis. However Skinner's (1957) Verbal Behavior showed the way for a research program to fill in much of what was missing in a manner that allowed us to operationalize complex cognitive repertoires.

In our commitment to a thoroughgoing scientific approach to schooling, we needed functional curricula that identified repertoires of verbal operants or higher order operants. Our efforts involved using the pre-existing conceptual and applied verbal behavior research, identifying the needs of children who were missing certain repertoires, and identifying the validity of untested components of Skinner's theory through new experiments done by others and us. Through this process, we have been able to meet real educational needs, or at least the most pressing needs—the recognition of which were missing in the existing science of behavior or cognitive psychology. Of course, these educational voids were also apparent in normative practices in education based on pre-scientific approaches that treat teaching as an art. We needed findings that worked in the day-to-day operation of our schools, if we were to educate the "whole child." Along the way, we discovered some interesting aspects of verbal behavior that may prove useful to a behavioral developmental psychology (Baer, 1970; Bijou & Baer, 1978; Gewirtz, Baer, Roth, 1958; Gewirtz & Pelaez-Nogueras, 1991).

Repertoires of Verbal Behavior for Instructional Purposes

First, applications of the research findings in verbal behavior in our CABAS schools led to the categorization of children for instructional purposes according to levels of verbal behavior that we extrapolated from Skinner's analysis of the different components of verbal behavior (Greer, 2002). [1] While traditional diagnoses, or developmental constructs are useful for some inquiries, they are not very useful for instructional purposes. However, the identification of the functional verbal capabilities of children that we extrapolated from Skinner's work was very helpful. Skinner described the different verbal repertoires of the speaker and the relation of the speaker and listener in terms of typically developing individuals. These repertoires seemed to constitute what individuals need to possess if they are to function verbally, and those verbal functions provided operational descriptions for most of the complex educational goals that had been prescribed by educational departments throughout the western world (Greer & Keohane, 2004). For educational purposes, the categories or stages provided us with behavioral functions for a curriculum for listening, speaking, reading, writing, and the combinations of these that made up complex cognitive functions.

The verbal categorization proved useful in: (a) determining the ratio of instructors to students that would produce the best outcomes for the students (Table 1), (b) identifying what existing tactics from the research worked for children with and without particular verbal capabilities (See Greer, 2002, Chapters 5 and 6), what specific repertoires children could be taught given what each child initially brought to the table, and a curricula composed of functional repertoires for complex human behavior.

Most importantly, the categories identified specific verbal capabilities we needed to teach, if we were to make real progress with our children. The categories provided a continuum of instructional sequences that provided a functional approach to cognitive academic repertoires, and the recasting of state and international educational standards into functional repertoires of operants or higher order operants rather than structural categories alone (Greer, 1987, 2002; Greer & McCorkle, 2003). Each of the major verbal categories also identified levels of learner independence (i.e., operational definitions of autonomy) as well as what we argue are valid measures of socialization. Table 1 lists the verbal stages as we have related them to independence and social function.

[1] For information on and the evidence base for teaching as a science in CABAS schools and the CABASÒ system see Greer (2002), Greer, Keohane, & Healy (2002), Selinski, Greer, & Lodhi (1991), and www.cabas.org. The findings of the research we describe have has been replicated extensively with children and adolescents in CABASÒ Schools in the USA, Ireland, Argentina and England and we believe they are robust. A book that describes the verbal behavior research and procedures in detail is in progress for publication in 2006 (Greer & Ross, in progress).

Table 1. Evolution of Verbal Milestones and Independence

Verbal Milestones	Effects on Independent Functioning
1) Pre Listener Status	Humans without listener repertoires are entirely dependent on others for their lives. Interdependency is not possible. Entrance to the social community is not possible.
2) Listener Status	Humans with basic listener literacy can perform verbally governed behavior (e.g., come here, stop, eat). They can comply with instructions, track tasks (e.g., do this, now do this), and avoid deleterious consequences while gaining habilitative responses. The individual is still dependent, but direct physical or visual contact can be replaced somewhat by indirect verbal governance. Contributions to the well-being of society become possible since some interdependency is feasible and the child enters the social community.
3) Speaker Status	Humans who are speakers and who are in the in the presence of a listener can govern consequences in their environment by using another individual to mediate the contingencies (e.g., eat now, toilet, coat, help). They emit mands and tacts and relevant autoclitics to govern others. This is a significant step toward controlling the contingencies by the speaker. The culture benefits proportionately and the capacity to be part of the social community is greatly expanded.
4) Speaker Listener Exchanges with Others (Sequelics and Conversational Units)	a) Sequelics. Humans with this repertoire can responds as a listener-speaker to intraverbals, including impure tacts and impure mands. Individuals can respond to questions for mand or tact functions or to intraverbals that do not have mand or tact functions. The individual can respond as a speaker to verbal antecedents and can answer the queries of others such as: What hurts? What do you want? What's that? What do you see, hear or feel? One is reinforced as a listener with a speaker response. b) Conversational Units. Humans with this repertoire carry on conversational units in which they are reinforced as both speaker and listener. The individual engages in interlocking verbal operants of speaker and listener. The individual is reinforced both as a listener for sensory extensions as well as a speaker.
5) Speaker as Own Listener Status Say Do Conversational Units Naming	a) Say and Do. Individuals with this repertoire can function as a listener to their own verbal behavior (e.g., first I do this, then I do that), reconstructing the verbal behavior given by another or eventually constructing verbal speaker-listener behavior). At this stage, the person achieves significant independence. The level of independence is dependent on the level of the person's listener sophistication. b) Self-talk. When a human functions as a reinforced listener and speaker within the same skin they have one of the repertoires of speaker-as-own-listener. The early evidence of this function is self-talk; young children emit such repertoires when playing with toys, for example (Lodhi & Greer, 1990). c) Naming. When an individual hears something as a listener and can use it as a speaker without direct instruction or can learn something as a speaker and use it as a listener without direct instruction, the individual has another repertoire of speaker as own listener. This stage provides the means to expand forms and functions through incidental exposure.
6) Reader Status	Humans who have reading repertoires can supply useful, entertaining, and necessary responses to setting events and environmental contingencies that are obtainable by written text. The reader may use the verbal material without the time constraints controlling the speaker-listener relationship. The advice of the writer is under greater reader control than the advice of a speaker for a listener; that is, one is not limited by time or distance. Advice is accessible as needed independent of the presence of a speaker.
7) Writer Status	A competent writer may control environmental contingencies through the mediation of a reader across seconds or centuries in the immediate vicinity of a reader on a remote continent. This stage represents an expansion of the speaker repertoires such that a listener need not be present at the time or at the same location as the writer.
8) Writer as Own Reader: The Self-Editing Status	As writers increase their ability to read their own writing from the perspective of the eventual audience, writers grow increasingly independent of frequent reliance on prosthetic audiences (e.g., teachers, supervisors, colleagues). A more finished and more effective behavior-evoking repertoire provides the writer with wide-ranging control over environmental contingencies such that time and distance can be virtually eliminated. Writing can be geared to different audiences without immediate responses from the target audience
9) Verbal Mediation for Solving Problems:	A sophisticated self-editor under the verbal expertise associated with formal approaches to problem solving (e.g., methods of science, logic, authority) can solve complex and new problems in progressively independent fashion. The characterization of the problem is done with precise verbal descriptions. The verbal descriptions occasion other verbal behavior that can in turn direct the action of the person to solve the particular problem. A particular verbal community (i.e., a discipline) is based on verbal expertise tied to the environment and modes of inquiry are made possible.

Much of our work as teacher scientists is devoted to experimentally identifying prerequisite or co-requisite repertoires needed by each child to progress. Once these were identified, we used or developed scientifically based tactics for moving a child with the lack of a particular verbal capability from one level of verbal capability to the next level in the continuum. When we found it necessary, and were able to teach the missing repertoires, the children made logarithmic increases in learning. As evidence accumulated with individual children and experiments, we also began to identify critical subcomponents of the verbal capabilities. Table 2 lists the verbal capabilities and the components and prerequisites that we are beginning to identify. As we began to identify more subcomponents, we worked our way inductively to the identification of the components within the verbal capabilities suggested by Skinner. The quest led serendipitously to increased attention on the listener and speaker as own listener repertoires, a focus that began to be evident in the work of others as well (Catania, Mathews, & Shimoff, 1990; Hayes, Barnes-Holmes, & Roche, 2000; Horne & Lowe, 1996).

Table 2. Verbal Milestones and Components

Pre-listener Components: Does the Child Have These Capabilities?

Visual tracking
Capacity for "sameness" across senses
Basic compliance based on visual contexts and the teacher or parent as a source of reinforcement

Listener: Does the Child Have These Capabilities?

Conditioned reinforcement for voices
Discrimination between words and sounds that are not words
Auditory matching of words
Generalized auditory matching of words
Basic listener literacy with non-speaker responses
Visual discrimination instruction to occasion instruction in naming
Naming
Observational naming and observational learning prerequisites
Reinforcement as a Listener (Listener reinforced by the effect the speaker has on extending the listener's sensory experience)
Listening to one's own speaking
Listening to one's own textual responses
Listening and changing perspectives: Mine, yours, here, there, empathy

Speaker: Does the Child Have These Capabilities?

Vocalizations
Parroting (Pre-echoic vocalizations with point to point correspondence)
Basic Echoic-to-mand function (consequence in and out of sight)
Echoic-to-tact function (generalized reinforcement control)
(Faulty echoics of echolalia and palillalia related to faulty stimulus control or establishing operation control that needs to be repaired through instruction)
Mands and tacts with basic adjective-object pairs developed as autoclitic frames
Transformation of establishing operations across mands and tacts
Impure mands (mands under multiple control)
Impure tacts (tacts under multiple control)
Tacts and mands emerging from incidental experience (naming and the speaker repertoires)
Comparatives: smaller/larger, shorter/longer, taller/shorter, warmer/colder in mand and tact functions
Specificity: in/on/under/beside/above/below, inside/outside as mand and tact functions
"Wh" questions in mand and tact functions

Speaker Listener Exchanges with Others: Does the Child Have These Capabilities?

Sequelics as speaker
Sequelics as listener-speaker
Conversational units (joint speaker and listener control)

Speaker as Own Listener: Does the Child Have These Capabilities?

Basic naming from the speaker perspective
Observational naming from the speaker perspective
Verbal governance of own speaker responses (say and do correspondence)
Conversational units in self-talk

Early Reader Repertoires: Does the Child Have These Capabilities?

Conditioned reinforcement for observing books
Textual responses: see word-say word at adequate rate improved by prior conditioning of print stimuli as conditioned reinforcement for observing
Match printed word, spoken word by others and self and printed word, spoken word and picture/object, printed word and picture/action
Responds as listener to own textual responding

Writer Repertoires: Does the Child Have These Capabilities?

Effortless component motor skills of printing or typing
Transformation of spelling across written and oral spelling and other joint stimulus control
Writes to affect the behavior of a reader for technical functions (mand, tact, autoclitic functions)
Transformation of stimulus function for metaphoric functions (word used metaphorically)
Writes to affect the emotions of a reader for aesthetic functions (mand, tact, autoclitic functions as well as simile and metaphor for prose, poetry, and drama and meter and rhyme scheme for poetry)

Writer as Own Reader (Self-Editing): Does the Child Have These Capabilities?

Is verbally governed by own writing for revision functions (finds discrepancies between what she reads and what she has written)
Verbally governs a technical audience by reading what is written as would the target audience (editing without assistance from others)
Verbally governs an aesthetic audience as a function of reading what is written as would the target audience (editing without assistance from others)

Verbal Mediation for Solving Problems: Does the Child Have These Capabilities?

Is verbally governed by print to perform simple operations
Is verbally governed by print to learn new stimulus control and multiple step operations
Is verbally governed by print to perform complex verbally mediated algorithms. (The characterization of the problem is done with precise verbal descriptions. The verbal descriptions occasion other verbal behavior that can in turn direct the action of the person to solve the particular problem. A particular verbal community, or discipline, is based on verbal expertise tied to the environment and modes of inquiry are made possible.)

It was evident that without the expertise to move children with language delays through a sequence of ever more sophisticated verbal capabilities, we could make only minimal progress with our children. As we began to identify ways to provide missing capabilities, the children began to make substantial gains. As the magnitude of the differences became apparent in what the children were capable of learning following the attainment of missing repertoires, we came to consider the possibility that these verbal repertoires represented developmental verbal capabilities.

We have shown that certain environmental experiences evoked the capabilities for our children. However, we are mindful that providing particular prerequisite repertoires that are effective in evoking more sophisticated verbal capabilities in children with language disabilities or language delays does not necessarily demonstrate that the prerequisites are component stages in all children's verbal or cognitive development. While Gilic (2004) demonstrated that typically developing 2-year old children develop naming through the same experiences that produced changes in our children with verbal delays, others can argue effectively that typically developing children do not require specially arranged environmental events to evoke new verbal capabilities. A definitive rejoinder to this criticism awaits further research, as does the theory that incidental experiences are not required. See Pinker (1999) for the argument that such experiences are unnecessary.

Milestones of the Development of Verbal Function: Fundamental Speaker and Listener Repertoires

Our rudimentary classifications of children's verbal development adhered to Skinner's (1957, 1992) focus on the verbal function of language as distinguished from a structural or linguistic focus. Skinner focused on antecedent and consequent effects of language for the individual as a means of identifying function, as distinguished from structure (Catania, 1998). Eventually, his theory led to a research program devoted to the experimental analyses of verbal behavior with humans. In a recent paper (Greer, & Ross, in press) and a book in progress (Greer & Ross, in progress), we have suggested that this research effort might be best described as verbal behavior analysis, often without distinction between its basic or applied focus. We have incorporated the listener role in our work, in addition to the speaker functions. While Skinner's self-avowed focus was the speaker, a careful reading of Verbal Behavior (Skinner, 1957/1992, 1989) suggests much of his work necessarily incorporated the behavior of the listener vis-à-vis the speaker (e.g., the source of reinforcement for the listener). Our research on the role of the listener was necessitated by the problems encountered in teaching children and adolescents with language delays, of both native and environmental origin, to achieve increasingly complex cognitive repertoires of behavior. Without a listener repertoire many of our children could not truly enter the verbal community. We needed to provide the listener roles that were missing and that were required if the repertoires of the speaker were to advance. Skinner made the point that a complete understanding of verbal behavior required the inclusion of the role of the listener (See the appendix to the reprint edition of Verbal Behavior, published by the B. F. Skinner Foundation, 1992, pp.461-470). Moreover, new research and theories based on Skinner's work have led to a more complete theory of verbal behavior that incorporates the role of the listener repertoire.

These include, but are not limited to: Research done by relational frame theorists (Barnes-Holmes, Barnes-Holmes, & Cullinan, 1999); Hayes, Barnes-Holmes, & Roche, B. (2000), Naming research by Horne and Lowe and their colleagues (Horne & Lowe, 1996); Lowe, Horne, Harris, & Randle (2002); Research on auditory matching and echoics (Chavez-Brown & Greer, 2004); Research on the development of naming (Greer, Stolfi, Chavez-Brown, & Rivera-Valdez, 2004); Research on conversational units and speaker-as-own-listener (Donley & Greer, 1993; Lodhi & Greer, 1989), and Research on learn units (Greer & McDonough, 1999).

Our levels of verbal capability incorporate the listener as part of our verbal behavior scheme. The broad categories that we have identified to date are: (a) the pre listener stage (the child is dependent on visual cues, or, indeed, they may not even be under the control of visual stimuli), (b) the listener stage (the child is verbally governed as in doing as others say) (c) the speaker stage (the child emits mands, tacts, autoclitics, intraverbal operants), (d1) the stage of rotating speaker-listener verbal episodes with others (the child emits conversational units and related components of learn units in interlocking operants between individuals), (d2) the speaker-as-own listener stage (the child engages in self talk, naming, speaker-as-own-listener editing function, and say-do correspondence), (e) reader (the child emits textual responding, textual responding as a listener and emergent joint stimulus control, and the child is verbally governed by text), (f) the writer stage (the child verbally governs the behavior of a reader for aesthetic and technical effects), (g) writer-as-own reader (the child reads and revises writing based

on a target audience), and uses verbal mediation to solve problems (the child solves problems by performing operations form text or speech). Each of these has critical subcomponents and the subcomponents of the categories that we have identified to date are shown in Table 2.

The Listener Repertoire

In the verbal community a pre listener is totally dependent on others for her care, nourishment, and very survival. Pre-listeners often learn to respond to a visual and tactile environment; but if they do not come under the control of the auditory properties of speech they remain pre-listeners. For example, in certain situations they learn to sit when certain visual cues are present. It is often not the spoken stimuli such as "sit still, "look at me," or "do this" to which they respond, but rather certain instructional sequences or unintentional visual cues given by teachers and caretakers. They do no respond to, or differentiate among, the auditory properties of speech as stimuli that evoke specific responses. When the basic listener repertoire is missing, children cannot progress beyond visual or other non-auditory stimulus control. However, substantial gains accrue when children achieve the listener capability, as we shall describe.

Auditory Matching. It is increasingly apparent, that children need to match word sounds with word sounds as a basic step in learning to discriminate between words, and even distinguish words from non-word sounds. While most infants acquire auditory matching with apparent ease; some children do not acquire this repertoire incidentally. Chavez-Brown & Greer (2003) and Chavez-Brown (2004) taught children who could not emit vocal verbal behavior or whose vocal speech was flawed to match pictures first using BigMackÒ buttons as a pre training procedure to teach them to use the apparatus to learn to match words. The teacher touched a single button in front of her that had a picture on it and she touched each of the two buttons the students had in front of them (one with the target picture and one with a foil picture). Then the students responded by touching one of the two buttons in front of them that matched the picture touched by the teacher. Once the children mastered the visual matching task, as a means to introduce them to the apparatus, we removed the pictures and taught them to match the sound generated by the teacher's button (the buttons produced individual pre-recorded words or sounds). At this second stage one of the students' buttons had a sound and one of their buttons had no sound. Once they mastered matching the words contrasted with no sound buttons, they matched words with non-word sounds as foils, and then they matched particular words contrasted with different words. Finally, they learned generalized matching for words produced by pushing the buttons (i.e., novel word sets). Our findings showed that children, who had never vocalized before, began to approximate or emit echoic responses under mand and tact establishing operations as they mastered generalized word matching. Moreover, a second set of children, who had only approximations (i.e., faulty articulations), learned full echoics that graduated to independent mands and tacts. This matching repertoire may be an early and necessary step in the acquisition of speaking and may also be key to more advanced listening. See also correlations between auditory matching and the emissions of verbal operants identified by Marion et al. (2003) that suggested the auditory matching research we described above.

The Emersion of Basic Listener Literacy. When children have "auditory word matching" they can be taught the discriminative function necessary to become verbally governed. In the past few years, we found that children without listener repertoires reached a learning plateau and were no longer making progress in instruction beyond extensions of visual matching. We believe that children around the world who have these deficits are not making progress in early and intensive behavioral interventions. These children require inordinate numbers of instructional presentations, or learn units, and still do not make progress on repertoires that require verbal functions that are the very basic building blocks of learning. In an attempt to help these children become listeners, we developed an intervention that we call listener emersion (Greer, Stolfi, Chavez-Brown, & Rivera-Valdez, 2004.). During listener emersion, we suspend all of the children's instructional programs and provide intensive instruction in responding to the discriminative acoustical properties of speech. This instruction continues until children's listener responses are fluent.[2]

In the listener emersion procedure, children learned to respond to words spoken in person by a variety of individual voices as well as to voices recorded on tapes and other sources. By fluent, we mean that the children learned to respond to four or more sets composed of five instructions such as "point to ___," "match ___", "do this," "stand up," and "turn around." The children also learned not to respond to nonsensical, impossible, or non-word vowel-consonant combinations that are inserted into the program as part of each set. These sets were presented in a counterbalanced format with criterion set at 100% accuracy. Next the children learned to complete the tasks at specified rates of accurate responding ranging from 12 to 30 per minute. Finally, they learned to respond to audio taped, mobile phone, or computer generated instructions across a variety of adult voices. Once the children's basic listener literacy emerged (i.e., the children met the listener emersion criteria), we compared the numbers of learn units required by each student to meet major instructional goals both before and after listener emersion. After acquiring the basic listener literacy, the numbers of instructional trials or learn units that they required to achieve instructional objectives across the range of their instruction decreased from four to ten times what had been required prior to their obtaining basic listener literacy.

The Speaker Stage

Acquisition of Rudimentary Speaker Operants. In the late eighties, we identified procedures for inducing first instances of vocal speech that proved more effective than the operant shap-

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[2] We chose the term listener emersion because it seemed particularly appropriate. The Oxford English Dictionary 2nd Edition describes one usage of the term emersion as follows, "The action of coming out or issuing (from concealment or confinement). Somewhat rare." (OED, p. 177) Thus, once a child has acquired the listener repertoire, the child may be said to have come out of confinement to a pre listener status. They have acquired an essential component of what is necessary to progress along the verbal behavior continuum.

ing of spoken words as linguistic requests (Williams & Greer, 1989). That is, rather than teaching parts of words as vowel consonant blends, that had been the existing behavioral procedure (Lovaas, 1977), we arranged the basic establishing operations and obtained true mands and tacts using echoic-to-mand and echoic-to-tact procedures (Williams & Greer, 1989). Once true verbal operants were taught, the children used "spontaneous speech." The children came under the relevant establishing operations and antecedent stimuli (Michael, 1982, 1984, 1993) associated with mand and tact operants and related autoclitics, rather than verbal antecedents such as, "What do you want?" They did not require intraverbal prompts as a means of teaching pure tacts. In another procedure Sundberg, Endicott, and Eighenheer (2000) evoked the emission of impure tacts and the emission of impure tacts and mands; these are necessary repertoires as well.

While children who do not speak can be taught verbal behavior through the use of signs, pictures, or electronic speaking devices, speech is simply more useful. Speech works in the community at large. When we are unable teach speech, we too, use these substitutes, although there are few children that we cannot now teach to speak. The second choice for topography for us is electronic speaking devices because such devices supply the possibilities for speaker as own listener. The importance of speech becomes apparent when we reach the critical verbal repertoires of speaker as own listener and reader.

Although the use of the above procedures significantly increased the numbers of children we could teach vocal verbal operants to, there were still some children we could not teach to speak. While we could teach these children to use substitute topographies for speech, the development of speech is critical for subsequent verbal capabilities. For those children who did not learn to speak using our basic echoic-to-mand and echoic-to-tact procedures (Williams & Greer, 1989), we , and others, designed and tested several tactics to induce first instances of speech. We taught children who had acquired fluent generalized imitation, but who could not speak, to perform chains of generalized imitation of large and small movement responses at a rate of approximately 30 correct per minute at 100% accuracy. These children were then deprived of preferred items for varying periods of time and were only able to obtain the items contingent on speech under conditions in which they first performed a rapid chain of generalized imitation (moving from large motor movements to fine motor movements related to touching their lips and tongue). As soon as the last motor movement step in the teaching chain was completed we offered the item under deprivation as we spoke its name. After several presentations as described, the children spoke their first echoic mands.

Some of these children were as old as nine years of age and their first words were not separate phonemes but were mands like "baseball card, coke, or popcorn." Once the echoic to mand was induced for a single word or words, other echoic responses were made possible and their independent mand repertoire was expanded. Follow-ups performed years after these children spoke their first words showed that they maintained and expanded their mand and eventually tact repertoires extensively (Ross & Greer, 2003). We currently think that the procedure acted to induce joint stimulus control across the two independent behaviors of imitating and echoing (see Skinner, 1957 for the important distinction between imitation and echoic responding). In an extension of this work, Tsiouri & Greer (2003) found that the same procedure could be used to develop tact repertoires, where the establishing operation was deprivation of generalized reinforcers. See Skinner (1957, page 229) for a source for the establishing operations for the tact. Moreover, tacts and mands could be evoked in tandem fashion where emission of the tact operants resulted in an opportunity to mand as a result of using the tandem procedures developed in Williams & Greer (1989).

The establishing operation is key to the development of these rudimentary operants (Michael, 1982, 1984, 1993). There appear to be three tested establishing operation tactics: (a) the interrupted chain (Sundberg, Loeb, Hale & Eighenheer (2001/2002), the incidental teaching procedure in which the incidental establishing operations opportunities are captured (Hart & Risely, 1975), and the momentary deprivation procedure (Williams & Greer, 1989). Schwartz (1994) compared the three procedures and found them equally effective but that the momentary deprivation procedure resulted in slightly greater maintenance and required significantly less time. It is suggested that more powerful results may accrue if each of these establishing operations are taught in a multiple exemplar fashion providing the child with a range of establishing operations for controlling the emission of rudimentary operants. Still other establishing operation tactics are needed like the identification of establishing operations for tacts described in Tsiouri and Greer (2003). Also, see Sundberg, et al. (2001/2002) for mand establishing operations. Indeed what is characterized in the literature as "naturalistic language" interventions are essentially suggestions for capturing establishing operations (G. McDuff, Krantz, M. McDuff, & McClannahan, 1988). The difficulty with relying solely on the capture of incidental establishing operations is that there are simply not enough opportunities to respond. There is now an abundance of tested tactics for evoking establishing operations in instructional sessions that can be used without waiting for the incidental occasion, although it is critical to capture the incidental opportunities.

From Parroting to Verbal Operants. The stimulus-stimulus pairing procedure of Sundberg, Michael, Partington and Sundberg (1996) evoked first instances of parroting of words as a source of automatic reinforcement. These investigators paired preferred events, such as tickling, while the experimenters said words and the children began to parrot the words or sounds. Moreover, the children emitted the words in free play suggesting that the saying of the words had acquired automatic reinforcement status. Yoon (1998) replicated the Sundberg et al. procedure, and after the parroting was present for her students, she used the echoic-mand tactic described above (Williams & Greer, 1989) to evoke true echoics that, in turn, became independent mands. Until the parroted words were under the echoic to mand contingencies, the children were simply parroting as defined by Skinner (1957); however, obtaining the parroting as an automatic reinforcer made the development of true echoics possible. The emission of the parroting response may be a crucial first step and may be as complex as acquiring stimulus transformation.[3] The children in these studies moved from the listener to

[3] It would seem that a certain history must transpire in order for a point-to-point correspondence between a word spoken by a parent and the repetition of the word by a child to qualify as an echoic operant rather than parroting. The child needs to say the word under the relevant dep-

the speaker stage as a result of the implementation of extraordinary instructional procedures (See Sundberg & Partington, 1998 for an assessment and curriculum). Once a child has acquired a speaker repertoire, the speaker-listener repertoire becomes possible. Speaker capabilities opened extraordinary new possibilities for these children, as they did for our ancestors in the combined evolution of phylogenic capabilities with capabilities evoked by cultural selection.

Transformation of Establishing Operations Across Mand and Tact Functions. Initially, learning one form (e.g., word or words) in a mand or tact function does not result in usage of the form in the untaught function without direct instruction (Lamarre & Holland, 1985; Ribes-Inesta, Gomar-Ruiz, & Rivas, 1975; Twyman, 1996). For example, a child may emit a word as a mand (e.g., "milk") under conditions of deprivation, such that the emission of "milk" results in the delivery of milk. But, the child cannot use the same form ("milk") under tact conditions (i.e., the emission of the word in the presence of the milk when the reinforcement is a social or other generalized reinforcement probability). While the independence of these two functions have been reliably replicated in young typically and non-typically developing children, at some point most children can use forms that they acquired initially as a mand and use the same forms as a tact, or vice versa. Some see this as evidence of something like a neurologically based universal grammar that makes such language phenomena possible (Pinker, 1999). Clearly, neural capacities must be present just as the acoustic nerve must be intact to hear. But, the unequivocal existence of a universal grammar does not necessarily follow; the source is at least as likely to lie in the contingencies of reinforcement and punishment and the capacity to be affected by these contingencies in the formation of relational frames/higher order operants. One example of the acquisition of a higher order operant is the acquisition of joint control of a form in either mand or tact functions after learning only one function. Although the mand and tact functions are initially independent at some point, a child can use a form in an untaught function without direct instruction.

Nuzzolo-Gomez and Greer (2004) found that children who could not use a form learned in a mand function as a tact, or vice versa, without direct instruction in the alternate function (Lamarre & Holland, 1985; Twyman, 1996a, 1996b), could be taught to do so when they were provided relevant multiple exemplar experiences across establishing operations for a subset of forms. Greer, Nirgudkar, & Park (2003) replicated these finding and we have used the procedure effectively with numerous children in CABAS schools. The new verbal capability doubled incidental or direct instructional outcomes.

Speaker Immersion. Even after the children we taught had acquired a number of rudimentary speaker operants, some did not use them as frequently as we would have liked. Speaking had emerged but it was not being used frequently, perhaps because the children had not received adequate opportunities of incidental establishing operations. We designed a procedure for evoking increases in speaker behavior that we called speaker immersion (Ross, 1995). Once we immersed the children, for whom the operants had already emerged, in instruction devoted to the continuous use of establishing operations requiring speaking responses for all reinforcement throughout the day, the children's use of verbal operants dramatically increased as they learned to maximize gain with minimal effort. The children learned that it is easier and more efficient to get things done by speaking than by emitting responses that require much more energy.

Milestones of Speaker and Listener Episodes: Interlocking Verbal Operants Between Individuals

Verbal Episodes Between Individuals

Verbal behavior is social, as Skinner proclaimed, and perhaps one cannot be truly social without verbal behavior. A major developmental stage for children is the acquisition of the repertoire of exchanging speaker and listener roles with others—what Skinner (1957) called verbal episodes. A marker and a measure of one type of verbal episode is the conversational unit, while another type of verbal episode is a learn unit. We developed these measures as indices of interlocking verbal operants. No account of verbal behavior can be complete without the incorporation of interlocking verbal operants.

Epstein, Lanza, and Skinner (1980) demonstrated verbal episodes between two pigeons. We argue that they demonstrated a particular kind of interlocking verbal operant that we identify as a learn unit. In that study, after extensive training, the researchers had two pigeons, Jack and Jill, respond as both speaker and listener in exchanges that simulated verbal episodes between individuals. Each pigeon responded as both speaker and listener and they exchanged roles under the relevant discriminative stimuli as well as under the conditions of reinforcement provided by each other's speaker and listener responses (a procedure also used in part by Savage-Rumbaugh, Rumbaugh, & Boysen, 1978). The pigeon that began the episode, the teacher pigeon, controlled the reinforcement in the same way that teachers deliver effective instruction (Greer & McDonough, 1999). That is, the teacher pigeon had to observe the responses of the student pigeon, judge its accuracy, and consequate the student pigeon's response. Premack (2004) noted that the lack of this kind of teaching observation in primates is one of the repertoires that are unique to humans. In the Epstein et al. study, special contingencies were arranged in adjacent operant chambers to evoke or simulate the teaching repertoire. Note that the pigeon that served as a student did not emit the reciprocal

rivation conditions associated with the mand or the tact and then have that echoic evolve into either a mand or a tact. Once at least one of these events transpires, the parroting can move to an echoic. While more sophisticated operants and higher order operants or relational frames are basic to many sophisticated aspects of verbal behavior, the move from parroting is probably just as complex. The acquisition of echoing is the fundamental speech component of verbal functioning. One wonders how long, and under what conditions, it took for the echoic repertoire to evolve in our species. To evoke true echoics in children who have never spoken is probably one of the major accomplishments of the behavioral sciences. Indeed, the procedures we now use in verbal behavior analysis to induce first instances of vocal verbal operants have never been tried with primates, nor have these procedures been used to induce parroting. However, procedures for inducing parroting and echoics and other first instances of vocal verbal behavior have been successful in developing functional vocal verbal behavior in individuals who probably would have never spoken without these procedures. Amazing! There are even more fundamental components underlying even these response capabilities and aspects of observation show rich potential (Premack, 2004).

observation that we argue needs to be present in a verbal episode that we characterize as a conversational unit. In a conversational unit both parties must observe, judge, and consequate each other's verbal behavior.

Conversational Units

We used the determination of verbal episodes as measures in studies by Becker (1989), Donley & Greer (1993), and Chu (1998) as well as related research by Lodhi & Greer (1989). However, the units of verbal episodes in these studies involved both individuals initiating episodes that involved reciprocal observation accruing from reinforcement as a speaker and as a listener. We called these episodes conversational units. In the first step of a conversational unit, a speaker responds to the presence of a listener with a speaker operant that is then reinforced by the listener. This verbal interaction is what Vargas (1982) identified as a sequelic. Next, the listener assumes a speaker role under the control of the initial speaker. That is, the listener function results in the extension of sensory experiences from the speaker to the listener as evidenced by the speaker response from the individual who was the initial listener. The initial speaker then functions as a listener who must be reinforced in a listener function (i.e., the initial listener as speaker extends the sensory capacities of the initial speaker as a listener). A new unit begins when either party emits another speaker operant. Interestingly, in the cases of children with diagnoses like autism, we can now teach them the sequelic speaker function in fairly straightforward fashion using procedures described above. However, these children often have little interest in what the speaker has to say. The reinforcement function for listening is absent. We are currently working on this problem.

Conversational units are essential markers of and measures of social behavior and, we argue, their presence is a critical developmental milestone in the evolution of verbal behavior. By arranging natural establishing operations, Donley and Greer (1993) induced first instances of conversation between several severely delayed adolescents who had never before been known to emit conversation with their peers. Coming under the contingencies of reinforcement related to the exchange of roles of listener and speaker is the basic component of being social. Chu (1998) found that embedding mand operant training within a social skills package led to first instances of, and prolonged use of, conversational units between children with autism and their typically developing peers. Moreover, the use of conversational units resulted in the extinction of assaultive behavior between the siblings extending Carr and Durand's (1985) finding.

Learn Units

Learn units are verbal episodes in which the teacher, or preprogrammed teaching device (Emurian, Hu, Wang & Durham, 2000), controls the onset of the interactions, the nature of the interactions, and most of the sources of reinforcement for the student. The teacher bases her responses on the behavior of the student by reinforcing correct responses or correcting incorrect responses. The interactions provided in the Epstein et al. (1980) and the Savage-Rumbaugh et al. (1978) studies are learn units rather than conversational units as we described above. (See Greer, 2002, Chapter 2, for a thorough discussion of the learn unit and Greer & McDonough, 1999 for a review of the research).

Milestone of Speaker as Own Listener: Verbal Episodes "Within the Skin"

As Skinner pointed out, the speaker may function as her own listener as in the case of "self-talk." Lodhi and Greer empirically identified speaker as own listener in young typically developing children who engaged in self-talk while playing alone (Lodhi & Greer, 1989). This appears to be an early, if not the first, identification of conversational units in self-talk emitted by individuals under controlled experimental conditions. The developmental literature is replete with research on self-talk and its importance, but until the functional components defining self-talk were identified, self-talk remained essentially a topographical measure because the speaker and listener functions were not identified. It is very likely that speaker as own listener types of learn units are detectable also, although we have not formally tested for them except in our studies on print control that resulted in students acquiring self administration of learn units (Marsico, 1998).

We agree with Horne and Lowe (1996) that a speaker as own listener interchange occurs in the phenomenon that they identified as naming. Naming occurs when an individual hears a speaker emit a tact, and that listener experience allows the individual to emit the tact speaker function without direct instruction and further to respond as a listener without direct instruction. Horne and Lowe (1996) identified the phenomenon with typically developing children. Naming is a basic capability that allows children to acquire verbal functions by observation. It is a bidirectional speaker listener episode. But what if the child does not have the repertoire? For example, matching, pointing to (both listener responses, although the point- to is a pure listener response), tacting, and responding intraverbally to multiple controls for the same stimulus (the speaker response as an impure tact) are commonly independent at early instructional stages. This is the case because, although the stimulus is the same, the behaviors are very different. The child learns to point to red but does not tact (i.e., does not say "red" in the presence of red objects, or tacts and does not intraverbally respond to "What color?"). This, of course, is a phenomenon not understood well by linguists because they operate on the assumption that understanding is an automatic given—a human example of generative verbal behavior, if you will. It is a source of many problems in learning for typically developing and non-typically developing children, as well as college students who demonstrate differences in their responses to multiple-choice questions (selection responding) versus their responses to short answer or essay questions (production responding). At some point, children can learn a match or point-to response and can emit a tact or intraverbal response without direct training. This is not, however, automatic for some children. Thus, if naming were not in a childs' repertoire, could it be taught?

Induction of One Component of Naming. Greer, Stolfi, Chavez-Brown, & Rivera-Valdes (2004) found that one could isolate experimentally a particular instructional history that led to naming for children who did not initially have the repertoire. After demonstrating that the children did not have the repertoire

for tacts, we provided a multiple exemplar instructional intervention with a subset of stimuli involving rotating match, point-to, tact, and intraverbal responding to stimuli until the children could accurately do all of the responses to the subset. We then returned to the initial set and a novel set as well and showed that the untaught speaker listener repertoires had emerged.

These data suggested that the acquisition of naming, or one component of naming (i.e., going from listener to speaker) could be induced with multiple exemplar experiences. Naming is a generative verbal repertoire that Catania (1998) has called a "higher order operant." The Relational Frame Theorists described this particular higher order operant as an incidence of transformation of stimulus function (Hayes, Barnes-Holmes, & Roche, 2000). Skinner referred to the phenomenon as responding in different media to the same stimulus (i.e., thematic grouping) and Relational Frame Theorists provided feasible environmental sources for this and related phenomena (i.e., multiple exemplar experiences). That is, a particular response to a single stimulus or category of stimuli when learned either as a listener repertoire or as a speaker repertoire is immediately available to the individual as a response without direct instruction once the individual has stimulus transformation across speaker and listener. We found that the naming repertoire emerged as a function of specific instructional experiences. This represents another case of the emergence of generative verbal behavior that is traceable to environmental circumstances. Fiorile (2004) replicated this finding. Naming also represents the acquisition of one of the speaker as own listener stages. When children have acquired it, they have new verbal capabilities. Other types of generative behavior are traceable to multiple exemplar experiences, as we will discuss later.

Induction of Untaught Irregular and Regular Past Tense Responding. Still another case of speaker as own listener repertoires probably occurs in the emission of verb endings colloquially often associated with the cliché "kids say the darnedest things" (Pinker, 1992). We recently found that we could evoke untaught correct usage of regular and incorrect but "spontaneous" emission of irregular verbs (i.e., "he singed last night") as a result of multiple exemplar instruction with young children with developmental disabilities who could not emit either regular or irregular novel past tense forms without direct instruction (Greer & Yuan, 2004). The children learned to emit novel regular past tense forms without direct instruction and this abstraction was extended to irregular verbs. That is they emitted incorrect irregular forms such as "he singed" as do young typically developing children. In a related study, Speckman (2004) found that multiple exemplar experiences also resulted in the emission of untaught suffixes as autoclitic frames for tacts. However, it is important to recognize that Pinker (1999) says the fact that children begin to use the correct irregular forms at some point, rather than the incorrect forms, without any direct instruction is a more important capability. We suspect that multiple experiences could induce this capability too, although this research remains to be done.

Milestones of Reading, Writing, Self-Editing: Extensions of the Speaker and Listener Repertoires

Reading

Reading involves textually responding (seeing a printed word and saying the word), matching various responses to the text as comprehension (printed stimulus to picture or actions, the spoken sound and all of the permutations of this relationship) (Sidman, 1994). At first glance, the reader stage appears to be simply an extension of the listener repertoire; however, on closer scrutiny, reading is necessarily an advanced speaker as own listener repertoire because the reader must hear what is read. Reading consists of speaker-listener relationships under the control of print stimuli, actions or pictures. Textually responding requires effortless rates of responding to print stimuli in order to "hear" the spoken word. After all, it was the Middle Ages before we began to read silently and many religious and other ancient cultural practices still adhere to ceremonies in which one person reads to an audience.

The capacity to hear what one reads is important because the acoustical physical properties of sound allow more "bits" to be transmitted by sound than is possible with signs. For example, children who are deaf from birth, have extreme difficulty developing reading comprehension beyond Grade 6 (R. Kretchmer, personal communication, October, 2003). There are special auditory properties of speech that allow a great deal of information or bits to be used for the benefits of the reader (aesthetic or functional), or at least this was the case before computers. Good phonetic instruction results in children textually emitting untaught combinations of morphemes and if those words are in their listener repertoire they comprehend (see Becker, 1992, for the relevant research on multiple exemplar instruction and the emission of textual responses to untaught morphemes). However, even if a child can textually emit an accurate response to the printed stimuli, if the listener comprehension is not present the child "will not understand" what she has read (i.e., be unable to match the sounds to a picture or action). One can read a foreign language aloud and have no idea about what one is saying. Thus, the listener component is key. For example, adolescents with multiple year delays in their reading achievement may not comprehend because they can not emit a textual response to a particular word or group of words, but once they hear a spoken version they immediately comprehend, because their listener vocabulary exceeds their textual repertoire. The listener component of reading is as important as the textual speaking component; thus, a reader must be a reader as own listener, so to speak.

There is still a more basic component of reading that we identify as conditioned reinforcement for observing print and pictures in books. Tsai & Greer (2003) found that when they conditioned books such that 2 and 3-year old children chose to look at such books in free time, with toys as alternate choices, these children required significantly fewer learn units to acquire textual responses. The book stimuli selected out the children's observing responses, and once the children were observing, they were already closer to acquiring print stimuli as discriminative stimuli for textual responses. Thus, an early predictor of children's success in textual responding appears to be the conditioned reinforcement for observing book stimuli. Conditioned

reinforcement for books may constitute a new capability. We currently also believe that pre-listener children who do not orient toward speakers and who are having listening and speaking difficulties may need to have the unfamiliar and familiar voices of adults acquire conditioned stimulus control for observing. This too may be a crucial stage in the acquisition of listener repertoires.

Writing

Writing is a separate behavior from reading and like the repertoire of speaking, represents a movement up the verbal scale. But, writing from a functional verbal perspective requires that the writer affect the behavior of the reader; that is they must observe the effects of their writing and in turn modify their writing until the writing affects the behavior of the reader. In the case of technical writing, the writer must provide technical information that affects the readers behavior ranging from influencing a shopper through provision of a shopping list, to the provision of an algorithm that affects complex scientific decisions. Writing, as in the case of speaking, needs to be under the control of the relevant establishing operations, if the writing is to be truly verbal. In several experiments, we provided establishing operations for writing with students whose writing did not affect the behavior of the reader, using a tactic we call writer immersion. In its basic form all communication is done in written form for extended periods throughout the day. Written responses are revised until the reader responds as the writer requires. This procedure resulted in functionally effective writing, measured in effects on readers, and improvements in the structural components of writing (grammar, syntax, vocabulary, punctuation, spelling) (Gifaldi & Greer, 2003; Keohane, Greer, & Mariano-Lapidus, 2004; Jadlowski, 2000; Madho, 1997). The experience taught the students to write such that they read as the target readers, or target audience, would read. The editing experience appears to evoke writer as own reader outcomes of self-editing, not unlike speaker as own listener (Jadlowski, 2000). This repertoire then appears to be an advanced speaker as own listener stage—one that requires one to read what one writes from the perspective of the target audience whose behavior the writer seeks to influence. Thus, like the reader function, the writer function builds on the speaker as own listener. Some difficulties in writing and reading are probably traceable to missing components of the speaker, listener, or speaker as own listener components.

Complex Verbally Governed and Verbally Governing Behavior

Technical Writing. Another key component of the complex cognitive repertoires of individuals involves reading or being verbally governed by print for technical outcomes. Marsico (1998) found that teaching students to follow scripts under conditions that allowed the investigators to observe the control of the print over the students' responses resulted in students "learning to learn" new concepts in math and more complex reading repertoires by acquiring verbally governed responding from print sources. This repertoire allowed the students to be verbally governed by print. As this repertoire becomes more sophisticated it leads to the more complex repertoire of solving complex problems from algorithms as in the case of the following of decision protocols. Keohane (1997) and Nuzzolo-Gomez (2002) in separate experiments showed that teacher scientists could perform complex data decision steps using algorithms based on the verbal behavior of the science that resulted in significant improvements in the outcomes of the teachers' students. Verbal rules guided data analysis and tactical decisions that were implemented with the teachers' students. These studies are analyses of the verbal behavior of scientists and the verbal stimulus control involved in complex problem solving repertoires suggested by Skinner (1957). We argue that these studies investigated observable responses that are both verbal and nonverbal and that such responses are directly observed instances of thinking.

While neuroscientists could probably locate electrical activity in the brain associated with our putative thinking responses, it is only the behavior outside the skin that distinguishes the electrical activity as thinking as opposed to some other event that might be correlated with the activity. Verbal stimuli control the complex problem solving, not the electrical activity—the electrical activity, although interesting, maybe necessary, and important, but is not thinking per se. One might argue that the electrical activity is light in a black box; although we see within "the black box", we do not see outside of the black box. This is an interesting reversal of the black box puzzle. If the electrical activity were to begin before the relevant contingencies in the environment were to be in place, the problem in the environment would not be solved.

One of the key components in writing is the process of spelling. Spelling involves two different and initially independent responses-- saying the letters for a dictated word and writing the letters. At some point we do emit an untaught response after learning a single one of these behaviors (see Skinner, 1957, 1992, p.99). How does a single stimulus (i.e., hearing the word) come to control these two very different behavioral topographies of writing and orally saying the letters? Recently we found that for children who initially could not perform the untaught function, providing multiple exemplar instruction for a subset of words across the two responses under a single audited vocal stimulus resulted in these students acquiring the repertoire with novel stimuli (Greer, Yuan, & Gautreaux, 2004). Like transformation of establishing operations for mands and tacts, and transformation of stimulus functions across speaker and listener in naming, the transformation of writing and saying in the spelling repertoires is still another environmental source for generative verbal behavior as an overarching operant or a higher order operant (Catania, 1998; Hayes, Barnes-Holmes, & Roche, 2000). These repertoires consist of learned arbitrary relationships between listening, speaking, and writing. It is not far-fetched to infer that typically developing children acquire this joint stimulus control across independent responses as higher order operants or relational frames through multiple exemplar experiences that the rotation writing and saying opportunities occur through similar incidental experiences rather than with the programmed experiences we provided our children. Once the child has transformation of stimulus control over written and spoken spelling, only a single response need be taught.

In related research, Gautreaux, Keohane, & Greer (2003) found that multiple exemplar instruction also resulted in transformation of selection and production topographies in geometry.

That is, middle school children who could not go from multiple choice responding to the production or construction prior to the multiple exemplar instruction, did so after an instructional history was created by multiple exemplar instruction across a subset of selection and production experiences. This study highlighted the difficulties experienced by some older children that may be due to a lack of prior verbal instructional histories. The replacement of missing verbal capabilities is may be the key to solving instructional difficulties experienced later in life with more complex subjects. When an individual is missing a component capability, it is possible that the remediation of the difficulty only truly occurs when the missing capability is put in place.

Aesthetic Writing. In an earlier section, we described writing repertoires that were of a technical nature. Aesthetic writing has a different function than technical writing (Skinner, 1957). Aesthetic writing seeks to affect the emotions of the reader. To date, little empirical work has been accomplished with the aesthetic writing repertoire. A critical, if not the most basic component of aesthetic writing, is the writer's use of metaphors as extended tacts. Meincke, Keohane, Gifaldi, and Greer (2003) identified the emergence of novel metaphorical extensions resulting from multiple exemplar instruction. This effort points to the importance of isolating and experimentally analyzing experiential components of aesthetic writing and suggests the role of metaphorical comprehension in reading for aesthetic effects. This also suggests that rather than teaching the aesthetics of reading through literary analysis as an algorithm, a student should have the relevant metaphoric experiences and perhaps these may be pedagogically simulated. It is likely that these metaphoric experiences provide the basis for the aesthetic effects for the reader. In order for the exchange to occur, the target audience for the writer must have the repertoires necessary to respond to the emotional effects. Of course the analysis of aesthetic writing functions is probably more complex than the analysis of technical repertoires, but we believe empirical analyses like the one done by Meincke et al. (2003) are becoming increasingly feasible. If so, the aesthetic and functional writer and reader repertoire may be revealed as new stages of verbal behavior.

From Experimental Effects to a Theory of Verbal Development

We believe we have identified several verbal repertoires that are key in children's development of successively complex repertoires of verbal behavior. Providing several of these repertoires to children who did not have them allowed these students to advance in their cognitive, social, technical, and aesthetic capabilities. As a result of this work we were increasingly persuaded that these levels of verbal capabilities did, in fact, represent empirically identifiable developmental milestones.

For our children, the capabilities that they acquired were not tied to tautological relationships associated with age (Baer, 1970; Bijou & Baer, 1978; Morris, 2002). Age may simply provide a coincidental relation between experiences that bring about verbal capabilities and the probabilities of increased opportunities for those experiences. Hart and Risely (1996) showed that impoverished children who had no native disabilities, but who had significantly fewer language experiences than their more well off peers, demonstrated significant delays by the time they reached kindergarten. When children with these deficits in experience with language continued in schools that did, not or could not, compensate for their sparse vocabulary, these children were diagnosed as developmentally disabled by grade 4 four (Greenwood, Hart, Walker, & Risely, 1996). It is not too farfetched to suggest that absence of the kinds of experiences necessary to evoke higher order verbal operants that we have identified, may also be part of the contribution to these delays.

We suggest that the presence of incidental multiple exemplar experiences provide the wherewithal for most typically developing children to seamlessly acquire the verbal milestones we described, probably because they have both the environmental experiences and neural capabilities (Gillic, 2004). For children without native disabilities who lack multiple exemplar experiences (Hart & Risely, 1996), as well as children with native disabilities who lack the necessary verbal capabilities, intensive multiple exemplar instruction may induce missing repertoires (Nuzzolo-Gomez & Greer, 2004). Such experiences probably result in changes in behavior both within and outside of the skin. Indeed biological evidence suggests that, " DNA is both inherited and environmentally responsive." (Robinson, 2004, p. 397; also see Dugatkin, 1996 for research on the influence of the environment on changes in genetically programmed behavior affected by environmental events). What may be an arbitrary isolation of behavior beneath and outside the skin may dissolve with increased research in the environmental effects on both types of behavior.

Our induction of these repertories in children, who did not have them prior to instruction, suggests it is not just age (time) but particular experiences (i.e., environmental contingencies including contingencies that evoke higher order operants) that make certain types of verbal development possible, at least for the children that we studied. Intensive instruction magnified or exaggerated these experiences and provided our children the wherewithal to achieve new verbal capabilities. We speculate also that the inducement of these verbal capabilities in children who do not have them prior to special experiences, creates changes in neural activity. Of course, a test of this is the real challenge facing developmental neuroscience (Pinker, 1999). A joint analysis using the science of verbal behavior combined with instrumentation of the neurosciences might prove very useful in assisting children. Incidentally, such an analysis might also act to enrich academic debate towards more useful outcomes.

Tables 1 and 2 showed the levels of verbal functions for the pre-listener through the early reader stages in summary form. We described the evidence that has proved useful in our efforts to induce and expand progressively sophisticated verbal functions. The capabilities that we addressed were originally identified based on the responses of individual children; specifically, they were based on our empirical tests for the presence or absence of the repertoires for individual children. In our educational work, when a particular repertoire was missing, we applied the existing research based tactics to provide the child with the repertoire. When we encountered children for whom the existing tactics were not effective, we researched new tactics or investigated potential prerequisite repertoires and related experiences that appeared to be missing for the child. The searches for possible prerequisite repertoires led to the identification of sev-

eral subcomponents which when taught, by providing subcomponent repertoires, led to the emergence of verbal capabilities that were not present prior to our having provided the prerequisite instructional experience.

We continue to locate other prerequisites and believe that there are many others that remain to be tapped. Examples of rudimentary verbal functions that have been identified in the research include: (a) the emergence of better acquisition rates across all instructional areas as a function of teaching basic fluent listening, (b) the induction of parroting and then echoics that led to independent mand and tact functions, and relevant autoclitics for children with no speech or other verbal functions, (c) transformation of establishing operations across the mand and tact function for children for whom a form taught in one function could not be used in an untaught function prior to multiple exemplar instruction, (d) the identification of interlocking speaker as own listener operants in self-talk with typically developing children (Lodhi & Greer, 1989), (e) induction of conversational units with children who had no history of peer conversational units (Donley & Greer, 1993), (f) the induction of naming in children who did not have naming prior to multiple exemplar instructional experience (Greer, Stolfi, Chavez-Brown, & Rivera, 2004), (g) the emission of untaught past tenses for regular and irregular verbs as a function of multiple exemplar instruction (Greer & Yuan, 2004), (h) the emission of untaught contractions, morphemes and suffix endings as a function of having children tutored using multiple exemplar experiences (i.e., observational learning through multiple exemplars) (Greer, Keohane, Meincke, Gautreaux, Chavez-Brown, & Yuan, 2004, Speckman, 2004)), (i) better acquisition rates for acquiring textual responses as a function of conditioning books as preferred stimuli for observing (Tsai & Greer, 2003), (j) and the induction or expansion of echoic responding as a function of the acquisition of generalized auditory matching (Chavez-Brown, 2004).

The more advanced writer, writer as own reader or self-editing milestones involve key complex cognitive repertoires. Research in this area includes: (a) teaching more effective writer effects on readers and structural responses of writing as a function of establishing operations for writing (Madho, 1997. Greer & Gifaldi, 2003), (b) the induction of rule governed or verbally governed responding and the effects on verbal stimulus control of algorithms (Keohane, 1997; Marsico, 1998; Nuzzolo, 2002), (c) the role of multiple exemplar instruction on the emergence of metaphors (Meincke et al., 2003), (d) transformation of stimulus function across vocal and written spelling responses (Greer, Yuan, & Gautreaux, 2004), and (e) the acquisition of joint stimulus control across selection and production topographies (Gautreaux, et al., 2003). These more complex repertoires, we argue, build on the presence of speaker as own listener capabilities.

While we are not ready to declare emphatically that the capabilities that we have identified experimentally, or by extrapolation from experiments, have been definitively identified as verbal developmental stages, the evidence to date shows that they are useful for instructional functions. Furthermore, they suggest natural fractures in the development of verbal function.[4] For typically developing children, these fractures may occur as a result by brief experiences with exemplars. For some typically developing 2-year old children that we have studied, simply having a few experiences with exemplars going from listener to speaker, followed by single exemplars going from speaker to listener, resulted in bidirectional naming that they didn't have prior to those separate but juxtaposed experiences (Gilic, 2004). While our children with language delays required the rapid rotation across listener and speaker exemplars to induce naming, investigators have yet to document the emergence of naming independent of experiences like those we describe; that is, to demonstrate that they emerge independent of experiences like those we describe would require rigorous isolation from such experiences. Simply pointing to certain repertoires and claiming that they evolved without experience no longer seems credible.

Some of the research we described is not yet published and our references include papers presented at conferences or unpublished dissertations not yet submitted for publication. Thus, these are early days in our work on some of the stages. But it is important to note also that we have been on a quest for the last 20 years to remediate learning problems based on verbal behavior deficits in children with and without disabilities. The quest has moved forward based on progressively more complex strategic analyses as we stumbled on what we now believe may be developmental milestones in verbal behavior. We have replicated most of the effects we have identified with numerous children in our CABAS schools in the USA, England, and Ireland. Thus, we believe that the evidence is robust and we hope that it can be useful to behavior analysts, neuroscientists, and linguists interested in a thorough analysis of the evolution of verbal behavior.

We have also speculated on the cultural evolution of verbal functions for our species relative to our proposed verbal developmental scheme (i.e., the role of cultural selection). Of course theories on the evolution of language are so extensive that some linguistic societies have banned their proliferation; yet, anthropologists and linguists are now suggesting there is new evidence to support the evolution of language (Holden, 2004). Some linguistic anthropologists may find the evolution of cultural selection of verbal operants and higher order verbal operants useful. It is even possible that the capacity for higher order operants and relational frames constitutes that which has been attributed to a universal grammar. Speaker and listener responses could have evolved from basic verbal operants to interlocking speaker and listener responding between individuals and within the skin of individuals (self-talk and naming)—an evolution made possible by our anatomical and physiological capacities to acquire higher order operants combined with cultural selection. Moreover, reading and writing functions also probably evolved

[4] We use the term natural fracture to differentiate numerically scaled hypothetical relations from relations that are absolute natural events as in the determination of geological time by the identification of strata. To further illustrate our point, "receptive speech" is a hypothetical construct based on an analogy made between the computer "receiving inputs" to auditory speech events. It is an analogy not a behavior or response class. Measures of receptive behavior are scaled measures tied to that analogy as in test scores on receptive speech. However, listener behavior is composed of actual natural fractures (i.e., the child does or does not respond to spoken speech by another). In still another example, operants are natural fractures, whereas, an IQ is a scaled measure of a hypothetical construct. Moreover, acquisitions of higher order operants such as the acquisition of joint stimulus control for spelling are also natural fractures.

as an extension of the basic speaker and listener functions; without them reading and writing would not have been possible at least in the way it has evolved for the species.

The human species, at its current level of evolution, is basically verbal, but it was not always so. A verbal behavior could have arisen from nonverbal sources and its transmission from generation to generation would have been subject to influences which account for the multiplication of norms and controlling relations and the increasing effectiveness of verbal behavior as a whole. (Skinner, 1992, p.470)

Speaker/writer operants and listener/reader responses constitute an important, if not the most important, aspect of human behavior as adaptation to what is increasingly a verbal environment. Simply speaking, verbal behavior analysis is the most important subject of a science of behavior. We hope it is not too presumptuous of us to suggest that verbal behavior analysis can contribute to a developmental psychology that treats environmental contributions as seriously as it treats the non-environmental contributions. After all, biology has come to do so (Dugatkin, 1996; Robison, 2004).

While we can simulate human listener and human speaker functions with nonhuman species (Epstein, et al., 1980; Savage-Rumbaugh et al., 1978), the simulation of naming and other speaker as own listener functions with nonhuman species remains to be demonstrated. Premack (2004) argues from the data that nonhumans lack the capacity for recursion. "Recursion makes it possible for words in a sentence to be widely separated yet be dependent on one another." (Premack, 2004, p. 320). We suggest that recursion may have been made possible by the evolution of speaker as own listener capabilities in humans as a function of both neural capabilities and cultural selection. Premack (2204) also presents convincing evidence that teaching is a strictly human endeavor. "Unlike imitation, in which the novice observes the expert, the teacher observes the novice—and not only observes, but judges and modifies." (Premack, 2004, p. 320; D. Premack & A. Premack, 2003). This describes the interaction we have characterized as in what takes place in a learn unit. The conversational unit differs from the learn unit in that the conversational unit requires a reciprocal observation. Observational repertoires like those Premack (2004) described may be fundamental components that underlie and presage the evolution of nonverbal to verbal behavior.

Observational Learning

While observation has been studied as a phenomenon, few if any studies have sought the possible environmental source for observational learning. We argue that observational learning differs from other indirect effects on behavior in that observational learning results in the acquisition of new operants. Other types of observational effects on behavior result in the emission of operants that were already in the observer's repertoire. The kind of behavior changes identified by Bandura (1996) were most likely of the latter sort since the presence or absence of the operants were not determined prior to the observational experience. Imitation results from a history that reinforces correspondence between the imitator and a model's behavior.

Some children do not have observational learning. They have weak observational repertoires. In cases where observational learning has been missing, we have induced it by providing certain experiences. It also may be possible that all children do not have observational learning until they have certain experiences. In one study, we increased observational learning as a function of having individuals function as tutors using learn units that required tutors to reinforce or correct the responses of their tutees. It was the application of the learn unit per se, specifically the consequence component that produced the new observational repertoire (Greer, Keohane, Meincke, Gautreaux, Pereira, Chavez-Brown, & Yuan, 2004). In another case with children who did not learn by observing peers, we taught them to monitor learn unit responses of their peers and observational learning emerged (Greer, Pereira, & Yuan, 2004).

This observing phenomenon involves a kind of consequent benefit similar to what the listener gains —specifically the extension of sensory reinforcement. Perhaps the teaching capacity involving reinforcement of the observed behavior of the learner is related to particular listener capabilities, while the recursion phenomenon is related to the interlocking speaker-listener capability. It is the interlocking speaker-listener-as-own-listener functions that make the more sophisticated milestones of verbal function possible. These functions make possible thinking, problem solving, true social discourse, and the development of repertoires compellingly described in relational frame theory (Hayes, Barnes-Holmes, & Roche, 2000). Speech and, we argue, the compression of information made possible by auditory stimuli in the human species, makes possible the more advanced speaker as own listener or textual responder as own listener and perhaps by extension the phenomenon of recursion. Regardless of whether our interpretation of the evidence is compelling, the evidence does reveal that a more complete picture of verbal behavior is evolving and that the role of the listener, and particularly the interrelationship between speaker and listener, is key to further advances in our understanding of verbal functions and their development within the individual.

Verbal Behavior Analysis and the Neuroscience of Language

None of the work we have described, or related work in verbal behavior, obviates the role of genetically evolved brain functions as the neurology correlated with the presence of our suggested milestones of verbal behavior and the generative aspects of behavior cum language. The research in verbal behavior does not question, or eliminate, the importance or usefulness of neuropsychological researches. Alternately, the work in the neuroscience of language does not obviate the environmental verbal functions of language as behavior per se and as higher order operants that are increasingly identified in verbal behavior analysis. They are simply different sciences involved with different aspects of language. On the one hand, work in verbal behavior analysis is beginning to identify key environmental experiences in cultural selection and suggests how neuropsychology can make the journey from MRI analyses to real verbal function—behaving with language outside of the skin. On the other hand, the work in the neurosciences of language is beginning to identify the behavior beneath the skin. It is compelling to consider the mutual benefit of obtaining a more comprehensive understanding of language to consider relating the efforts. Most importantly, combining the evidence and types of inquiry

from both fields can help us teach a few more children to be truly verbal.

Behavior analysts have simulated language functions in non-humans (Epstein et al., 1980; Savage-Rumbaugh et al., 1978) and comparative psychologists have identified differences between the verbal behavior of primates and the verbal behavior of humans (Premack, 2004). Non-human species have not demonstrated speaker as own listener. However, research in verbal behavior analysis has led to the acquisition of listener repertoires, speaker repertoires, speaker as own listener repertoires, and generative verbal behavior in humans who did not have those repertoires prior to special environmental experiences. Perhaps work in verbal behavior analysis with individuals who can acquire verbal repertoires as a result of special interventions provides a bridge. While our particular work is driven by applied concerns, it may have some relevance to the basic science of behavior and even comparative psychology. Hopefully, readers who are more knowledgeable about these issues than we, will excuse our large canvas on the grounds that we are but simple teacher scientists. However, to us, there are few establishing operations as compelling for the growth of a science than the need to save a few children.

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Author's Note:
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