The Ontogenetic Selection of Verbal Capabilities: Contributions of Skinner's Verbal Behavior Theory to a More Comprehensive Understanding of Language

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Abstract

I describe how Skinner's (1957) *Verbal Behavior* and subsequent research that extended his theory contributes to a more comprehensive understanding of language with regard to the ontogenetic selection of verbal behavior. A large corpus of research has shown the applied utility of the theory for inducing verbal behavior in children missing certain verbal capabilities and developmental cusps. Other related work on Relational Frame theory, Naming theory, and Stimulus Equivalence provided the basis for identifying verbal developmental cusps and capabilities. Evidence on the initial independence of the speaker and listener, and research identifying the experiences that lead to the joining of the speaker and listener within the skin, suggests an empirically based theory of verbal development. This work identifies the preverbal foundations, the speaker and listener components and the experiences that lead to the capability for learning language incidentally and productive language. The growing evidence on the ontogenetic sources of language and its development in children complements the work of other scholarship in language and provides neuroscience with better tools to validate the relation between brain activity and the effects of experience.
Keywords: ontogenetic selection of verbal capabilities, higher order verbal operants, verbal development, speaker-as-own-listener.

Resumen

Se describe cómo *Conducta Verbal* de Skinner (1957) y la investigación relacionada contribuyen a una aproximación más integradora del lenguaje basada en la selección ontogenética del comportamiento verbal. Un gran corpus de investigación ha mostrado su utilidad aplicada para inducir el comportamiento verbal en niños con carencias verbales. Otros trabajos, desde la Teoría del Marco Relacional, la Teoría del *Naming*, y de la Equivalencia de Estímulos, han permitido identificar hitos y capacidades del desarrollo verbal. La evidencia sobre la independencia inicial del oyente y el hablante, y la investigación que ha identificado las experiencias que llevan a la conjunción del oyente y el hablante en la propia piel, sugieren una Teoría del Desarrollo Verbal con base empírica. Este trabajo identifica los fundamentos preverbales, los componentes de hablante y oyente y las experiencias que llevan a la capacidad de aprender el lenguaje de forma incidental, y al lenguaje productivo. La evidencia creciente sobre las fuentes ontogenéticas del lenguaje y su desarrollo en niños, complementa otros estudios académicos sobre el lenguaje, y proporciona a la neurociencia mejores herramientas para validar la relación entre la actividad cerebral y los efectos de la experiencia.
Palabras clave: selección ontogenética de capacidades verbales, operantes verbales de orden superior, desarrollo verbal, hablante como propio oyente.

* Correspondence concerning this article should be adressed to the author: Teacher's College, Columbia University. 525 West 120th Street. New York-NY.10027. E-mail: rdg13@columbia.edu. I would like to acknowledge the many colleagues, current students, and former students who contributed to the numerous studies in verbal behavior in which I have been fortunate to be involved.

B. F. Skinner believed that *Verbal Behavior* (Skinner, 1957, 1986) was his most important contribution and there is growing evidence that this is the case (Greer & Ross, 2004; 2008; Greer & Speckman, in press; Michael, 1984; Sundberg, 1998). By verbal behavior we mean all of the producing and mediating functions of language responses (speaking, signing, gesturing, Morse code, smoke signals, drumbeats); the term verbal is not synonymous with vocal or oral language. Despite the widely held view that Chomsky's influential review buried Skinner's theory (Chomsky, 1959), this is evidently not the case.

What evidence exists to affirm this verbal behavior theory is alive and flourishing? Firstly, the present article is part of a collection of papers in an international journal devoted to the fiftieth anniversary of the publication of the book. Secondly, there has been an exponential increase in experimental analyses of many of the tenets of the theory, especially with the addition of the treatment of the role of the listener qua speaker (Hayes, Barnes-Holmes, & Roche, 2001; Greer & Ross, 2008; Horne, Hughes, & Lowe, 2006; Horne & Lowe, 1996; Horne, Lowe, & Randle, 2004; Lodhi & Greer, 1989; Lowe, Horne & Hughes, 2005; Lowe, Horne, Harris, & Randle, 2002; Lowenkron, 1991, 1996, 1997). Thirdly, applications of the theory of verbal behavior are found to be effective in inducing or accelerating verbal development and the identification of developmental stages of verbal capabilities (Greer & Keohane, 2005; Greer & Ross, 2008; Greer & Speckman, in press). Indeed, in the intervening 50-years since the publication of *Verbal Behavior* many linguists, psychologists, and anthropologists have demonstrated a renewed interest in the theory that the verbal capability in humans is a result of evolution and ontogenetic development (Culotta & Hanson, 2004; Deacon, 1997). This change signaled an end to a long period of eschewing that language evolved (Chomsky, 1959). Moreover, Chomsky's generative theory and its various permutations have as many critics as advocates (Kineally, 2007, Chapter 1 and page 306, note number 1990). Some of the problems with other aspects of Chomsky's generative theory of language are that there is a lack of evidence to support it; and in fact, some evidence shows disconfirmation. For example, one linguist recently reported on a newly discovered language that disproves Chomsky's theory that recursion is a universal attribute of languages (Colapinto, 2007).

The current attempts for a multidisciplinary approach to how language may have evolved (Culotta & Hanson, 2004) suggest that verbal behavior analysis can provide critical information needed in any comprehensive approach to the evolution of language within the species and within the development of the individual. Verbal behavior contributes an understanding of how the environment selects verbal behavior and how the phylogenetic capacity for operant and respondent conditioning eventually makes the cultural functions of language possible. These provide the bridge between natural selection and the cultural selection of language function (Catania, 2001, 2007). Neither behavioral analyses of the individual nor structural analyses alone can reveal the full scope of language; rather they are complementary (Catania, 2007). For example, Skinner based much of his treatment of verbal behavior on a particular linguistic analysis (Bloomfield, 1961). Indeed, many disciplines play unique roles in our understanding of language including: anthropology, neurophysiology, pathology, linguistics, lexicology, the history of writing, sociology, paleontology, and need we say, verbal behavior analysis.

In order to include the operant and respondent analyses of the function of language as part of a more comprehensive understanding of the ontogeny of language, the role that verbal behavior analysis can play in this pursuit needs to be understood by scholars in a multitude of relevant disciplines (see Kineally, 2007, pp. 28, 29, 30 for the usual misconception). Perhaps one of the reasons that other language disciplines have not understood how the science of verbal behavior can contribute to a more comprehensive understanding of language stems from Chomsky's (1959) influential review of Skinner's (1957) book. Cleary the uncritical acceptance of Chomsky's review thwarted an understanding of what Skinner's book was about. The review itself was not based on the book, as Chomsky himself admits (Chomsky & Place, 2000). Chomsky reported that he based his review on his own impression of what the science of behavior was about and there is record of his misconceptions (Chomsky & Place, 2000; MacCorquodale, 1970; Michael, 1984). Another part of the problem is that the current excitement about a neuroscience of language often overlooks the importance of a reliable and valid analysis of behavior outside of the skin relative to the analysis of the behavior of the brain.

The science of verbal behavior can contribute a key and necessary part of any advancement in our understanding of relations between neurophysiology and language function (Barnes-Holmes *et al.*, 2005). By neurophysiology I do not mean psychological constructs as brain behavior but real neurophysiology (Uttal, 2001). Scientific analyses of verbal behavior focus on investigations of the functions of verbal behavior including the control of the environment: an environment that includes the control exerted by the audience on the speaker and, more recently, the function of verbal behavior for the listener. Perhaps, the analysis of verbal behavior can contribute most to our understanding of the ontogeny of language functions. As such it is ideally suited to providing the function of language for studies of the relation between neurophysiology (behavior beneath the skin) and behavior outside of the skin. Verbal behavior assumes that certain evolved physiological capabilities made it possible for the adventitious selection of language functions in cultures through social learning -social learning made possible by our capacities to benefit from respondent and operant conditioning experiences reflected in the basic principles of behavior (Skinner, 1986). Research based extensions of those principles have now made it possible to identify higher order operants that provide explanations of complex verbal functions and their ontogeny (Barnes-Holmes, Barnes-Holmes, & Cullinan, 2000; Greer & Keohane, 2005, 2006; Greer & Ross, 2004, 2008; Greer & Speckman, in press; Lowenkron, 1991, 1996, 1997). Other linguists and psychologists of reading and spelling (McGuiness, 2004, 2005; Robinson, 2004) share a similar interest in the role of experience in the pragmatics of language.

The evidence in verbal behavior analysis fits nicely with this latter work and adds substantially to the roles of experience in reading and writing, as I shall show. As is the case of any complex scientific problem, no good science can be ignored if we are to make useful strides. I believe that wider dissemination of what verbal behavior analysis is about, and the evidence it can contribute to a multidisciplinary approach to language will allow the broader community of psychologists, like those who read this journal, to understand the unique contribution to be made by the analysis of language as behavior with operant and respondent underpinnings.

Regardless of the widespread misunderstanding of Skinner's work, there is solid evidence that *Verbal Behavior* (Skinner, 1957) and the subsequent research based on the expanded theory, have significantly improved the educational and developmental prognosis of many children. Moreover, findings from this research portend substantial benefits for many children far beyond the current applications. The benefits for children with native language disabilities (e.g. autism spectrum disorders) are well documented (Arntzen & Almas, 2002; Chavez-Brown, & Greer, in press; Chu, 1998; Greer & Bruno, 1997; Greer, Chavez-Brown, Nirgudkar, Stolfi, & Rivera-Valdes, 2005; Greer & Ross, 2004; Greer, Nirgudkar, & Park, 2003; Greer & Ross, 2004, 2008; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005; Greer, Stolfi, & Pistoljevic, 2007; Greer & Yuan, 2008; Greer Yuan, & Gautreaux, 2005; Lamarre & Holland, 1985; Lee, 1981; Lee-Park, 2005; Lodhi & Greer, 1998; Madho, 1997; Marsico, 1997; Miguel, Petursdotir, Carr, & Michael, 2001,2002; Nirgudkar, 2005; Nuzzolo-Gomez, & Greer, 2004; Partington & Bailey, 1993; Partington, Sundberg, Newhouse, & Spengler, 1994; Pereira-Delgado & Oblak, 2007; Petursdottir, Carr, & Michaels, 2005; Pistoljevic & Greer, 2006; Poulson, Kymiss, Reeve, Andreatos, & Reeve, 1991; Rehfeldt & Root, 2005; Reilly-Lawson & Greer, 2006; Reilly-Lawson & Walsh, 2007; Ross & Greer, 2003; Ross, Nuzzolo, Stolfi, & Natarelli, 2006; Schauffler & Greer, 2006; Schwartz, 1994; Sigafoss, Doss, & Reichle, 1989; Sigafoss, Reichle, Doss, Hall, & Pettit, 1990; Simic & Bucher, 1980; Smith, Michael, & Sundberg, 1996; Speckman & Greer, in press; Speckman-Collins, Park, & Greer, 2007; Spradlin, 1985; Stafford, Sundberg, & Braam, 1988; Sundberg, 1993; Sundberg, Loeb, Hale, & Eigenheer, 2001; Sundberg, Michael, Partington, & Sundberg, 1996; Sundberg & Sundberg, 1996; Sundberg, San Juan, Dawdy, & Arguelles, 1990; Tsiouri & Greer, 2003, 2007; Twyman, 1996; Williams & Greer, 1993; Yoon, 1998; Yoon & Bennett, 2000). Moreover there is evidence of the utility of findings from verbal behavior on advancing the verbal development of typically developing children who are language disadvantaged by poverty or for whom the language spoken at home differs from that taught in schools (Greer & O'Sullivan, 2007; Greer, Wiegand, & Kracher, 2006; Greer, Yuan & Gautreaux, 2005; Hart & Risley, 1995). Finally Gilic (2005) reported that the verbal development of typically developing two-year olds could be accelerated by several months.

Given the mounting evidence, it is possible that no other language theory has, to date, achieved the applied impact made by Skinner's treatment of language function as behavior selected out by social contingencies. This does not mean that the evidence will be taken seriously by scholastics, although I hope to show why no scholarship (as distinguished from scholasticism) concerned with language can afford to ignore findings from the analysis of verbal behavior. I will also show how verbal behavior has led to a new empirical account of verbal development based on experimental analyses rather than correlations with age (Baer, 1983). This has implications for a psychology of language development and, in turn, for the evolution of language. Moreover, the verbal developmental account requires neither psychological constructs, nor collateral fMRI evidence. Although, I argue that fMRI research can profit from procedures that lead to the emergence of verbal capabilities, as a science of verbal behavior can benefit from the extension of behavior outside the skin to behavior beneath the skin (Barnes-Holmes *et al.*, 2005).

A New Way to Analyze the Development of Language Function

There are many ways to analyze language, both its structure and function. Clearly the lexicon tradition of language is a critical key to description of the topography of behavior and communities of verbal behavior. Lexical methods provide ways of documenting the rapid change of "meanings" or the way in which topographies change their verbal function within any given language. Moreover, the analysis of syntax and grammar are key also. The identification of unique aspects of language also plays a role. Pinker (1999) provides numerous examples of aspects of language that appear to not have been taught or learned experientially. But such examples do not themselves provide evidence that language is instinctual in the human; rather they describe the questions to be addressed. Chomsky (1959) pointed to the fact that children acquire thousands of words and the many "rules" that combine them without direct instruction; in fact, it would be impossible for children to acquire such an extensive repertoire by direct instruction. He referred to this as the "poverty of the stimulus": "They must be born with a mental component that helps them learn language." (Kineally, 2007, p.29). But again, the acknowledgement that children demonstrate facility with thousands of words and "rules," and that these require the presence of neurological underpinnings does not eliminate ontogenetic influences. While neurophysiological capabilities are obviously necessary, this does not translate into language modules or "mental components." Rather than psychological constructs, what is needed is real analyses of physiology and real analyses of environmental sources.

The effect of Chomsky's review and its resulting notoriety had an impact beyond language *per se* -Chomsky and colleagues became, ipso facto, psychologists of language:

> The role for the language specialist was fundamentally changed by these [Chomsky's theories]. Linguists were no longer catalogers but scholars who were perfectly positioned to unearth the deepest mysteries of their subject. What mattered about language was not that it came from a particular region… but that it came from our heads. With generative linguistics, the terrain that the linguist explored shifted from the corners of the planet to the depths of the human mind.
> Generative linguists began to divide language in the brain the same way [that they had divided syntax in the 1950s]. They looked for evidence of a module that controlled syntax, a module that controlled meaning, and a module that processed sound. It was thought that these modules were independent of one another and that language was produced by a coarse-grained interaction between them. (Kineally, 2006, pp. 31, 32) (Italics in brackets added.)

The problem with all of this was that studying the structure does not identify the function, nor how it develops. Also, a robust neurophysiology results in real physiology, not theorized "modules." Obviously experience plays a part in learning languages and that analysis is the special purview of verbal behavior. Clearly the environment plays a role and clearly physiological capabilities play a role. The focus and contribution of scientists of verbal behavior is to identify the environmental role and how this plays a part. The focus of neurophysiology is the behavior beneath the skin. The joint problem

is how behavior beneath the skin relates to behavior outside the skin and the interaction of the environment with that behavior (Dickins, 2005).

An analysis of the ontogenetic development of verbal behavior (i.e., how verbal development occurs within the lifespan of the individual) can provide important information on the role of the environment. One tried and true way is to test the language skills of infants and children at different ages descriptively by comparing what typical children do or cannot do at different ages. Another is to design experiments to test the presence or absence of foundations of language such as facial imitation, object imitation, or generalized imitation (see Meltzoff, 1983, 1996, for an impressive program of research). Clearly these efforts provide important information. Still another way is to compare non-human species with humans (Premack, 1976, 2004). Comparative psychology plays an important role (although see Greer, 2006, for the problem of attributing language to modules that has characterized interpretations of some comparative evidence). However, there is still another way that we can study language development.

We can study language development also by identifying children who are missing certain verbal capabilities or verbal behavioral developmental cusps (Rosales-Ruiz & Baer, 1996, 1997). Next, we can attempt to develop interventions designed to supply those missing capabilities or cusps. If successful, we can then point to environmental experiences that led to the verbal capabilities. This can provide an experimental-within-species analysis and together with the other methodologies we can gain a clearer picture of the role of environmental histories in the development of language functions (Greer & Keohane, 2005, 2006; Greer & Ross, 2008; Greer & Speckman, in press).

I argue that the latter approach is just what has occurred in verbal behavior analyses designed to instigate verbal capabilities in children who are missing them. The initial impetus was an applied one -how could we provide children with certain verbal capabilities? However, provided the analyses are well designed, they can tell us a great deal pertaining to the basic science of the role of experience. In the following sections I will describe just such a program of research in broad strokes and how that work can relate to and supplement other evidence on language development. But first, I must describe terms that are the cornerstones of our current verbal developmental theory.

Developmental Cusps, Capabilities and Repertoires

In the last few decades research in stimulus equivalence (Sidman, 1986, 1994), Relational Frame Theory (Barnes-Holmes, & Roche, 2002; Hayes *et al.*, 2001; Luciano, Herruzo, & Barnes-Holmes, 2001), Naming (Horne & Lowe, 1996), and The Verbal Development Theory (Greer & Keohane, 2005, 2006; Greer & Ross, 2008; Greer & Speckman, in press) have led to a higher order operant and respondent account of complex verbal behavior and its development that extends Skinner's theory substantially. One of the results of this work is an empirically based verbal behavioral developmental account: how verbal behavior develops within the ontogeny of the individual. Three terms clarify the importance of certain verbal "stages" that accrue from experience and how the presence or absence of these stages allows children to benefit or not benefit

from experiences. These are developmental cusps, developmental capabilities, and repertoires. The distinctions among these were made in the process of the formation of behavior analytic approaches to developmental psychology and verbal developmental theory and require explanation.

A key concept in contemporary behavior analyses of development is the notion of behavioral developmental cusps (Gewirtz, 1969; Novak, 1996; Novak & Palaez, 2004; Rosales-Ruiz & Baer, 1996, 1997). Rosales-Ruiz and Baer described a behavioral developmental cusp as follows:

> A cusp is a change that (1) is often difficult, tedious, subtle, or otherwise problematic to accomplish, yet (2) if not made, means little or no further development is possible in its realm (and perhaps in several realms); but (3) once it is made, a significant set of subsequent developments suddenly becomes easy or otherwise highly probable which (4) brings the developing organism into contact with other cusps crucial to further, more complex, or more refined development on a thereby steadily expanding, steadily more interactive realm. (Rosales-Ruiz & Baer, 1996, p. 166).

A behavioral developmental cusp allows the child to come into contact with experiences that in turn result in new learning from the stimulus-stimulus pairings and consequences of behavior. New experiences teach new operants and condition new reinforcers and punishers including verbal behavior. However a cusp need not necessarily lead to a new way of learning. When the acquisition of a cusp also leads to a new way of learning verbal behavior we refer to it as a verbal developmental capability. For example when children acquire the capability to learn language or verbal behavior incidentally this is not only a cusp, but also a change in how the child can learn verbal responding. One type of incidental learning capability is called Naming (Catania, 2007; Greer & Ross, 2008; Greer & Speckman, in press; Horne & Lowe, 1996). (We distinguish the layperson usage of naming as labeling of things from the developmental capability by capitalizing Naming when we refer to the developmental stage or capability.) Once children acquire a verbal developmental capability, that is also a cusp, they also acquire a new way to learn. This usage of capability as a new capacity that originates from behavior/environment interactions differs from the usage of capability as a physiological capacity. Thus, all verbal developmental capabilities are cusps, but not all verbal developmental cusps are capabilities. Finally, we use repertoires as a term for the range of learned relations that are possible when a cusp or capability is present. A cusp results in new opportunities to learn, a capability is a cusp that allows one to learn differently, and a repertoire is the extent of learned relations in a category that is made possible by cusps and capabilities. For example, once a child has auditory phonemic control of some responses as a listener they can learn to respond to many other speaker instructions. This is a cusp and not a capability because, although the child can learn from contact with the speech of others as a listener, they still learn only through direct reinforcement. The range of learned listener responses within the capability constitutes the repertoire.

One of the most implicit concepts in Skinners verbal behavior theory is that the listener and speaker are separately evolved and naturally selected types of behavior, and that the intercept of them in the evolution of language within the individual's

lifespan is key. But even more basic is the distinction between observing and producing responses and how they are joined, and the differences in the types of observing and producing responses.

The Evolution of Separate Observing and Producing Reponses and the Cultural Joining of Them

Language involves the joining of observing and producing responses: responses categories that are initially independent (Skinner, 1957, 1986, 1989). If we ignore the metaphors of receptive and expressive components of language as a single entity, and, instead, regard them as two categories of behaving, observing and producing, and that these evolved independently, the role of the environment in this process becomes more transparent (see Donahoe & Palmer, 2004, Dinsmoor, 1983, and Holland, 1958, for the evidence on observation as an operant, and Tsai & Greer, 2006, for how stimuli may be conditioned for operant observing; also see Greer and Singer-Dudek, 2008, and Greer Singer-Dudek, Longano, & Zrinzo, 2008, for how stimuli may be conditioned through observation as a result of special contingencies). However, these initially independent response classes become joined as a result of certain outcomes made possible by natural selection and behavioral selection for cultural outcomes.

At a basic level we can identify at least four different cultural outcomes of the joining of different types of observing and producing responses. They are: dance, music, the visual arts and verbal behavior. Some developmental and comparative psychologists have proposed that these distinctions evolved from the natural selection of psychological constructs such as modules or intelligences (Pinker, 1999); however, no intervening variable explanations (i.e., psychological constructs) are needed.

One case involves dance, where seeing (visual observations) and doing (imitative production) involves the observation and duplication of movements and the subsequent joining of seeing and doing (generalized imitation or a higher order operant where novel imitations emerge). After multiple exemplar experiences of seeing and reproducing physical movements, interpretative and non-corresponding movements may emerge as creative responding -an example of still another type of emergent behavior (Sidman, 1983, 1994).

Another example of see and do involves the observational process of seeing the outcomes of behavior resulting in emulation. Nonhuman animals emulate (Zentall, 1996; Zentall, Galizio, & Critchfield, 2002) also; and in fact chimpanzees do it better than young infants (Whiten & Custance, 1996). Rather than the imitation of movements, the outcomes or products of behavior are emulated. In studies on emulation, experiments are designed to separate imitation from emulation. The survival value of emulation is obvious. But there are purely human cultural or non-biological collateral outcomes for emulation, just as dance is a collateral cultural outcome of generalized imitation. The visual arts are a conspicuous example of the cultural manifestation of emulation. The artist learns correspondence between visual objects and the drawings, paintings, or sculpture she produces. Multiple experiences of producing correspondence, in say, representative art may eventually lead to non-corresponding indirect reproductions

described as creative innovations in style (Picasso's art for example). We might even characterize the latter as another type of emergent behavior (i.e., higher order operants, stimulus equivalence, relational frames) brought about by the multiple exemplar experiences across observing and producing. In the two examples described thus far, the reinforcement for the producer-as-own observer resides in the effects that accrue from these processes as a kind automatic reinforcement (i.e., direct duplication of movement in one case, and emulation of the outcome in another). In these cases the correspondence between what is observed and what one produces constitutes reinforcement.

In still another case (and one that is more closely related to hearing and speaking) one hears music and reproduces the musical phrase. Both music, in many cases, and speech involving echoing or parroting (the point to point correspondence between hearing words and saying them) are similar, where the duplication of what is observed cannot be directly observed visually -it is more like emulation, where the product is compared to the observed sample. Once the musical sounds are conditioned as reinforcers for observing (a well-documented phenomenon, see Greer, Dorow & Hanser, 1973; Greer, Dorow, & Randle, 1975; Greer, Dorow, Wachhaus, & White, 1973) and the sounds can be reproduced, automatic reinforcement accrues for producing the sounds (e.g., singing in the shower).

One likely source of the automatic reinforcement for the generalized imitation in dance and music production is Pavlovian second order conditioning not unlike what Skinner described as ostensive learning (Skinner, 1957, p. 227; see also Stemmer, 1973, 1985, 1990, 1996). Audiences for performances bring in a social operant function later. Speech can involves a similar joining of hearing and saying. The speaker or the producer may simply "parrot" the responses of caregivers (Skinner, 1957) where the response itself reinforces repetition, much like how the emission of music is automatically reinforced. That is, when a child has acquired conditioned reinforcement for correspondence between hearing and saying the child is reinforced by her reproduction of what is heard. However, parroting is not verbal. It becomes verbal when the child behaves such that a listener mediates for the speaker. This mediation function distinguishes the joining of the observing behavior and the producing behavior of language from the joining of other observing and producing behaviors. When the child says "mama" repeatedly, with no learned experience with a prior effect on a listener, the behavior is not verbal. When the emission of "mama" by the child results in certain effects on the behavior of a listener the behavior becomes verbal at the level of speaking. Of course signs may be substituted for those who are deaf. In this case, it is not reproductions of what are observed, or interesting variations of that observation, that is the primary source of reinforcement; rather, the reproduction is a means to the end of having the listener or audience mediate the world for the speaker/producer: mama shows up. This distinction is what makes the category of speaker behavior verbal -the audience reinforces relations between production and the nonverbal world. The reinforcement for each type of observation and production capabilities described above and the joining of them differs.

Again, no special psychological module is inferred or necessary, although neurophysiological behavior beneath can be identified. Rather, the eventual joining of the two originates with the phylogenetically evolved physiology that made the observation

and production possible, along with the evolved capacity for conditioned reinforcement, and together these provide the basis for the cultural utility for the joining of the two (e.g., "Look out for the car"). The joining occurs from social learning made possible by the accidental and adventitious selection as a part of acculturation. A special joining of observing (listening) and producing (speaking or signing) resulted in a useful human capability -verbal behavior.

An Evidence-Based and Higher Order Account of the Ontogenetic Origins of Verbal Behavior

The following is a brief overview of studies on the induction of various verbal capabilities that led to a theory of verbal development. Space does not permit a detailed explanation. The specifics of the evidence are described in detail in Greer & Ross (2008), Greer & Keohane (2005, 2006) and Greer & Speckman (in press).

The independent evolved human capabilities that allowed the Cultural Selection of being verbal

I have already described the independence of observing and producing responses and how this resulted in verbal behavior along with other categories of responding in humans. Other aspects of verbal behavior show independence also, at least early in development. One may acquire certain aspects of listener literacy without corresponding speaker behavior. That is, one can respond to the behavior of a speaker without having the capability to speak. Mands and tacts are initially independent types of speaker operants (Lamarre & Holland, 1985; Twyman, 1996a, 1996b). The listener capability may outdistance the speaker capability (Chavez-Brown & Greer, in press; Greer, Chavez-Brown, *et al.*, 2005). Vocal spelling involves different responses than written spelling (Greer, Yuan *et al.*, 2005): writing differs in topography from saying or signing. One appears to acquire the listener half of learning names for things (i.e., Naming) before the speaker half (Greer, Stolfi, *et al.*, 2005; Horne, Hughes, & Lowe, 2006). These and other aspects of verbal behavior, particularly vocal verbal behavior, suggest their initial independence. Moreover, there are preverbal foundational cornerstones, foundational behavioral developmental cusps, that illustrate the independence of different responses that ultimately lead to verbal functions (Luciano & Polaino-Lorente, 1986). These include the acquisition of voices as conditioned reinforcement for listening (Keohane, Luke, & Greer, 2008), the acquisition of tabletop visual stimuli as visual reinforcement for visual observing (Keohane, Greer, & Ackerman, 2006), and the acquisition of the capacity for sameness across the senses (Keohane, Luke, *et al.*, 2008; Greer & Ross, 2008). While these are not capabilities they appear to be behavioral developmental cusps that make the induction of listener literacy, accurate visual match to sample responding, and the capacity for sameness possible, and they may be the foundations of the acquisition of verbal capabilities

Conditioned Reinforcement and phylogenetic foundations of speaker and listener responding

Decasper and Spence (1986) report evidence that mothers' voices are conditioned reinforcers for observing shortly after birth, suggesting that the conditioning process occurs in uttero with the pairing of nutrients with hearing the mothers' voices. Once the child orients to the mother and can see the mother, the conditioned voice stimulus is paired with the mother's face resulting in the face of the mother reinforcing observation. Other senses are involved also such as tactile stimuli and olfactory stimuli. Simultaneously, independent movements are present and they are separate from observing behavior, as Skinner proposed that they are simply emitted as part of the phylogenetic contribution. For example, Donahoe and Palmer (2004) describe the infant swimming motions that are present in uttero and after birth. These are initially independent motions unrelated to observing responses. Some of the movements are joined with observing shortly after birth. For example, Meltzoff and Moore (1983) reported that newborn infants imitate facial movements. We speculate that the conditioned reinforcement for observing the mother and the mother's actions, as the child observes her own actions, leads to correspondence between the mother's actions and the infant's actions and the acquisition of the correspondence itself as a conditioned reinforcer.

Babbling is emitted early on independently of what is heard. When correspondence between the mother's phonemic sounds and the child's babbling occurs parroting ensues. When the child emits the phonemic sounds like those of the mother the child's response is automatically reinforced since they are producing the sounds like those of her mother. This reinforcement originates from a conditioning history that conditions correspondence between observing and producing itself as conditioned reinforcer. This is not yet verbal but it sets the stage. Sundberg, Michael, Partington, and Sundberg (1996), Yoon (1998), and Yoon and Bennett (2000) conditioned babbling as automatic reinforcement in children with severe language delays (also see Esch, Carr, & Michael, 2005).

Early on Holland (1958) showed how observing is an operant response. Dinsmoor (1983) and Tsai and Greer (2006) found that preconditioning of stimuli as conditioned reinforcement for observing facilitated discrimination learning. Several studies have shown that conditioning reinforcement for caregivers' voices (Keohane, Luke, *et al.*, 2008) or visual stimuli (Keohane, Greer, & Ackerman, 2006, Pereira-Delgado, Speckman, & Greer, 2008) or combinations of these protocols (Keohane, Luke, & Greer, 2008) in preschool children lacking listener or speaker capabilities resulted in drastic acceleration in learning relevant discriminations. Moreover, developing the capacity to match across seeing, hearing, touching, tasting, and smelling such that the capacity for sameness across senses was mastered resulted in drastic accelerations in learning. These studies together with those described above suggest how conditioned reinforcement for observing stimuli resulted in accelerated learning that was not possible prior to acquiring these kinds of conditioned reinforcement (Keohane, Pereira-Delgado, & Greer, in press). As in the cases of typically developing infants, acquiring conditioned reinforcement for observing led to developmental cusps that made other learning possible -learning that is foundational to verbal behavior (Roche & Barnes-Holmes, 1997). Mastering the

arbitrarily applicable relation of matching across the senses would appear foundational to verbal behavior: the categorization of sameness across senses is an arbitrary relation. Providing that relevant user-friendly technology can be adapted for such investigations, the identified means to induce capabilities like these in children who are missing them provides neuroscience with strong behavioral measures within and outside the skin. In summary, we can contribute to the neuroscience of language development in important ways.

Inducing listener literacy

When children do not respond to vocal verbal instructions we describe them as lacking basic listener literacy. Children missing listener literacy cannot respond to the phonemic vocal verbal behavior of speakers. Often these children have learned to cope by visual observation alone. Perhaps repeated instruction results in even more reliance on visual cues. When children have certain prerequisites we have been successful in inducing basic listener literacy using a developmental intervention or protocol that we call "listener emersion." We suspend most instruction and provide an intensive listener emersion program in which we rotate sets of simple instructions consisting of four commands and a nonsense command. We insure that the only way that they are reinforced is by responding to instruction that eliminates any possibility of responding from visual cues. After they master each set with accuracy they are required to respond to sets of commands at 30 commands per minute. When this is achieved we provide recordings of the commands with different voices and when they master these we compare their rate of instructional trials to criteria in all curricular areas before and after the intervention. This has resulted in acceleration in the rate of their curricular learning from four to 10 times faster than before the intervention (Greer, Chavez-Brown, Nirgudkar, Stolfi, & Rivera-Valdes, 2005). This outcome has been replicated with numerous children in CABAS® schools (see http://www.CABAS.com) and appears robust. Once children can respond to these commands we consider they have achieved basic listener literacy. The children can then profit from vocal verbal instruction that introduces new vocal stimuli. The term emersion indicates that they have emerged from pre-listener to listener status. As listeners they can learn from contact with stimuli; hence it is a a developmental cusp.

When they have difficulty with this we use an intervention that teaches them to match recordings of different words, beginning with words versus sounds and progressing to words that are very different than words that sound similar. In some cases this results in their then being capable of mastering the listener emersion protocol. Use of this protocol requires that voices are already conditioned reinforcers for attending.

From listener to speaker (Auditory Matching as Selection Behavior)

In the auditory matching protocol the acquisition of auditory matching as a selection response has resulted in partial or full echoics in children missing echoics and significant improvement in the clarity of speech for children with faulty speech (Chavez-

Brown & Greer, in press; Marion, Vause, Harapiak, Martin, Yu, Sakko, & Walters, 2003). Instructional applications of the auditory matching also have resulted in some children who could not master the listener emersion protocol doing so after mastering the auditory matching protocol or acquiring the listener component of Naming (Speckman & Greer, in press).

Expanding speaker verbal repertoires following the induction of Vocal Verbal Behavior

Once children have acquired a few mands (speaker behavior that specifies its reinforcer) we proceed with tact training provided that the child is reinforced by attention for the tact response; a type of conditioned reinforcement that is learned (Greer, Singer-Dudek, Longano, *et al.*, 2008). Tacts are speaker operants that make contact with the environment where the reinforcement is generalized or social reinforcement. The child says "airplane" and the caregiver says, "Yes, that is an airplane." We hasten that process by teaching tacts under conditions in which the emission of the tact results in the opportunity to mand. Gradually, we fade the opportunity to mand and provide only social reinforcement for tacts (Williams & Greer, 1992). When the tacts begin to accrue, as a result of social reinforcement alone, we provide an intensive tact instruction procedure in which the students receive a minimum of 100-tact learn units daily in addition to their normal curricular instruction. This has resulted in significant increases in tacts in non-instructional settings ("spontaneous speech") and increases in "wh" questions that appear to be attempts to recruit new tacts (Pistoljevic, 2008; Pistoljevic & Greer, 2006). The intensive tact protocols continue until the child has acquired the capability of acquiring language incidentally as a result of acquiring the Naming capability (Fiorile & Greer, 2007; Greer *et al.*, 2005; Greer *et al.*, 2007; Horne & Lowe, 1996). In a recent study, mastery of several sets of tacts in the intensive tact procedure also resulted in Naming (Pistoljevic, 2008).

Inducing the capability to learn language functions from incidental experience: Naming

The capability to learn language incidentally has been identified as Naming. While our focus in this paper is on the emergence of Naming as a developmental capability, Naming has also been shown to facilitate certain emergent relations in numerous studies (Miguel, Petursdottir, Carr, & Michael, 2008; Randell & Remington, 2006; Stromer & Mackay, 1996). The term Naming refers to the capability of a child to learn from simply hearing the name or tact of a stimulus and as a result they acquire the listener and speaker components without direct instruction. At this point the listener and speaker responses intercept (Greer & Speckman, in press; Smeets, & Striefel, 1976). That is, children orient to or point to the object when the word for the object is said, and they say the tact or "name or label" for the object when it is present in the presence of a caregiver. Several experiments have resulted in the acquisition of Naming as a function of a multiple exemplar intervention across speaker and listener responding

for a subset of stimuli (Feliciano. 2006; Fiorile & Greer, 2007; Gilic, 2005; Greer, Nirgudkar, & Park, 2003; Greer, Stolfi *et al.*, 2005, 2007) or as a result of the intensive tact intervention (Pistoljevic, 2008). Moreover, still another recent study showed that conditioning voice and visual stimuli as reinforcement for observing responses also resulted in Naming (Longano, 2008). The latter study suggests the possibility that the source of the echoic serving as reinforcement for Naming may itself be the result of a Pavlovian second order conditioning experience.

The source of reading comprehension for novel words including affect and how reading and writing joins speaking and listening

In our theory of verbal behavior development (Greer & Keohane, 2005, 2006; Greer & Ross, 2008; Greer & Speckman, in press) we proposed that children with Naming and fluent phonemic decoding will have immediate reading comprehension and possibly what Skinner (1957) identified as conditioned seeing for reading novel text. Studies by Lee Park (2005), Reilly-Lawson (2008), and Helou-Caré (2008) lend support to this theory. Children, who lacked phonemic responding, but who had Naming could not respond accurately to comprehension questions for contrived words and stories. However, once they mastered phonemic decoding they answered the comprehension questions that they could not answer before acquiring phonemic reading skills (Reilly-Lawson, 2008). In another experiment (Helou-Caré, 2008), older children who had fluent phonemic responding but who had poor comprehension and lacked Naming had comprehension after Naming was induced. In this experiment, stories were written using contrived noun words and contrived symbols for the noun words. Prior to reading the stories the children, who did not have Naming, were provided Naming experiences. They then read the story with the contrived words and were asked comprehension questions about the stories and they demonstrated poor comprehension, even though they read the story fluently at better than 160 words per minute. Next, the children received the MEI Naming intervention, as described above, with training sets of different stimuli. After the Naming training, they reread the story that they could not comprehend before and they demonstrated comprehension with no additional Naming observational experiences. These two studies showed the relations between Naming, phonemic responding, and reading comprehension.

Multiple exemplar training across saying and writing resulted in derived relations between saying and writing for novel words. Greer, Yuan, & Gautreaux (2004) found that accurate spelling for novel words emerged from the joining of say and write as a result of multiple exemplar instruction across saying and writing: presumably as a result of derived relations between saying the sounds and writing the letters. In cases where a child with phonemic fluency decodes novel words (e.g., the child sees the printed word elephant for the first time) if the child has Naming and has had an observational naming experience with an elephant the child will have reading comprehension for Naming. By comprehension we mean she will have derived relations between the print, the sounds of the word, a visual match for the print and sound, and other attributes we will describe. For example, in the past the child heard someone say

"elephant" as the child attended to a real or representation of an elephant. This experience then allows the child, on hearing herself read e-l-e-p-h-a-n-t, will understand to what the word refers. The child sounds out, "e-l-e-p-h-a-n-t". On hearing the word (said covertly or overtly as her own listener) the child will respond to the word consistent with her experience. Any respondent experiences associated with the observation, such as a funny or fearful stimulus response relation, will be elicited on hearing the word she reads. Thus, the emotions that are part of aesthetic reading experiences are elicited because of the Naming capability and the relevant observational experience.

The auditory stimulus comes to control multiple responses as a result of specific instructional or environmental experiences. The heard word evokes operants and respondents: accurate written or spoken spelling, conditioned seeing/smelling/hearing/tasting, and emotional responses. Of course signs may be substituted for phonemic sounds but deaf children experience much difficulty with reading beyond the sixth grade level (Karchmer & Mitchell, 2003).

How Verbally Governed and Verbally Governing Behavior leads to effective methods of inquiry

Another speaker as own listener capability is correspondence between say and do. When print is joined to say and do other experiments suggests how verbally governed behavior (i.e., the capability to follow or respond to vocal or written verbal stimuli) and verbally governing behavior (the capability to evoke others to behave by spoken or written verbal stimuli) leads to following or the production of algorithms in complex problem solving associated with various modes of inquiry such as the methods of authority, logic, and science (Keohane & Greer, 2006; Marsico, 1997; Pierce, 1935). In the Keohane and Greer paper verbal stimulus control was shown to result in the identification of learning problems, identification of the likely source of the problem, the selection of a relevant scientific tactic to solve the problem, the reliable use of the tactic, and the reliable implementation of the tactic or tactics resulting in the solution. Hence, this study demonstrated the role of verbal stimuli in the behavior of the scientist as described in the chapter on the behavior of scientists in Skinner's (1957) Verbal Behavior. Marsico (1997) demonstrated similar verbal stimulus control in learning in children with emotional disabilities or behavioral disorders.

The Developmental Trajectory

The developmental trajectory resulting from this program of research on the identification of verbal cusps and capabilities in children has been described at length in Greer and Ross (2008) and Greer and Speckman (in press). In this theory of verbal behavior development, the experimental studies on the induction of verbal capabilities and prerequisite cusps point to a developmental trajectory. We propose that this work in combination with evidence from Relational Frame Theory (Barnes-Holmes, Barnes-Holmes, Roche, Healey, Lyddy, Cullinan, & Hayes, 2001; Hayes *et al.*, 2001), Stimulus Equivalence Theory (Sidman, 1986, 1992, 1994), and Naming Theory (Horne & Lowe,

1996) can play a significant role in providing a more complete account of language and its development within the species and its development within the lifespan of the individual.

The fact that these capabilities have been identified and that these could be induced by environmental interventions has important ramifications for a more comprehensive treatment of language. With regard to neuroscience, measures of brain activity before and after the induction of verbal capabilities such as basic listener literacy, echoic responding, Naming (or the capability to acquire listener and speaker behavior from incidental exposure), for examples, provide neuroscientists with the wherewithal to investigate changes in brain activity as a function of the acquisition of each or all of these behavioral developmental stages. For example, the neurophysiology of the brain prior to the acquisition of Naming can be compared with the neurophysiology of the brain following the induction of Naming. The same may be done for the onset of vocal verbal behavior, listener literacy, auditory matching of speech, and transformation of stimulus control across saying and writing. The ability to induce these capabilities in children who are missing them provides an unparalleled means to study the relation between changes in overt behavioral capabilities and changes in brain behavior (Uttal, 2001). In most, if not all of these cases, the newly acquired capability has been characterized in contemporary behavior analysis as a higher order operant or an overarching operant. The potential to identify changes in brain behavior is also a critical step in testing the possible relations between brain behavior and the concept of higher order operants (Healy, Barnes-Holmes, & Smeets, 2000). Clearly, the potential to induce verbal behavior cusps and capabilities stands to benefit both sciences.

Conclusions

Skinner's (1957) theory of verbal behavior and the more recent higher order operant extensions of the theory have provided an environmental account of complex verbal behavior including an evidence-based account of the ontogeny of verbal behavior. This work provides language scholars and psychologists with accounts of the influence of experience on the emergence of novel verbal behavior. In addition, the work provides ways to enhance the work of neuroscientists who are investigating relations between brain behavior and overt verbal functions. The work may also prove useful to those attempting to piece together an account of how language evolved in the human species. Finally, an empirically derived theory of the development of verbal functions in children provides developmental psychologists with information on how the environment influences language development and how children come to learn novel verbal behavior.

While an understanding of Skinner's *Verbal Behavior* and the development of a research program has required decades, it does seem that there is considerable evidence that the theory has led to important new information about a key component of language: how experience contributes to the expansion of verbal behavior and the emergence of novel verbal behavior. The dissemination of this work to the range of language scholars and psychologists will likely contribute to a more comprehensive understanding of language. While recent evidence and interpretations of that work has extended the

range of what verbal behavior is about, all of that work grew from Skinner's treatment of language as behavior. It seems increasingly evident that Skinner was right: it may be his most important work.

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