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THE INTEGRATION OF SPEAKER AND LISTENER RESPONSES: A THEORY OF VERBAL DEVELOPMENT

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We provide an empirically updated Skinnerian-based account of verbal behavior development, describing how the speaker-as-own-listener capability in children (the capability of children to behave as speaker and listener within their own skin) accrues and how it is pivotal to becoming verbal. The theory grew from (a) findings in experiments with children with and without language delays and (b) findings from research devoted to the identification of derived and emergent behavior (i.e., novel, creative, and spontaneous behavior). Experiments identified preverbal instructional histories leading to separate listener and speaker capabilities and experiences that joined the listener and the speaker. Once this learned intercept is present, children engage in conversational self-talk, engage in say–do correspondence, and acquire new vocabulary without direct instruction. These developmental capabilities make it possible for most complex behavior to be learned, including reading, writing, emission of novel tenses and suffixes, and the following of and construction of complex algorithms.

> "We need separate but interlocking accounts of the behaviors of both speaker and listener if our explanation of verbal behavior is to be complete…. In many important instances the listener is also behaving at the same time as a speaker" (Skinner, 1957, p. 34).

Contemporary accounts suggest that to be truly verbal, the speaker must also simultaneously behave as a listener (Barnes-Holmes, Barnes-Holmes, & Cullinan, 2001; Greer & Ross, 2008; Horne & Lowe, 1996). But, how does that ability develop within the child's life? A growing body of evidence suggests a developmental sequence on how the initially independent speaker and listener classes of responding come to be integrated within the individual.

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Verbal behavioral development refers to children's *experientially* acquired capabilities to learn and be taught new relations, to learn multiple responses and multiple stimulus control from a single experience, to learn at a faster pace, and to learn in ways they could not prior to the attainment of verbal developmental capabilities. In this article we describe findings and methods from a program of research that led to the identification, and induction, of verbal developmental capabilities that were missing in children, and these served as the basis for our theory. The theory was made possible by, builds on, and complements research and theory that identified sources of complex human behavior, including verbal behavior (Barnes-Holmes et al., 2001; Barnes-Holmes, Healey, & Hayes, 2000; Catania, 2007; Hayes, Barnes-Holmes, & Roche, 2001; Hayes & Hayes, 1989; Horne & Lowe, 1996; Sidman, 1986).

Findings and theories from each of these programs, and interactions with scientists involved in each of these programs of research, led to a greater emphasis in our research on the listener functions in verbal behavior, and a resurgence of a longtime interest in speaker-as-own-listener (Lodhi & Greer, 1989). Relational Frame Theory (Hayes et al., 2001), Naming Theory (Horne & Lowe, 1996), and Stimulus Equivalence Theory (Sidman, 1986, 1994) have suggested the importance of the listener and related observing responses, as well as potential experiential sources for emergent behavior. Experiments that manipulated instructional histories subsequently identified preverbal foundational developmental cusps, speaker and listener cusps, and verbal capabilities or stages, together with protocols to advance them or induce them in children in whom they were missing (Greer & Keohane, 2005; Greer & Ross, 2008).

The protocols that we identified from the experimental program simply revolutionized practices that can be used to advance children's verbal development and how children could learn and be taught. Most of the procedures from this research have been replicated with children in CABAS® research and development schools (Selinski, Greer, & Lodhi, 1991) numerous times with considerable success (Greer & Keohane, 2005). A recent book (Greer & Ross, 2008) describes practices that professionals can use to advance children's verbal development. However, the book also contains an empirically based theory of language development that may be of interest to a wide range of psychologists who are not the primary audience for the book. In this article we describe the theory emphasizing the joining of speaker and listener, particularly speaker-as-own-listener (Skinner, 1957). The concept of the speaker-as-own-listener is at the heart of anecdotal linguistic evidence about what some linguists as well as contemporary scholars of verbal behavior believe is unique and novel about language functions (Barnes-Holmes et al., 2001; Crystal, 2006; Greer & Ross, 2008; Hayes et al., 2001; Horne & Lowe, 1996).

Indeed, this concept may be the critical gateway to complex human verbal behavior. We argue that it is also a critical *stage of behavioral development,* and a growing body of evidence suggests (a) the foundational behavioral development that makes the intercept of speaker-as-own-listener possible and (b) the subsequent learning and development that is made possible by this intercept. We first present the evidence that the speaker *(a production response)* and the listener *(an observing response)* are initially developmentally independent.

Observation and Production

An individual becomes verbal when the speaker and listener capabilities are joined within him or her. On the way to becoming verbal, infants and young children come to observe certain stimuli within their environment. Biological preparedness and adventitious experiences with certain stimuli allow the stimuli to select out the observing responses. These stimuli may be auditory, visual, tactile, olfactory, or gustatory stimuli, and all senses may be involved in observational responses (Keohane, Pereira-Delgado, & Greer, 2009). Observational responses consist of listening, looking, touching, smelling, and tasting. The listener response, as one type of observational response, is of particular importance to our analysis and thus deserves special attention.

Skinner (1957) spoke of the listener's role in verbal behavior as providing "the conditions *we have assumed in* [italics added] explaining the behavior of the speaker" (p. 34). More recent accounts include analyses of the *role of the assumed listener* (Barnes-Holmes et al., 2001; Greer & Ross, 2008; Hayes et al., 2001; Horne & Lowe, 1996). The listener mediates and shapes the behavior of the speaker, and sometimes that speaker is the listener himself or herself. Thus, a verbal person is not a "processor" of language or a "retriever" of information stored in long- or short-term memory, but instead is one who observes stimuli in a specific way and responds appropriately to them. For purposes of this analysis, listening is interchangeable with reading, because both are part of the observing side of verbal behavior. The listener and reader have their senses extended by listening and reading.

Verbal production responses are, for the purposes of this analysis, interchangeable with speaking and writing. The speaker produces behavior that functions to mediate between the environment and the listener (Skinner, 1957). A listener, or an audience, that serves to consequate the speaker governs the speaker's behavior. Speaker behavior differs from other behavior in that listeners mediate the contingencies that affect the speaker. For example, instead of reaching for something, a speaker can ask a listener to hand the item to the speaker. Hence the listener mediates for the speaker by handing the item to her or him.

Skinner (1957) described verbal thinking as the "speaker and the listener in the same skin" (p. 11). The degree to which a speaker is able to mediate his or her own speaker behavior is dependent on the degree to which the speaker listens to his or her own speaker behavior. When the speaker and the listener become joined, there is evidence to suggest that this joining is a function of experiences that occasion the intercept (Greer & Ross, 2008; Greer, Stolfi, Chavez-Brown, & Rivera-Valdes, 2005).

The Initial Independence of Observing and Producing Responses

One of the *paradigmatic shifts* (an expression we do not use loosely) introduced by Skinner's (1957, 1986) theory of verbal behavior was his position that the speaker and listener capabilities were, at least initially, independent types of responding, including their *independent evoking, eliciting, and consequating controls*. Other theoretical treatments of the listener and speaker capabilities relegate them to a single language entity with *receptive* and *expressive* attributes (Crystal, 2006; Pinker, 1999). Because our focus is on environmental sources rather than psychological constructs, we avoid the use of the terms *receptive* and *expressive*, as we are talking about the behavioral

capabilities of listening and speaking between individuals and within one's own skin—*much more is involved here than receiving and sending.*

We define verbal behavior as the language functions of both speaker and listener as the individual functions with others *and within his or her own skin.* However, the "behavior beneath the skin" that we discuss is a covert version of the overt, not a psychological construct (Uttal, 2001). Study of the physiological behavior beneath the skin will eventually be joined with the overt behavior (Barnes-Holmes et al., 2005; Dickins, 2005) as simply different sides of the same phenomenon. Both sides are important. Linguists provide necessary structural analyses (Crystal, 2006), and that is their unique contribution to an account of language. The unique contribution of verbal behavior analysis is to provide an account of the behavior–environment relations relative to how the speaker affects the behavior of others and how the listener's environment is mediated by the speaker. The structural, functional, and neurophysiological accounts are all necessary for a more complete treatment of language. It should be noted that vocal or oral language is not synonymous with our subject matter of verbal behavior, either, because verbal behavior may occur in various topographies (e.g., sign language, Morse code, smoke signals, drum beats, logograph symbols, hieroglyphics). However, as we will see later, vocal verbal behavior has advantages for advancing verbal development over other topographies (Karchmer & Mitchell, 2003; McGuinness, 2004; Robinson, 1995).

We treat listening and speaking as separately evolved physiological capabilities, whose joining is key to several contemporary accounts of verbal behavior and our developmental account. The presence of the independent physiological underpinnings (Davidson, 1978) of verbal and nonverbal behavior, including the implicit respondent and operant control, was likely determined by natural selection. These underpinnings then allowed for the *adventitious emergence of verbal behavior from cultural contingencies that drew on respondent and operant physiological capabilities* (Catania, 2001). This view of the role of environmental and cultural contingencies in the evolution of language has gained considerable cross-disciplinary acceptance (Culotta & Hanson, 2004), whereby the science of verbal behavior joins with linguistics, anatomy, physiology, anthropology, neuropsychology, and other disciplines. In our study of language as behavior–environment relations, we seek to know how independent behaviors, and their separate controls, were joined by experience in the development of key verbal behavior capabilities within the life span of the individual (Greer & Keohane, 2005/06).

Anecdotal and Empirical Evidence of Separate Listener and Speaker Capabilities

One may distinguish the sounds of an unfamiliar language as different from one's own but still not be capable of responding to these sounds as either listener or speaker within that language. The expression "It's Greek to me" says this well. Moreover, one might even learn to translate the language by relating print in another language to print in English (without the auditory component) without being able to "understand" the language as a listener or emit speaker responses (Hayes et al., 2001). To be truly verbal, the listener and speaker must be joined (Barnes-Holmes, 2001). How the speaker and listener functions come to be joined is central to an account of verbal development.

Several reports have identified children with and without disabilities

for whom listener and speaker functions were initially independent (Feliciano, 2006; Gilic, 2005; Greer & O'Sullivan 2007; Greer, Stolfi, et al., 2005; Greer, Stolfi, & Pistoljevic, 2007; Horne, Lowe, & Randle, 2004; Lee, 1981; Lowe, Horne, & Hughes, 2005; C. Sundberg & Sundberg, 1990; Tsiouri & Greer, 2007). It also appears that certain listener and speaker capabilities develop differently and even at different rates within one's life span. It is possible, and maybe even probable, that much of language development involves the differential processes joining these two capabilities.

Methods for Identifying Verbal Capabilities in Experiments

If we are to understand verbal development, it is necessary to identify how the listener and speaker functions are formed and then joined by experiences. Clearly this cannot be accomplished via descriptive analyses of the covariance between age and verbal capabilities alone. Experiments are necessary, but how can they be done?

One approach is to compare the behavior of different species with that of humans (Heyes & Galef, 1996; Zentall, 1996). Another approach is to induce language functions in primates (Premack, 1976, 2004; Savage-Rumbaugh, 1984) or simulate verbal behavior with other species (Epstein, Lanza, & Skinner, 1980). However, these lines of evidence do not tell us how verbal behavior develops within the life span of the human.

The best scientific alternative would be to discover a tribe of preverbal humans and test various environmental interventions that lead to the emergence of verbal behavior. Interestingly, something like this does exist. Our own species has both verbal and nonverbal members. Given that fact, if we can identify ways to induce verbal behavior when it is missing in members of our own species, we can provide within-species evidence.

Within-Species Experiments on Incremental Steps

The potential for incremental experimental analyses became possible with the development of behavior-analytic interventions to induce speaker and listener functions in individuals who, most likely, would not have become speakers and listeners (Guess & Baer, 1973; Lovaas, 1977; Ross & Greer, 2003; M. Sundberg, Michael, Partington, & Sundberg, 1996; Tsiouri & Greer, 2003; Williams & Greer, 1993). These interventions made it feasible to study the incremental steps involved in how the listener and speaker functions intercept. Evidence is now available to show that the two are initially independent but become joined (Greer & Ross, 2008).

Listener and Speaker Distinctions and Verbal Development

The distinctions between listener and speaker were particularly helpful in attempts to remediate language deficits. For example, it is now common for children with severe verbal delays to be taught good functional speech-production repertoires using well-known behavioral procedures, particularly the emissions of mands, which are requests or words that specify reinforcers (Skinner, 1957), and yet continue to lack important listener responses. For example, a child may have mands in his or her repertoire but not be influenced by the phonemic sounds emitted by others (Greer, Chavez-Brown, Nirgudkar, Stolfi, & Rivera-Valdes, 2005). In Greer et al.'s study, eight children with mand

repertoires could not respond to simple vocal instructions when no visual cues were missing. In the experimental intervention, the only way that the children could be reinforced was by accurately responding to the consonant–vowel sounds of the experimenter's speech. After this intervention, the children could respond as listeners. Also, for children with autism spectrum disorders, it is possible that problems with the more advanced listener capabilities contribute to what is characterized as "social deficits," the lack of a "theory of mind," or a kind of "choice to withdraw." We think that part of these problems are tied to these individuals' lacking the conditioned reinforcement control for functioning as a listener, and other related observing responses (see Reilly-Lawson & Walsh, 2007, for evidence to this effect).

The speaker's verbal function, as identified by Skinner (1957), is for the speaker to have his or her environment "mediated" by a listener. But the speaker mediates for the listener, too (Greer & Ross, 2008; Hayes et al., 2001; Horne & Lowe, 1996). The reinforcement for a listener is the extension of the listener's senses from the behavior of the speaker (Skinner 1957, 1986). The listener profits when a speaker warns the listener of consequences, as in "It is raining," "The food is terrible there," "You must see the huge moon," "Your friend may not be a real friend," or "I am upset." In addition, the acquisition of a new tact (Skinner's term for the direct control of a stimulus, as in seeing a stimulus and saying its "name") reinforces future listening to recruit tacts (as a function of prior reinforcement for emitting tacts). It is also possible that the reinforcement for being a listener needs to be present if one is to have empathy (Barnes-Holmes et al., 2000; Reilly-Lawson & Walsh, 2007).

Differences and Similarities Between Listening and Other Types of Copying

Complex Vocal Copying in Speaker, Nonverbal, and Verbal Functions

Echoics are vocal responses that have point-to-point correspondence with the vocal emissions of other speakers and that come to serve verbal functions (Skinner, 1957). A child may point to a toy and attempt to gain access to it. If a parent holds the toy while saying "toy" and the child then says "toy" in order to gain the toy, this is an example of an echoic response, in that the copying moves to a mand function. Indeed, the very first vocal copying responses are instances of what Skinner described as *parroting*. Parroting is not a speaker operant, although parroting is dependent on hearing the correspondence between what is heard and what is said. Parroting (e.g., repetitions of saying "mama" that have no functional effect for the speaker relative to a listener) may then lead to serendipitous effects on the behavior of a listener and result in speaker operants such as mands and tacts. When a short history of vocal copying results in speaker effects on a listener, the parroting shifts to echoic operant functions. Whereas Skinner characterized these speaker operants as being verbal, others have suggested that they are not fully verbal if the speaker is not simultaneously a listener (Barnes et al., 2001).

Very young children and children with language deficits may have speaker operants that are not verbal (Ross & Greer, 2003; Tsiouri & Greer, 2003, 2007). However, this does not mean that a child has the speaker-as-own-listener capability needed to be fully verbal (Barnes-Holmes et al., 2000; Greer, Stolfi, et al., 2005; Greer, Stolfi, et al., 2007; Horne & Lowe, 1996).

Nevertheless, the speaker operants are critical in advancing the special mediated reinforcement that separates verbal observe-and-produce effects from other types of human observation-and-production relations (e.g., see–do, hear–sing, see–draw). The speaker operants are necessary for establishing one of the mediating functions of verbal behavior. The echoic is a necessary *speaker operant,* and it can be induced as a result of special arrangements for joining see–do and hear–say as a higher order copying class (Greer & Ross, 2008; Ross & Greer, 2003; Tsiouri & Greer, 2003). A higher order operant results when two or more previously independent operants join as an overarching operant (Catania, 2007).

Ross and Greer (2003) and Tsiouri and Greer (2003) reported procedures that resulted in children acquiring functional speech who had never spoken, one of whom was 9 years old. This occurred when opportunities to echo were preceded by teaching them generalized imitation or the capability to imitate novel behavior. This new capability for generalized imitation was then used as a part of an intervention to induce speech. Several body-imitation responses (see–do) were alternated with the opportunity to echo words in mand functions under relevant deprivation conditions for emitting the mand (echoic-to-mand). The observing-and-producing responses for imitation are independent because seeing-and-doing involves (a) seeing someone perform a response, (b) emitting the response, and (c) observing the visual correspondence between one's own response and the response of the other. This is not easy, as anyone who has ever tried to learn a new dance step can attest. However, whereas hearing-and-saying is a copying response, as is seeing-and-doing, acquiring the correspondence between what is observed and one's own production is more difficult for the hear-and-say relations because one only "observes" the speech of another aurally. One can observe only the outcome because the process remains hidden from view, for the most part. We must match the observed speech with our own sounds, without the advantage of seeing how it can be done (Vargas, 1982). Moreover, we must observe the correspondence between our spoken sounds and the speech of others in the process of emitting the echoic. Indeed, the echoic is similar to what has been identified in the social learning research as emulation (Heyes & Galef, 1996). In emulation, the product is copied, whereas in imitation, the process is copied. However, what the see–do and hear–say relations have in common is that *they both involve correspondence between observing and producing* as an overarching class of operants. Tsiouri and Greer (2007) found these two different observing-and-producing classes to be initially independent. However, in the experiments by Ross and Greer (2003) and Tsiouri and Greer (2003), they were joined into an overarching operant as a result of multiple exemplar rotations across the different classes (i.e., generalized imitation and the echoic-to-mand conditions). The new relation is a higher order cross-modal relation involving the joining of two different classes of observing-and-producing responses.

Although higher order operants occur within either of the speaker categories, special benefits accrue with the *emergence of higher order operants across speaker and listener responding* that lead to being fully verbal. This is made possible by more advanced listener roles in the speaker-as-own-listener capability. A more advanced listener results when a child incidentally acquires new vocabulary from hearing others "label" or tact aspects of the environment. This special listener capability of acquiring the tact, or label

for an object, without direct instruction is a much more advanced listener capability, as we will describe later.

Differences in Reinforcement Effects of Verbal and Nonverbal Observation and Production

Although observing and emulating are important for language functions, observing and producing correspondences are found in other types of complex human behavior, as in the making of music, dance, or visual art. The reinforcement for the latter is direct, immediate, and automatic. Automatic reinforcement occurs when behavior itself is the reinforcer (e.g., a child swinging on a swing). However, language functions are unique because the reinforcement is indirect and another person mediates it. Creative and seemingly untaught outcomes (i.e., derived relations) occur in the arts and in language. As described earlier, novel, creative, or spontaneous behavior is derived behavior, in that it is not directly taught but instead emerges as a function of the acquisition of certain types of stimulus control. This kind of control emerges because of certain histories (Greer & Ross, 2008). We suggest that derived relations are possible in each of these categories of observing and producing responses. Thus, higher order operants are not restricted to verbal functions. However, a critical component of being verbal occurs when higher order operants involve reinforcement that results from language functions.

Rotation of the Listener and Speaker

The rotation of speaker and listener responses between individuals, or turn-taking, is readily observable, and there is an extensive linguistic literature (e.g., Crystal, 2006) on the structure of these episodes. There is also a verbal behavior literature identifying certain types of rotations as particular types of interlocking verbal behavior units themselves (Donley & Greer, 1993; Pistoljevic & Greer, 2006). The latter studies demonstrated what Skinner characterized as episodic verbal behavior between individuals. When both listener and speaker responses are reinforced for an individual in a dyad involving turn-taking, it is an observable incidence of an episode in which both speaker and listener responses for each of the individuals are reinforced. Moreover, the rotation between speaker and listener within the individual's own skin is observable also, as in when young children talk to themselves aloud while engaged in fantasy play (Lodhi & Greer, 1989).

Audience Control

As most, but not all, children gain more experiences with audiences, they cease to speak aloud to themselves in the presence of others, due to the repressing effects of having an audience. Some children and adults continue to talk aloud using contextually inappropriate speech because they lack the contextual audience control. The presence of the audience for older children punishes the overt speaker and listener responses—a phenomenon that Skinner (1957) referred to as one of many types of audience control.

In a controlled experiment, Hugh (2006) compared several consequences for children's talking aloud in free-play settings when they emitted what appeared to be contextually inappropriate speech. She found that the contingent removal of or production of 3-s recordings of the children's self-talk or music

resulted in the children's ceasing to talk aloud in free-play settings. Apparently, these contingencies resulted in the child discriminating the presence of an audience. The opposite happens when individuals sing aloud, as in situations where they listen to recordings wearing earphones (often followed by the appearance of embarrassment when the person realizes an audience is present). However, we suggest that one's speaker and listener responses within the skin do not stop, they simply become covert—a progression not unlike the process whereby one goes from reading aloud to reading silently. For example, when certain audiences are not present, adults continue to emit both speaker and listener responses aloud—for example, when they talk to their computer, seatbelt alarm, a recalcitrant drawer or shirt button, or their pets. Clearly, audience control, or the lack thereof, is at work here (Epting & Critchfield, 2006). A more advanced level of self-talk occurs when a writer, in the process of editing, rotates the covert speaker and listener roles. The effective reader "listens" to what is read, and an effective editor listens to what she or he writes *as the target audience would listen to what is written;* that is, he or she listens for the responses that would reinforce the target reader.

Gaining Reader and Listener Control

Several studies have demonstrated written and vocal verbally governed behavior where the verbal stimulus control for performing algorithms was isolated and shown to result in verbally governed problem solving (Keohane & Greer, 2005; Marsico, 1998). In these experiments, written directions or algorithms for performing problems were provided to participants. In the Marsico study, middle school students were taught algorithms to solve math problems until they could learn new math operations solely by following print instructions. Probes with novel algorithms for learning other subject matter showed that the students were now under the written control of verbal print stimuli. In this experiment and the Keohane and Greer study, prior to acquiring verbal stimulus control, written instructions did not result in use of problem-solving operations, whereas afterwards they did. Such verbally governed behavior is facilitated by the connection of written language to phonemic sounds in speech. This is evident in the history of written languages and the best research on reading and spelling, wherein phonemic auditory control is shown to be essential (McGuinness, 2004; Robinson, 1995). However, what of the child who, for native or environmental reasons, lacks a listener capability or has a weak listener repertoire? Or, what of the child who does not receive, or has not yet received, the experiences necessary to join the listener and speaker within the same skin?

It is very likely that many complex verbal problem-solving tasks involve the joining of the listener and speaker repertoires within one's own skin, or substitutes, if one is deaf. However, members of the deaf community seldom have reading comprehension beyond the sixth-grade level (Karchmer & Mitchell, 2003). The lack of phonemic auditory components of reading is regarded as the source of the problem. Thus, one speaks and, when able, listens to oneself, or goes from listening to matching first instances of speaking with what is heard.

The Merging of Listener and Speaker

The evidence for how the listener and speaker are joined grew out of

research tracing the emergence of certain verbal developmental cusps and capabilities; one of the most important is a phenomenon identified as *Naming* (Horne & Lowe, 1996; Horne et al., 2004; Lowe et al., 2005). The verbal developmental capability of *Naming* (capitalized herein to distinguish it from common usage) is not merely saying or labeling things using language; rather, it is a *verbal developmental cusp* (Rosales-Ruiz & Baer, 1996) and a *verbal developmental learning capability* that allows a child to simultaneously acquire speaker and listener vocabularies incidentally. That is, the child acquires new vocabulary without direct instruction and seemingly without reinforcement.

Naming

Horne and Lowe (1996) first identified Naming as a verbal developmental capability and provided a series of experiments on Naming as a facilitator of emergent categorizations. Naming has been described as the real beginning of what is essentially being verbal (Barnes-Holmes et al., 2001; Hayes et al., 2001; Horne & Lowe, 1996). Horne and Lowe also proposed a program of research on Naming as a dependent variable—the origin of this developmental phenomenon.

> To study Naming directly entails … experimental investigation from birth, of how the young child learns the behavioral relations involved in Naming. This approach would certainly be more parsimonious; it is also in the best tradition of behavior analysis. Such a study would enable researchers to come to terms with the full complexity of the phenomenon, both in terms of the conditions that give rise to it and the interactions between the multisensory stimulation and the multi-modal responding that it entails, including emotional behavior and the effects of classical conditioning. (Horne & Lowe, 1996, p. 238)

Horne and Lowe (1996) identified Naming as a developmental phenomenon, and much of the research on Naming has treated it as an independent variable or as a process leading to categorical or derived responding (Miguel, Petursdottir, Carr, & Michael, 2008). This research tests whether being verbal (having Naming) is essential to, or facilitates, certain types of derived relations. However, Naming itself is emergent behavior involving derived relations, and it is a developmental verbal cusp and capability (Fiorile & Greer, 2007; Gilic, 2005; Greer & Keohane, 2005/06; Greer, Stolfi, et al., 2005; Greer, Stolfi, & Pistoljovic, 2007). The research that we describe focused on Naming as a developmental cusp and capability in cases where children who lacked the Naming capability acquired it as a function of experimental interventions. The experiments described below were pre- and postintervention time-lagged multiple-probe designs, or designs that combined experimental-control group designs with nested time-lagged multiple-probe designs, and provided controls for maturation and instructional histories. These studies were not demonstrations of Naming as an example of emergent behavior or tests of the relation of Naming to derived relational responding, although that occurred too; rather, they were experimental tests *for the effects of interventions on the emergence of Naming itself.*

The Experimental Analyses of the Acquisition of Naming: Procedures

Testing for the Presence or Absence of Naming. The test for the presence or absence of Naming is done as follows. Visual stimuli (both contrived and uncontrived pictures or symbols) with corresponding contrived or uncontrived vocal labels (tacts, to use Skinner's term for seeing and saying) are presented to a child in a match-to-sample arrangement in which correct and incorrect matches are present. The child is then given a card that matches one of the samples while the experimenter says the tact for the stimulus (e.g., "match zog," as a contrived tact for a contrived stimulus, or "match hawk," as a tact of a particular bird). The child is then required to place his or her sample card on the correct match. This experience provides a *controlled simulation* of the conditions under which a child with Naming would naturally acquire a new speaker response (e.g., "that's a hawk," as a tact) and the relevant listener response (point to or look at the hawk when someone emits the tact or says "hawk") without direct instruction. These conditions, under which the child matches the correct visual stimuli *while hearing the experimenter say the tact for the stimulus*, ensure the joint attention of the child and the experimenter to the visual stimuli and set the occasion for the child to learn the tact. If the child masters the visual matching requirement while the tact is spoken by the experimenter, but cannot emit both the speaker and listener response, the child is identified as not having the Naming capability. The child may have the listener component but not the speaker component (most typically) or vice versa (in rare cases) and is then identified as having either the listener or speaker half of Naming. If the child emits both listener and speaker responses, she or he is identified as having Naming as a verbal developmental cusp and capability. (We will describe the distinctions between cusps and capabilities later.)

Naming as a Dependent Variable

Another common feature of these experiments is that individuals without Naming became the participants in experiments designed to test for the effects of interventions on the emergence of Naming as a dependent variable. The conditions outlined in the prior paragraph constitute the pretest. After the intervention, the children are tested again for Naming using the same procedures as in the pretest described above; however, in the posttest, the children do not repeat the matching trials while hearing the spoken words for the visual stimuli. Rather, the children must point to the stimuli as a listener and tact the stimuli as a speaker—responses that they could not make prior to the experimental intervention. If the child emits unreinforced correct responses as a listener and speaker to 80% of the probe trials, he or she also receives a novel set of stimuli. The child is then taught to match the novel set of stimuli *while hearing the experimenter say the tact for the stimuli* and then probed for untaught speaker and listener responses. If he or she meets the 80% criterion on the initial probe set and the novel set, the child is deemed to have the Naming capability.

Instructional Components of Multiple Exemplar Instruction: The Independent Variable

Our early intervention consisted of what we describe as multiple exemplar instruction (MEI) across listener and speaker responding for one

or more instructional sets of stimuli (i.e., five different stimuli presented four times in 20 instructional trial sessions/blocks). The child receives instructional trials on stimuli different from the stimuli used in the pre- and postintervention probe trials. The instructional trials consist of reinforcement for correct responses and a correction for incorrect responses in which the child must emit the correct response while attending to the stimulus but is not reinforced. Providing the correction appears to be more efficient than differential reinforcement alone, as Skinner (1968) found when he developed the *frame* in programmed instruction (Kangas & Branch, 2008). The presence of all of these components in instructional trials, as in the frame, meets the requirements for what has been identified in several experiments as learn units. Learn units consist of instructional presentations that have all of the tested components, described above, that were found to ensure mastery (Albers & Greer, 1991; Emurian, 2004; Emurian, Hu, Wang, & Durham, 2000; Greer, 1994; Greer & McDonough, 1999; Ingham & Greer, 1992; Selinske et al., 1992; Skinner, 1968).

Multiple Exemplar Instruction Across Listener and Speaker Responding

Using learn units, we do visual match-to-sample presentations with pictures or objects while the child hears the experimenter tact or say the "name" for the picture or object. Next, a listener trial may be presented in which the child is asked to point to a stimulus in an array that includes a correct stimulus and incorrect stimuli; however, the stimuli are counterbalanced such that they are not presented in immediate serial proximity for the different speaker and listener responses. This ensures that the visual stimuli will control the response, along with vocal stimuli, for listener and match-to-sample trials. Next, a speaker response is presented. The presentations continue until the child masters all of the listener and speaker responses for the instructional set (five pictures or objects). If one response is mastered for all stimuli, it is still presented in rotated fashion but not reinforced, with the responses not mastered until all responses to the five stimuli are mastered for the instructional set. Mastery is a criterion of 90% across two consecutive sessions (80 trial sessions/blocks) for all speaker and listener responses to all five stimuli in the instructional set.

Experiments on the Induction of Naming: Findings

In the process of screening for children missing Naming in our experimental analysis for the sources of the acquisition of Naming, we coincidentally acquired some evidence about a correlation between age and the presence of Naming. In screening for children with and without Naming, Gilic (2005) tested 19 typically developing 2- and 3-year-olds. She found that 9 out of 9 typically developing and sensory-intact 3-year-olds from upper middle class families (a demographic that suggests they had rich language histories; Hart & Risley, 1995) had both the speaker and listener responses for three-dimensional objects after hearing an adult say the tacts for stimuli as the child learned to match the stimuli as described above.

In the same sample, 8 out of 10 upper middle class 2-year-olds could not do this. Some could respond as listeners but not as speakers, or vice versa. We determined they lacked Naming if, as a result of the Naming test, they (a) could respond to the stimuli as listeners but could not say the words for the stimuli, (b) could respond as speakers but not as listeners, or (c) could do neither. The children who lacked Naming became candidates for the MEI intervention described earlier. After the MEI interventions, they responded with both listener and speaker responses to the original stimuli (unfamiliar objects) to which they did not respond initially with the contrived "names." The instructional history that led to Naming was shown to be experimentally traceable to the multiple exemplar experience because the relevant pre- and posttests and the interventions were time-lagged to control for history and maturation. Moreover, in this and other experiments, the design also included an experimental and control group component (Gilic, 2005; Greer, Stolfi, et al., 2007; Pistoljevic, 2008). In each of the experimental and control group designs, 4 children who did not have Naming remained in a matched control group that did not receive MEI until the first 4 participants attained naming. The control groups did not attain Naming. Subsequently, the children in the control groups received the MEI intervention that was introduced in a multiple-probe time-lagged design, and they attained Naming. These experiments and others that we shall describe showed that the capability accrued from experiences, not age. Age often provides opportunities for relevant experiences, but only if the child has the prerequisite experiences that, in turn, allow her or him to make contact with the special contingencies that lead to the emergence of Naming and other verbal developmental capabilities (Greer & Ross, 2008).

Capabilities, Cusps, and Repertoires

We have come to make certain distinctions between capabilities, cusps, and repertoires. Our distinctions are not universal in behavior analysis, but differences in the outcomes associated with each suggest that they are important distinctions.

Behavioral Developmental Cusps

One of the most important conceptual contributions to a behavioral treatment of development was the notion of behavioral developmental cusps. Rosales-Ruiz and Baer (1996) identified behavioral developmental cusps. Their identification and description of behavioral cusps are key to the contemporary study of development from the behavioral perspective:

> 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. (p. 166)

Cusps That Are New Capabilities

For example, once a child learns to walk, she or he comes into direct contact with new contingencies or experiences that result in new learning opportunities. The child learns from direct contact with new contingencies, or reinforcing or punishing experiences, that she or he could not contact before. However, when the induction of a behavioral developmental cusp also results in a child's being able to learn in a way he or she could not before, we identify that as an *experientially derived verbal developmental capability* and higher order or overarching operant (Healy, Barnes-Holmes, & Smeets, 2000). For example, once children have Naming, they acquire new words in speaker and listener functions without direct instruction. Thus, they can learn in ways they could not before. Once they have the Naming capability, their vocabulary expands commensurate with their having experiences in which speakers tact objects. Until children have Naming, they must be taught new speaker and listener responses via direct instruction involving differential reinforcement and corrections. While a developmental capability is a cusp, not all cusps are developmental capabilities.

Capabilities allow children to learn in ways they could not before, and they are crucial to language development. For example, McGuinness (2004), in an exhaustive review of the literature on reading and spelling, reported evidence that children need 55,000 words for normal discourse and 86,000 words to be successful over the course of the elementary school years. If this is the case, it is not likely that these were learned via direct instruction. Hart and Risley (1996) reported few incidences of direct instruction in language in their longitudinal study of the development of language. This phenomenon, whereby children seem to acquire language seemingly without direct instruction, has led some, but not all, linguists to posit innate psychological language constructs, and discount the role of learning, based on anecdotal descriptions of emergent language (Pinker, 1999). Of course, now that Naming and other verbal capabilities have been shown to be the result of experimentally isolated experiences, these construct theories seem to have less face validity (Barnes-Holmes et al., 2005; Feliciano, 2006; Fiorile & Greer, 2007; Gilic, 2005; Greer, Nirgudkar, & Park, 2003; Greer, Stolfi, et al., 2005, 2007; Greer & Yuan, 2008; Miguel et al., 2008).

The Importance of Naming in Incidental Learning and Formal Education

Much of what we learn incidentally and in classrooms must occur from the following: (a) the Naming capability (Greer & O'Sullivan, 2007), (b) the ability to learn from *indirect contact* with learn units (Greer, Singer-Dudek, & Gautreaux, 2006), and (c) the emergence of conditioned reinforcement from observation (Greer & Singer-Dudek, 2008; Greer, Singer-Dudek, Longano, & Zrinzo, 2008). Catania (2007) suggested that it is likely that the Naming repertoire is also the basis for the ability to speak about things in their physical absence, consistent with Skinner's term *conditioned seeing*. Naming is also important for children's success in most educational settings. Children can profit to some degree in typical classroom settings if they have Naming, but if they do not, the lack of direct learn units (direct reinforcement and corrections) in most educational settings means that they cannot be successful (see Greer, 1994, for data on the lack of direct instruction in classrooms).

For those who teach young typically developing children, it is common to find that when children are taught, for example, to point to colors as the teacher says the word for the color (a listener response), they cannot say the "name" of the color (a speaker response) even when they can match the stimuli visually (Engelmann & Carnine, 1991; Lee, 1981). This difference is true for the range of curricula, such as pointing to and saying letters, phonemes, numbers, objects, and shapes. The child's reaching a point at which he or she can emit the speaker response after learning the point-to response and vice versa is made possible, it would seem, by acquiring the Naming capability. Chase, Johnson, and Sulzer-Azaroff (1985) identified what we believe is a more advanced case of the persistence of the independence of the speaker and listener, and problems in the joining of the two. They found significant differences between production and selection responding in mature and intellectually capable college undergraduate students, where performances on multiple choice questions (a selection response more in keeping with a listener response) and essay exams (a production or writing response) were different. Moreover, some impoverished middle-school-age children were found recently to also lack Naming (Helou-Care, 2008). These students were similar to the children from low-SES families who were identified in the Hart and Risley (1995) longitudinal study as having low levels of verbal language experiences compared to middle income families and professional families.

Other Speaker-as-Own-Listener Capabilities

Naming is a critical speaker-as-own listener capability, but it is only one of the three such capabilities that have been identified (Greer & Keohane, 2005; Greer & Ross, 2008). The other two types identified in the research include say–do correspondence (Paniagua & Baer, 1982; Rogers-Warren & Baer, 1976) and self-talk conversational units involving the speaker and listener in the same skin (Lodhi & Greer, 1989). All three of these speaker-as-own-listener capabilities are cases of the joining of the speaker and listener within the individual.

When children have say and do correspondence (saying what you are going to do and then doing it), we have some evidence that the child's speaker repertoire is responded to by her or his listener capability. There is something much more basic here than "self-management." That is, if a child says, "I am going to play with an item" and then proceeds to do so, we say there is correspondence between what *she or he says* and *what she or he does* (Paniagua & Baer, 1982); however, as Paniagua and Baer pointed out, to be true say–do correspondence, the effect cannot be the result of direct instruction. This is evidence that the phonemic sounds and the vowel/consonant blends of words said by the individual have correspondence with the individual's own listener responding. The individual's own speaker stimuli join the individual's own listener responses.

Lodhi and Greer (1989) identified speaker-as-own-listener responding when they studied self-talk during the solitary play of typically developing 5-year-olds. Independent observers, who were naïve to conditions, observed videotapes of children engaged in solitary fantasy play. The children occasionally "directed" their activities, demonstrating say–do correspondence. In addition, the children talked aloud to anthropomorphic toys (stuffed animals, dolls, and pictures of people and animals that were used to evoke

speaker-as-own-listener responding in fantasy play). In that fantasy self-talk, they responded in both speaker and listener roles, changing their tone of voice and function such that they completed conversational units. Conversational units are units of verbal exchange or turn taking between two or more individuals, or within a single individual, that result in an exchange in which each party (or separate capability within the individual) completes interlocking verbal operants as both speaker and listener (Donley & Greer, 1993; Lodhi & Greer, 1989; Pistoljevic, 2008; Pistoljevic & Greer, 2006).

For example, in one case of a self-talk conversational unit taken from Lodhi and Greer (1989), the child speaks to a stuffed horse and says, "Hi, horsy," and the horse responds in a different voice as a listener-speaker, "Want to play with me?" Subsequently the child responds, "Let's play in the dollhouse," the horse and child move to the dollhouse, and play occurs (a listener response). The original speaker responded to the presence of the horse, the horse responded as listener and speaker, and the original voice responded as a listener by moving to the play area. When the pair then went to the dollhouse, they also demonstrated say–do correspondence and perspective taking (Y. Barnes-Holmes et al., 2000; Luciano, Herruzo, & Barnes-Holmes, 2001). Note in this case that the correspondence was not the result of prior instruction (Paniagua & Baer, 1982).

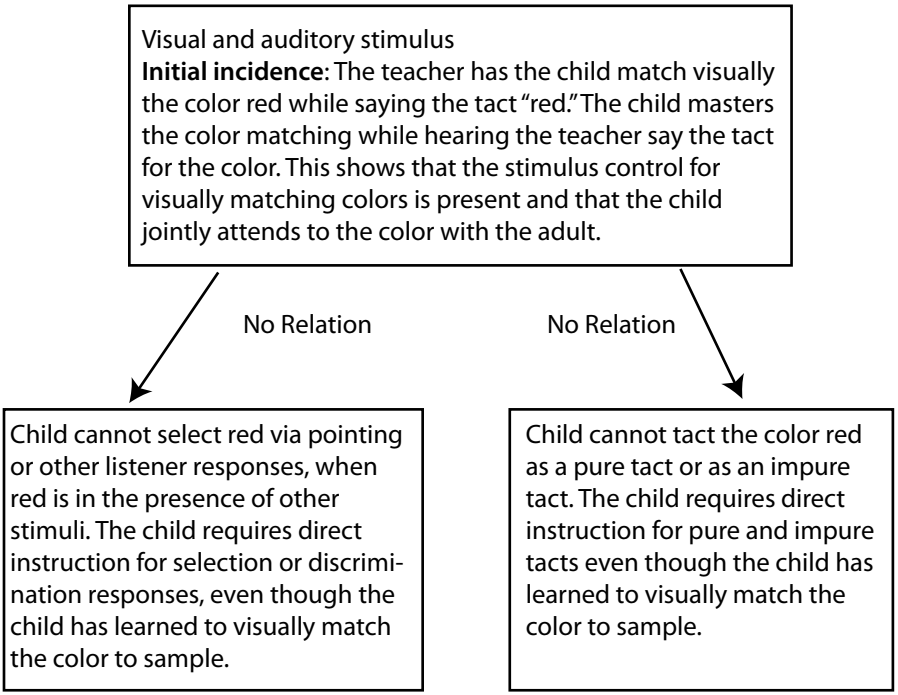

Figure 1. A child for whom the Naming capability has not yet emerged.

We can observe the same phenomenon in adults as they serve as both speaker and listener with their preverbal infants. A mother may produce the question, "Does Mommy love you?" and respond for her baby, "Yes, I know

Mommy loves me very much." Although the mother's overt speaker behavior for the most part may be under audience control, this type of self-talk is culturally acceptable and, to most people, endearing. Conversational units, and self-talk involving correspondence between saying and doing, together with Naming are components of the joining of the speaker and listener capabilities in the individual. These, in turn, are foundational to most complex verbal behavior.

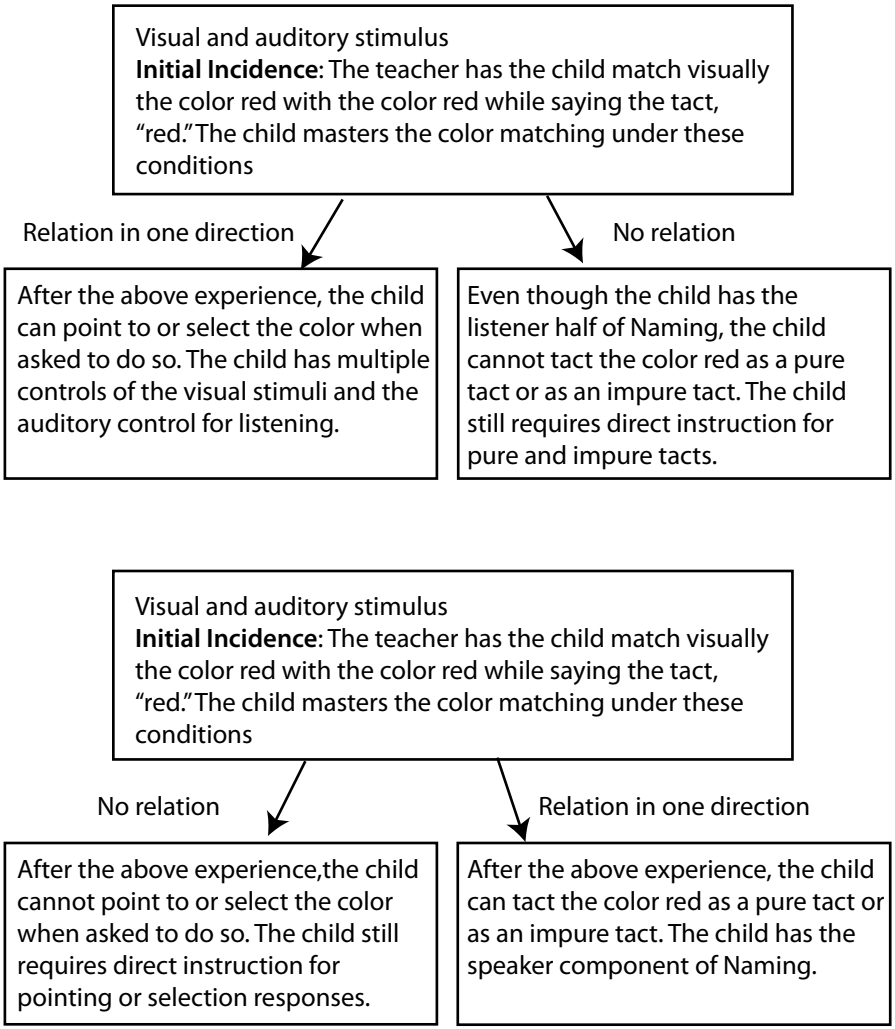

Figure 2. Children for whom only the listener or speaker halves of the Naming capability have emerged.

Development of the Components of Naming

Figures 1 though 5 illustrate how one of these speaker-as-own-listener capabilities, Naming, emerges as a result of the transformation of stimulus control across speaker and listener and how it can also incorporate abstraction

or categorization (the example of red used in Figures 1 and 2, or maple trees in Figure 3). By "transformation of stimulus control" we mean the following. Prior to the acquisition of Naming, the experience of hearing others tacting visual or other sensory stimuli did not result in learning the tact or listener response; or, one of the responses was learned but the other was not. After Naming, the stimuli found in such experiences were transformed to control the untaught speaker and listener components of Naming. Note that this is not stimulus or response generalization; rather, certain instructional histories transformed the control of these stimuli from observation alone.

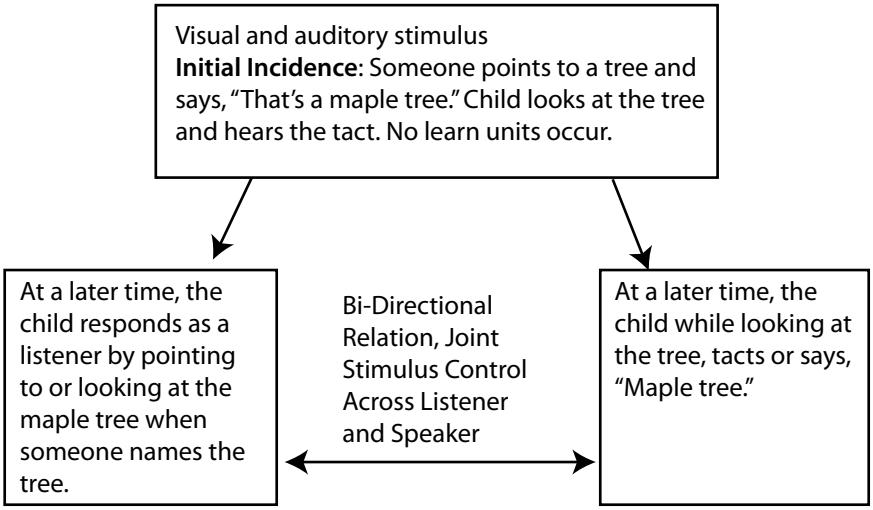

Figure 3. A child for whom the Naming capability has emerged.

Figures 1, 2, and 3 provide examples of children without Naming, children with either the listener or speaker components of Naming only, and children with full Naming. Figure 3 shows how the stimuli in Figures 1 and 2 were transformed. Several studies using the experimental procedures we described earlier have identified typically developing children and children with language delays who lacked Naming, had speaker or listener components of Naming, or had full Naming (Fiorile & Greer, 2006; Gilic, 2005; Greer & O'Sullivan, 2006; Greer, Stolfi, et al., 2005, 2007; Lowe, Horne, Harris, & Randle, 2002; Lowe et al., 2005;). Also, several experiments have shown that children who lacked Naming acquired it as a function of a multiple-exemplar intervention or related interventions (Feliciano, 2006; Fiorile & Greer, 2007, two experiments; Gilic, 2005, two experiments; Greer, Stolfi, et al., 2005, 2007, two experiments; Helou-Care, 2008; Longano, 2008, two experiments; Nirgudkar, 2005; Pistoljevic, 2008, two experiments).

When Naming Joins Print Control: Reading and Writing

Naming plays other critical roles. For example, as a verbal developmental capability, Naming may be basic to the manner in which print stimuli become a critical part of verbal functions (Lee-Park, 2005). When children learn to say the *sounds of letters,* or phonemes, they can say the printed words that Skinner (1957) called *textual responding.* As they speak the words in the

textual response, they also hear what is said. That is, if a child decodes (i.e., textually responds to or says) the phonemes K-A-N-GA-R-OO and the child has the tact and listener responses for *kangaroo* that accrued from hearing someone tact a kangaroo, the listener component of Naming provides comprehension (see Figure 4). Helou-Care (2008) demonstrated this relation in a recent experiment. Students were selected for the experiment who (a) were fluent phonemic textual responders (i.e., they "decoded" words accurately and at 160 words per minute or faster) but (b) had poor comprehension for contrived stories and (c) lacked Naming. On the pretest with contrived stimuli and words, they could not answer comprehension questions. Following the induction of Naming, the participants demonstrated comprehension on their

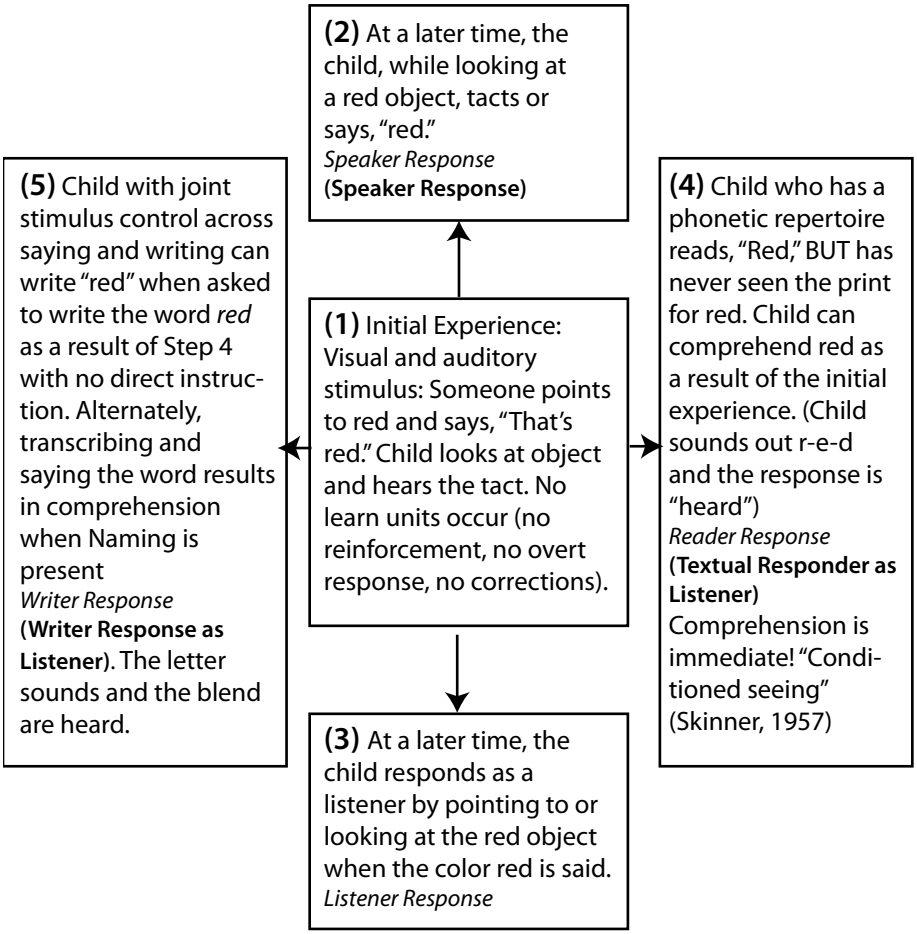

Figure 4. The joining of print to the Naming capability, where a child with Naming who also has phonemic stimulus control can emit textual and spelling responses without instruction and who will have comprehension as a function of a Naming experience.

posttest performance with the contrived story. In a related experiment, Reilly-Lawson (2008) found that students who achieved Naming but lacked fluent

phonemic decoding had comprehension as a function of being taught fluent phonemic decoding. The auditory stimulus and the listener capability play a key role. One may substitute verbal signs for stimuli (e.g., American Sign Language). Thus, a child may have Naming that involves observing signs for stimuli along with observing the stimuli designated by the sign. All of the other relations leading to reading and writing may follow a similar path as described for the listening child with speech. However, without the auditory phonemic control of listening, deaf children achieve reading comprehension at only the sixth-grade level (Karchmer & Mitchell, 2003). The listener is key in the Naming capability–derived relations between print and textual responding, and derived relations between hearing or saying and writing.

Figure 5 illustrates the possible emotional effect of "conditioned seeing" (Skinner, 1957), which accrues from the joining of Naming and phonemic responding to text. In the Naming experience, emotional effects are also conditioned, and these can be elicited by reading (Leader, Barnes-Holmes, & Smeets, 2000; Longano, 2008; Roche & Barnes-Holmes, 1997). The term *frame* seems to capture the extensive potential of these relations (Hayes et al., 2001) relative to the environmental sources for their formation. In our early experiments we did not test for mutual or combinatorial entailment. Testing for these constitutes the litmus test for a relational frame. However, in a recent study, Reilly-Lawson (2008) did show the role of mutual and combinatorial entailment.

Naming is not the only way in which readers achieve comprehension. The second condition under which they may have comprehension occurs when readers receive learn units for the novel words they read. That is, they are taught the tacts, as when we learn new abstract terms from direct instruction (e.g., instruction in the difference between types of molecules). The third condition involves indirect contact, as in observing others receive instructional contingencies for tacting and emitting listener responses to a stimulus (Greer et al., 2006). An example of this occurs when a lecturer questions other students and an observing student observes reinforcement and corrections received by others. Of course, if a lecturer simply lectures and illustrates, but does not provide learn units or observational experiences of others receiving learn units, students will learn only if they have Naming.

If the child has still another type of derived relational responding across saying and writing, he or she can also spell a novel word. That is, if the child has derived relations between the phonemic sounds and the writing of letters for those sounds when he or she hears a word, the child can spell the word in a written response or say the letter "names" for the word. This is not a case of generalization or transfer, as the responses are different. When children are taught to spell by saying the phonemes, writing the letters is an entirely different behavioral topography. Similarly, if taught to write the letters, saying the letters phonemically is a different response. Saying the letter names is still another response.

Greer, Yuan, and Gautreaux (2005) found that multiple-exemplar instruction across saying and writing letters with a training subset of dictated words led to children's producing either untaught written responses or untaught vocal responses without direct instruction when they could not do this prior to a multiple-exemplar intervention. During the interventions, the children learned to respond to dictated words by saying the letters and then writing the letters. Afterwards, they could spell the words they originally could not in both written- and spoken-response form. The two experiments, each with four participants, used multiple-probe and time-lagged designs, again controlling for maturation and history.

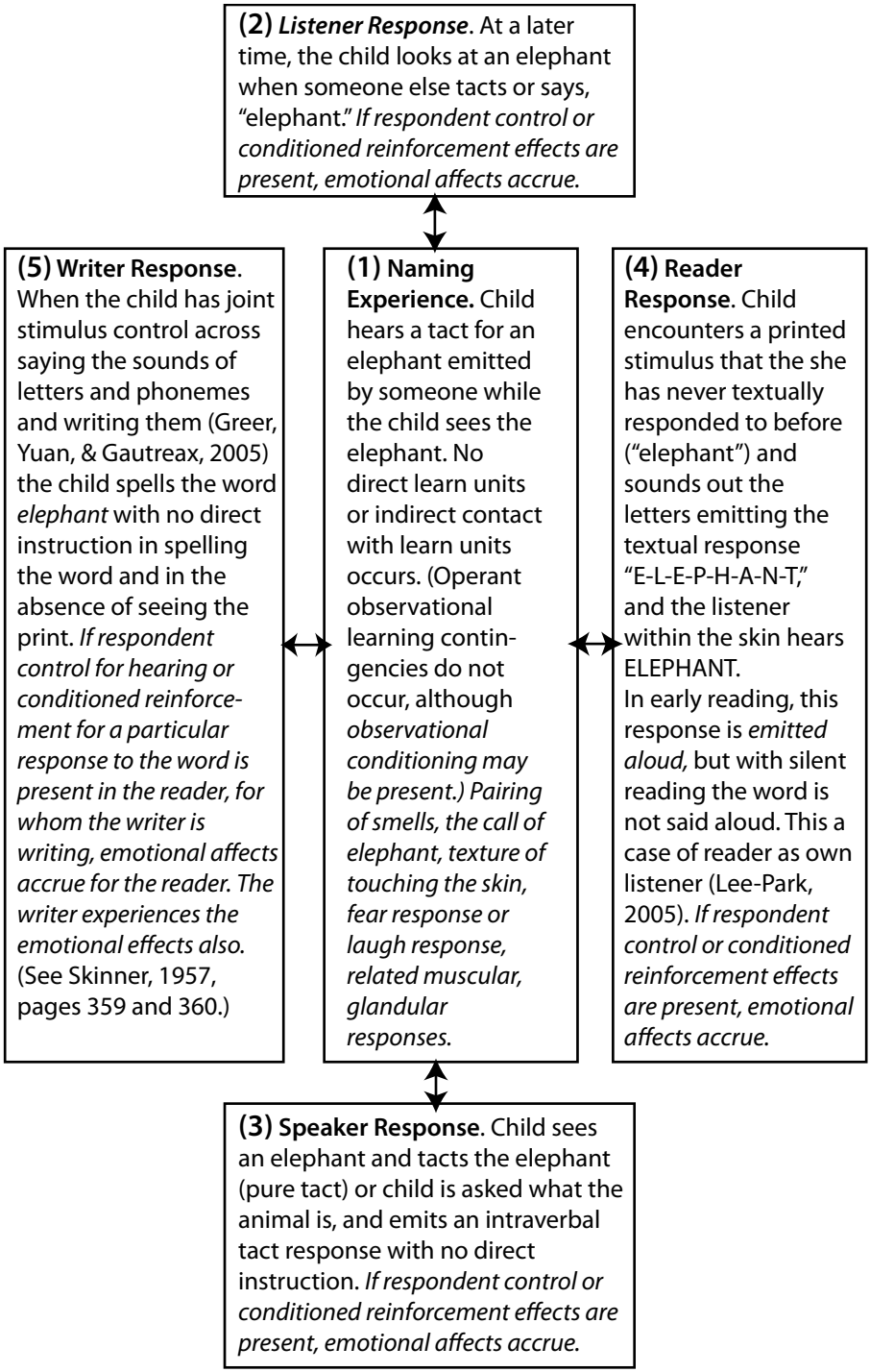

Figure 5. Possible source of emotional effects for a child who has the capabilities shown in Figure 4.

Development of Preverbal Cusps and Speaker and Listener Capabilities That Allow the Joining of the Speaker and Listener

There is growing evidence regarding some of the prerequisite developmental cusps and capabilities that make it possible for the speaker and listener to be joined. Though space does not permit an in-depth discussion here, a recent book and article describe these in detail, along with the evidence base for them (Greer & Ross, 2008; Keohane et al., in press). Here we provide a brief overview before returning to a discussion of how the joining of speaker and listener in the three speaker-as-own-listener functions leads to the most complex human verbal behavior.

Numerous developmental foundations seem to provide the child with the potential to benefit from coming in contact with experiences that allow the joining of speaker and listener. For this part of our story we draw on literature in developmental psychology, as well as work in behavior analysis. We suggest that the process begins in the uterus, where the pairing of the mother's voice with in-uterus feeding apparently conditions her voice as a reinforcer for the observing response of listening (Decasper & Spence, 1987). Decasper and Spence, in a well-controlled experimental work, found that newborn infants orient to their mother's voice. When vision develops, the voice of the mother is paired with her face, along with other sensory experiences (scents, olfactory kinesthetic or tactile sensory experiences). Respondent and operant relations are joined in ways described by Donahoe and Palmer (2004). When infants can see their mother's face, feel her touch, detect scents, and taste the milk, these sensory experiences provide introductions to see and do, as when the children perform as their mothers do. Skinner (1957) made brief reference to these processes as *ostensive learning* (see Stemmer, 1992, for elucidation). In other words Pavlovian conditioning processes play a large role (Leader et al., 2000; Longano, 2008; Roche & Barnes-Holmes, 1997). Numerous responses, and evoking and eliciting stimuli for those responses, accrue. These lead to still other relations that we suggest are behavioral developmental cusps that, in turn, lead to verbal behavior. The acquisition of conditioned reinforcement for the correspondence between observing and producing appears key.

Emitted Behavior and Sensory Experiences

Vocal sounds, along with other naturally selected emitted behavior (e.g., swimming motions present before and after birth), are emitted from the outset and come to be related to the aforementioned observing responses (Donahoe & Palmer, 2004; Novak, 1996). Stereotypical play with production or emission of motor movement, including vocal sounds and observing, occurs simultaneously. The range of observing responses accrues, including conditioned reinforcement for the correspondence between what is observed and what is produced. Observations involving the senses of smell, taste, oral mouthing, touch, and the relation between being touched and touching progress (Luciano & Polaino-Lorente, 1986; Meltzoff, 1996; Meltzoff & Moore, 1983). Derived relations between the behavior of caretakers and the child accrue, including touching and imitation, because of the conditioned reinforcement for correspondence (Meltzoff, 1983; Peláez-Nogueras et al., 1997; Poulson, Kymiss, Reeve, Andreatos, & Reeve, 1991).

Movement and Observation

Movement and observing responses come under the control of both visual and auditory stimuli, either separately or paired. These operants occur and are maintained by generalized reinforcement in the form of conditioned auditory, kinesthetic, olfactory, gustatory, and visual stimuli (e.g., mother's voice, touch, and smile). Imitation responses occur in response to caregivers' movements and gestures, and parroting occurs in response to caregiver vocal sounds. It is possible that the source for the emission of these and other copying responses is conditioned reinforcement for the correspondence between observing and producing responses. Generalized imitation is one of the cusps and capabilities that accrue from conditioned reinforcement for the correspondence between observing and producing.

Evidence for Pre-Speaker and Pre-Listener Cusps

These preverbal foundational cusps lead to the development of the separate speaker and listener operants. They also precede the joining of speaker and listener within the skin that constitutes being truly verbal (Barnes-Holmes et al., 2001; Horne & Lowe, 1996). These cusps include acquisition of reinforcement for observing responses. Several experiments have demonstrated a functional relation between reinforcement conditioning protocols and acceleration of learning associated with these senses. Children who are severely delayed do not orient or attend to voices, look at novel visual stimuli, or leaf through children's books; rather, they engage in stereotypy or "self-stimulation." Our work suggests that they have missed the early and incidental conditioning of voices that occurs for typically developing infants reported by Decasper and Spence (1987). For example, we found that when we conditioned recordings of voices as reinforcement for listening (measured by children's choosing to listen to recordings of human voices in free play), children learned listener discriminations that they could not learn prior to the conditioning process (Keohane, Greer, & Ackerman, 2006c). Similarly, visual match-to-sample learning occurred when visual stimuli attained reinforcement for visual observing as a function of stimulus–stimulus conditioning processes (Keohane, Greer, & Ackerman, 2006b). These children could not master visual match-to-sample tasks without extensive prompting procedures. After the visual stimuli were conditioned as reinforcers for observing, the children could master visual match-to-sample instruction solely via the use of learn units. Thus, stimulus–stimulus pairing procedures were performed until the various stimuli acquired conditioned reinforcement for observing; subsequently, the children required 4 to 10 times fewer learn units to master relevant instructional objectives. These findings are consistent with Dinsmoor's (1983) basic findings of the observational facilitation of discrimination learning in pigeons. These are cusps, because they allow children to learn from stimuli they could not contact before.

Another developmental cusp that we believe is foundational to verbal behavior is the cross-modal *capacity for sameness* (Engelmann & Carnine, 1991; Keohane, Greer, & Ackerman, 2006a). Children who have difficulty matching are often lacking this developmental capability. The intervention that we use to induce this is a protocol that we call cross-modal sensory matching. In that procedure, we rotate having children match across the senses. They match,

in rotated presentations, scents, textures, olfactory stimuli, sounds, and visual stimuli (i.e., multiple-exemplar instruction). Once they master these at criterion levels, their learning across matching and other realms accelerates significantly (Keohane et al., 2006a). Because the notion of *sameness across the senses* is an arbitrary human invention, developing the capacity for sameness may lay the foundation for the kinds of cross-modal arbitrary applicable relations, or those relations that are not controlled by the physical attributes of stimuli, that are found in emergent verbal behavior and its subsequent potential in categorizing functions. See Keohane et al. (2009) for a summary of this research.

Acquiring Listener Cusps

After children acquire the foundational observing cusps (capacity for sameness, conditioned reinforcement for tabletop stimuli or print/pictures, conditioned reinforcement for observing voices and faces, and generalized imitation), they can be brought under the control of the vowel/consonant commands of others, as in hearing what others say and doing what they hear—a new cusp. When children respond differentially and correctly to two or more arrangements of vowel and consonant sounds produced by a speaker, we identify this as the beginning of "listener literacy." We have used a protocol that we call "listener emersion" to induce basic listener literacy that we tested using multiple-probe time-lagged designs to control for maturation and history. In this procedure, we provide a sequence of instructions such that the child must respond to sets of commands based only on properties of speech. First, they master the sets (usually five to six sets of five commands) to mastery, with frequent recombination of component sets that include a nonsense command, after which they must respond to sets at 30 responses per minute. Finally, they respond to recorded commands given by different voices (Greer, Chavez-Brown, et al., 2005). Once they have achieved this basic listener literacy, they acquire educational repertoires 4 to 10 times faster than before they mastered listener literacy.

Phonemic Control

Chavez-Brown and Greer (in press), also in multiple-probe and time-lagged experiments across six children, found that an intervention involving the acquisition of selection responses for matching vocal speech sounds of others led to echoics or clear speech by children lacking those capabilities. The children were taught to activate switches to accurately match recorded spoken words when the choice was an accurate match and an inaccurate match. The experimenter pressed a switch sounding a spoken word that was the target sample; the experimenter then pressed two switches, one with the correct match and one with a nonmatching word. The child then pressed a switch for the matching word to attain a correct response. Thus, mastery of auditory selection responses appears to have assisted the children in matching their own speaker responses that consisted of their emitting point-to-point correspondence between hearing words and saying those words. Hearing and matching the consonant/vowel sounds of others lead to matching one's own emitted and heard vocal sounds (Chavez-Brown & Greer, in press; Marion et al., 2003). Perhaps saying phonemic sounds or phonemic blends at first

results in automatic reinforcement for the production of vocal responses with point-to-point correspondence that has not yet acquired verbal functions. We refer to this type of responding as parroting because the correspondence itself becomes reinforcing as a result of the infant's experiences (M. Sundberg et al., 1996). At the next stage, saying the vowel/consonant has effects on the behavior of caretakers who mediate for the speaker. At this point, the echoic is controlled by a history of having the echoed sounds affect the behavior of the listener; the response is not controlled by automatic reinforcement. The response now has a speaker function. Instances of the emission of certain vowel/consonant sounds specify reinforcers, and the class of mands is formed (Williams & Greer, 1993). In other cases, instances of emission of certain vowel/consonant sounds results in attention from caretakers, and if attention is a conditioned reinforcer, the tact operant function forms (Tsiouri & Greer, 2003). At this point, the response learned under mand conditions is not likely to function as a tact or vice versa, consistent with findings by Lamarre and Holland (1985), Twyman (1996), and Williams and Greer (1993).

Acquiring Speaker Cusps: Tact Speaker Operants

Once the listener literacy and the speaker capabilities are in place for children with language delays, we can expand the tact repertoire with intensive tact instruction. However, even with all of the above listener and speaker repertoires, children without the Naming capability acquire tacts, or listener responses, only with direct instruction.

Probably the most important speaker response that is needed is the tact (Gewirtz, 1969; Greer & Ross, 2008; Horne & Lowe, 1996; Skinner, 1957). When attention from adults is a conditioned reinforcer, which apparently originates from very early pairings or from interventions like those we described previously, tacts can be acquired via direct instruction. Attention and approval are often missing as reinforcers in children with language delays (Greer, Singer-Dudek, Longano, & Zrinzo, 2008); however, once attention is a reinforcer, the emission of tacts is an efficient means for the child to attain reinforcement. Although mands are useful, relevant unconditioned establishing opportunities are limited to conditions of deprivation and alleviation of aversive conditions. In homes with good caretakers, aversive conditions are often avoided, and children are not under frequent deprivation. However, tact responses are a limitless means for reinforcement because the conditioned motivational conditions have to do with momentary deprivation of social attention, whether that deprivation is the result of direct deprivation (Tsiouri & Greer, 2003, 2007) or observational deprivation (Greer & Singer-Dudek, 2008; Greer, Singer-Dudek, Longano, et al., 2008; Singer-Dudek, Greer, & Schmelzkopf, 2008).

In our developmental interventions with children for whom we have provided the basic speaker and listener capabilities through interventions, we emphasize the expansion of the tact repertoire. To do this, we use the intensive tact protocol (Lyndon, Healy, Leader, & Keohane, 2008; Pereira-Delgado & Oblak, 2007; Pistoljevic & Greer, 2006; Schauffler & Greer, 2006). In this procedure we increase tact instruction in addition to maintaining pre-intervention levels of instruction across all other curricular areas. In several controlled experiments, we have found that this instruction has led to significant increases in children's emission of spontaneous pure tacts (tacting stimuli without being asked) in noninstructional settings,

such as lunchtime, free play, or transition (Lydon, et al., 2008; Pistoljevic & Greer, 2006, Schauffler & Greer, 2006). Interestingly, the majority of the tacts emitted in the noninstructional settings are not those that were taught in the tact instruction. In another study, there was a significant increase in "wh" questions in addition to increases in tacts (Reilly-Lawson & Walsh, 2007). These findings suggest to us that the intervention provides new means for children to receive increased attention and even provides establishing operations for "wh" questions that, in turn, allow the child to recruit more tacts and subsequent attention by emitting more frequent tact responses. At this point, the developmental learning history has established attention as a conditioned reinforcer for tacts *and observational responding*, a cusp that appears to develop incidentally for typically developing children.

On the listener side, the child builds on prior cusps such that after hearing the "name" or tact of stimuli, while jointly attending to the stimuli spoken of by a speaker, she or he can respond as a listener without direct instruction (e.g., "That's a robin," followed by the child's pointing to a robin when asked to do so (Feliciano, 2006; Horne et al., 2004). In the Feliciano experiment, children with no or little speech acquired the listener half of Naming as a result of multiple-exemplar instruction across the matching and hearing condition and the listener responses of pointing, suggesting that the listener half can be acquired prior to the child's having a speaker response. Presumably, as children like these acquire speaker responses, both the speaker and listener responses of Naming accrue, and in fact, this did appear to be the case for one of Feliciano's participants, who began to echo the listener instructions. Covert echoics are suggested as one possible source of the reinforcement for Naming (Longano, 2008; Lowenkron, 1991, 1998), while stimulus–stimulus pairing is the possible source for why the echoic may reinforce Naming (Longano, 2008; Stemmer, 1992). It is also possible that both of these play a role. Full Naming then emerges as the listener and speaker components of observing and producing are further joined. After hearing tacts of objects, and later two-dimensional representations, the child echoes the tact form and emits pure tacts and impure tacts, as well as the listener component of naming (Fiorile & Greer, 2006; Gilic, 2005; Greer, Stolfi, et al., 2005, 2007).

In the above sequence, the listener components and other observational components may proceed at different rates compared to the speaker and other production components. However with Naming and the other speaker-as-own-listener capabilities (see and do and self-talk conversational units), the verbal observing and producing are joined, at least to some degree.

Transformation of Establishing Operations Across Mands and Tacts

Establishing operation is a term used to describe something that momentarily alters the effectiveness of a stimulus as reinforcement (Michael, 2004). The reinforcement for a mand is specified, whereas the reinforcement for a tact is generalized and usually comes in the form of feedback from a listener. However, the form of the behavior itself (the actual word) may of course be identical for both the mand and the tact, as described above. At some point in children's development, learning a response as a tact results in the untaught capability to emit the response under mand establishing operation conditions or vice versa (Arntzen & Almas, 2002; Petursdottir, Carr, & Michaels, 2005).

Nuzzolo-Gomez and Greer (2004) found in an experiment that controlled for maturation and history that multiple-exemplar instruction could lead to this capability. They identified children with language delays for whom the mand and tact functions for responses were independent. If children were taught a tact, they could not use the response under the establishing operations for the mand or vice versa. The experimenters then provided a multiple-exemplar instructional intervention in which a set of speech responses was taught across both types of establishing operations using contrived conditions. For example, after the child had learned a tact function for a word but could not use it as a mand, conditions were arranged in which the child needed to emit the response under mand conditions. Similarly, responses that had mand functions were placed under contrived establishing operations for the tact function. The two functions were rotated for a subset of trained responses until the responses had both mand and tact functions controlled by the contextual establishing operations for the respective functions. After the intervention, the children could use the pretest words that were formerly independent responses in either condition. In addition, following the MEI intervention, they were taught novel responses in single functions and they could emit the untaught functions. Greer et al. (2003) and Nirgudkar (2005) replicated these findings, again in experiments controlling for maturation and history. We characterize the onset of this capability as the acquisition of "transformation of establishing operations" across mand and tact functions. The derived relations between the mand and tact functions were controlled by the relevant contextual establishing operations after the intervention and were not controlled by them before; thus, the responses were transformed from control by one type of contextual condition to control by either condition.

Suffixes in the Tact Repertoire

Once the reinforcement contingencies for tacts are in place, further expansion of a tact repertoire may occur when autoclitic frames in the form of affixes are combined with tacts. Greer and Yuan (2008) tested the effects of contextual control—pictures taught for conditional stimulus control—on the emergence of novel past tense verb forms in children who lacked that capability. The intervention required the children to master the contextual control for emitting past tense in multiple-exemplar instruction that rotated learn units across present tense and past tense responses. They were taught to emit the present tense when pictures were shown of children engaged in the verb actions where the sun and a blue sky were present. They were also taught to add the "-ed" ending when the pictures had dark skies and a moon. This intervention resulted in abstraction of the "–ed" autoclitic frame (a partially conditioned tag that changes the meaning of other verbal behavior) to novel regular *and irregular* verbs. Emissions of novel verb forms such as "He singed last night" have been regarded as "benchmarks of arguments that language is acquired by a neural network independent of experience" (Pinker, 1999, p. 190). In a similar study on suffixes, Speckman and Greer (2006) implemented an MEI intervention for teaching a subset of positive and comparative regular and irregular adjectives as well as "contrived" adjective forms, again using a multiple-probe and time-lagged experimental design. The procedure induced derived relations for the "-er" autoclitic frame across regular, irregular, and contrived adjectival forms (e.g., "blooby" and "bloobier"). Both

of these were experimental analyses that controlled for maturation and history. The recombination of tact forms with abstracted autoclitic frames as affixes allows for a significant increase in children's vocabulary, as well as a more precise speaker capability (i.e., autoclitic functions as in "the bigger one"). These findings also weaken the face validity of linguistic developmental theories that deny the role of learning (Pinker, 1999).

Readiness for Joining the Listener and Speaker

At this point, the child is prepared to contact the contingencies for joining the listener and speaker. Verbal episodes involve rotation of speaker and listener exchanges between individuals. Conversational units may be one of the strongest measures of socialization, in that they consists of verbal interactions in which each person in a turn-taking exchange is reinforced as *both speaker and listener.* Donley and Greer (1993) experimentally identified contextual conditions (a setting where only verbal interaction with peers was possible) that resulted in the emission of conversational units between peers with mental retardation. Chu (1998) also experimentally demonstrated contextual conditions for inducing and expanding conversational units between children with autism and nonhandicapped siblings in two separate experiments.

We suggest that the joining of the listener and speaker progresses from listener–speaker rotations with others *as a likely precedent for* the three major components of speaker-as-own-listener—say-do correspondence, self-talk conversational units, and Naming. Several experiments suggest that most, if not all, of the foundational components described earlier must be present for Naming to emerge as a result of the Naming MEI protocol (Longano, 2008; Pistoljevic, 2008; Speckman-Collins, Park, & Greer, 2007). Introducing Naming instruction to a child who does not orient to voices, faces, other visual stimuli, or sounds is likely futile. Moreover, children who lack auditory selection, fluent echoics, and tacts cannot likely profit from the protocol to induce Naming. These appear, at present, to be the developmental cusps on which Naming and other speaker-as-own-listener capabilities are built. It is probable that many more remain to be identified.

The rotation of speaker and listener roles, or turn-taking between individuals, where the reinforcement for the listener and speaker roles is present (Donley & Greer, 1993), prepares the way for joining of the speaker and listener in the individual in self-talk (Lodi & Greer, 1989) and say-and-do correspondence (Paniagua & Baer, 1982). The intercept of listener and speaker within the skin, in turn, makes the subsequent more complex verbal behavior possible. These independent observing and producing responses come to be joined by a sequence of exemplar experiences and pairing experiences that result in the higher order classes that we describe next.

More Complex Verbal Behavior Made Possible by the Intercept of Speaker and Listener

The Reader and Writer Learn to Listen

Reading involves a form of listening, just as saying and doing involve a form of listening. Phonemic sounds lead to word sounds, and the Naming capability allows prior experiences to result in comprehension and conditioned

seeing. At the same time, the writer must come to be controlled by the effects of his or her writing on a reader (Reilly-Lawson & Greer 2006), and the reader must read and do accurately. Reilly-Lawson and Greer (2006), building on experimental research by Madho (1997) and Marsico (1998), arranged an intervention in which the writer was required to continue to rewrite until the behavior of a reader corresponded with the objective the writer sought from the reader. This intervention led to significant improvements in both the functional and structural components of writing. Jadlowski (2000), in a controlled experiment, found that editing others' writing acted to decrease the number of rewrites participants needed to affect the behavior of readers. We suggest that, in all three of these experiments, the effects that accrued from these interventions were derived from speaker-as-own-listener joining print and that the speaker-as-own-listener plays the key role in self-editing. The speaker must listen, so to speak, to what she or he has written, as the reader would listen. Listening to what one has written is key to self-editing—writer-as-own-reader. When the reader listens to his or her textual response and has the Naming capability (i.e., the relevant tacts are present or a minimal number are present), comprehension and its reinforcement occur immediately. By "comprehension and its reinforcement," we mean that the reader responds to precise instructions for technically reinforced purposes, or the reader's senses are extended for emotional effects.

Acquisition of self-editing (listening to what one has written relevant to the audience the writer seeks to affect), verbally governed responding (responding to written or spoken verbal stimuli), and verbally governing responding (writing or speaking algorithms evokes simple responses or complex problem solving by listeners or speakers) result from the joining of print to Naming, self-talk, and say–do correspondence. These make problem solving using the methods of authority, logic, and science (Peirce, 1935) possible because they are types of verbally governing and verbally governed behavior.

Conclusion

We propose that our evidence on the identification and induction of missing verbal capabilities, and experiments isolating the instructional histories for doing so, suggest a developmental sequence, some of which we describe above and in other articles (Greer & Keohane, 2005, 2006; Keohane et al., in press) and a book (Greer & Ross, 2008). Moreover, the protocols derived from these experiments provide ways to provide children with missing verbal capabilities.

The findings from Naming, Relational Frame Theory, Stimulus Equivalence, mainstream developmental psychology and verbal development research contributed to our theory of verbal development. Indeed the basic research on the existence and sources of various types of emergent behavior provided us with the questions and the tools to identify and induce what we propose are nonverbal and verbal developmental cusps and capabilities. Rosales-Ruiz and Baer's (1996) paper on the concept of behavioral developmental cusps, the concept of higher order operants (Catania, 2007), Horne and Lowe's (1996) seminal work on Naming, the pioneering work on emergent behavior (Sidman, 1986), major contributions of Relational Frame Theory research, and our interaction with behavior analysts in Ireland led us to procedures that revolutionized what we could do with children. The

new and more complete account of verbal behavior that emerged from these various programs of research made it possible for us to provide an account of verbal development.

One of the reviewers asked us what our position was on the different theories pertaining to emergent verbal behavior. Rather than differences, we saw amazing consistency for our purposes—the induction of verbal capabilities in children who were missing them. For example, Naming is a higher order operant (Catania, 2007; Horne & Lowe, 1996) or overarching operant (Hayes et al., 2001), and this suggested that verbal developmental capabilities and some cusps were themselves higher order operants. Barnes-Holmes et al. (2001) provided a convincing argument that to be truly verbal the listener and speaker must be joined in ways that make arbitrarily applicable relations possible—both speaker and listener operants are foundational, but ultimately it is the intercept that is fully verbal. Derived relations make transformation of stimulus control possible, and the contribution of Sidman (1986) was simply basic to all of this. Hayes et al. (2001) identified and profoundly expanded the potential explanatory role of relational responding and suggested sources in MEI histories. Horne and Lowe (1996) discovered Naming as a verbal developmental capability, and this led us to consider other steps in development as verbal developmental capabilities, too. Lodhi and Greer (1989) identified self-talk conversational units, and Paniagua and Baer (1982) identified say-and-do correspondence early on. Foundations of verbal behavior, like the development of observational stimulus control, also owe a great deal to Pavlovian second-order conditioning that underlies complex derived relations and allows verbal capabilities to emerge (Donahoe & Palmer, 2004; Leader et al., 2000; Longano, 2008). There is now considerable evidence about the role of the listener in verbal behavior, making the account of verbal behavior more complete—we know much more about the origins of so-called novel verbal behavior. Though there are differences in interpretation about these various phenomena, we are interested in findings and theories that work in inducing verbal behavior.

We drew on the *similarities* in the findings of these programs of research to deal with seemingly intractable learning problems. What we viewed as convergent findings suggested that the learning problems that we encountered regularly were, in fact, behavioral developmental obstacles that were missing higher order operants and relational responding. Findings and interpretations from all of the work suggested possible interventions to induce verbal capabilities in children who were missing them. The interventions have consisted of multiple-exemplar instruction across listener and speaker responses (Fiorile & Greer, 2007; Greer, Stolfi, et al., 2005, 2007), saying and writing (Greer, Yuan, et al., 2005), contextual establishing-operations control for manding and tacting (Nuzzolo-Gomez & Greer, 2004), contextual control for literal and metaphoric expressions (Meincke-Matthews, 2005), and contextual control for suffixes (Greer & Yuan, 2008; Speckman & Greer, 2006). Other interventions included conditioning reinforcement of stimuli for the range of observing responses (Dinsmoor, 1983; Donahoe & Palmer, 2004; Keohane, Greer, & Ackerman, 2006a, 2006b, 2006c; Longano & Greer, 2006; Tsai & Greer, 2006) that resulted in accelerated learning and developmental cusps that were not capabilities, yet seem to be foundational cusps that prepare the potential for capabilities. We are exploring other possibilities and there are likely many more. The

range of findings across verbal capabilities, and their foundations, made the proposal of a verbal *developmental* theory irresistible.

However, any theory should be treated with caution, and ours is no exception. For example, we presume much in extrapolating our findings from work with children with language or learning delays to the verbal development of typically developing children. Moreover, we do not have the benefit of large-group studies that have been the mainstay of traditional approaches to development. Population studies have been the mainstay of developmental psychology, where the population is grouped by age. Of course, group studies are necessary for studying populations and testing for generality from representative samples of populations to the populations themselves. However, they do not provide tests for generality to individuals. Also, presuming that age constitutes the population for a particular developmental capability/cusp is just that: a presumption. Our objective is to isolate the role of experience. Experimental analyses at the level of the individual are useful for obtaining generality to individuals, and it is individuals who are our targets. We have also done several studies that combined experimental-control-group designs with single-case designs, and this approach may provide the means for testing the generality of findings to both individuals and populations.

Many developmental theories are driven by hypotheses and are essentially deductive in nature. However, all theories need not be deductive. While there are some compelling advantages of deductive approaches, there are equal if not stronger advantages to an inductive approach. The theory we propose grew out of a more inductive approach. In such an approach, replications of the findings with individuals who have similar cusps and capabilities expanded the generality to individuals with similar characteristics. Moreover, the time-lagged multiple-probe designs, thorough knowledge of the children's entering capabilities, and close, continuous contact with the participants following the experiments contributed to the generality and validity of the procedures. We are confident that the educational and developmental contributions are robust because we have replicated them with many children.

However, the validity of our interpretation of this work, remains to be tested by research and close scrutiny by other scholars. Although we did begin to test the applicability of Skinner's (1957) verbal behavior theory to solving verbal deficits in a program of research that began over 27 years ago, we did not set out to find a theory *of verbal development*; rather, it found us. The early direct applications of Skinner's theory were helpful in inducing speaker operants, in particular, identifying the source and procedures to teach "spontaneous speech." However, with the advent of Naming theory, relational frame theory, stimulus equivalence theory, the notion of higher order operants and behavioral developmental cusps, and the incorporation of the listener role, a more complete account of verbal behavior emerged, particularly the joining of the speaker and listener within the skin. Our research then built on this more complete understanding of verbal behavior to identify verbal developmental cusps and capabilities and the means to induce them. The sequence of these cusps and capabilities suggests a trajectory of verbal development in children. Hopefully, this theory will prove a useful addition to the body of scholarship devoted to understanding language and its evolution and development.

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