

The Current Status of the Experimental Analysis of Verbal Behavior

Anna Ingeborg Petursdottir
Texas Christian University

Sixty years have passed since the publication of Skinner's (1957) *Verbal Behavior*. Although its influence on empirical research was limited in the past, there has recently been a proliferation of both applied and basic research studies related to this work. This article provides an overview of the research topics represented in 369 empirical research articles on verbal behavior published between 2005 and 2016 that were identified in a prior study (Petursdottir & Devine, 2017). Comments on the current status of and future directions for the experimental analysis of verbal behavior are provided.

Keywords: experimental analysis, language, B. F. Skinner, verbal behavior

Sixty years ago, in *Verbal Behavior*, Skinner (1957) proposed that human language was operant behavior, governed by the same principles as the lever-pressing and key-pecking responses of nonhuman animals typically studied in the operant laboratory. The meaning of a verbal utterance, according to Skinner, did not reside within the mind of the speaker or the listener, but rather, in the independent variables—prior reinforcement history and current stimulus conditions—of which the utterance was a function. This conceptualization suggested the possibility of an experimental analysis of human language: By manipulating said independent variables, prediction and control over the form and rate of verbal behavior should, in theory, be achievable. But *Verbal Behavior* itself, as an “exercise in interpretation” (p. 11) contained scant experimental data on human verbal behavior, and the possibility of experimental analysis remained largely unexplored for decades (McPherson, Bonem, Green, & Osborne, 1984).

Empirical support for certain aspects of Skinner's (1957) analysis had certainly long existed. The rate and form of adult verbal behavior had been shown to be sensitive to social consequences (e.g., Conger & Killeen, 1974; Greenspoon, 1955; Salzinger & Pisoni, 1960) and it had been demonstrated that operant reinforce-

ment contingencies could be applied to teaching multiple aspects of language to individuals with impaired verbal repertoires (e.g., Baer & Guess, 1973; Garcia, Guess, & Byrnes, 1973; Lovaas, Berberich, Perloff, & Schaeffer, 1966; Sailor & Taman, 1972). However, most of this work did not address the complexities of antecedent control that occupied much of *Verbal Behavior* and perhaps could have been accomplished without the benefit of its prior publication (Michael, 1984). Additional work that began to appear in the 1970s and the 1980s was more directly influenced by *Verbal Behavior*, provided tentative support for functional distinctions between verbal operants, and suggested avenues of practical utility (Oah & Dickinson, 1989).

By the mid-2000s, a growing influence of *Verbal Behavior* on empirical research was evident, as measured by increases in citations from empirical journal articles (Dymond, O'Hara, Whelan, & O'Donovan, 2006) and the publication of studies in which a verbal operant was manipulated or measured (Dymond et al., 2006; Sautter & LeBlanc, 2006). Nevertheless, the level of empirical activity remained modest, with less than five new articles published each year on the average (Dymond et al., 2006). In addition, concerns were raised about the limited scope of the research. Dixon, Small, and Rosales (2007) reported that a majority of the new studies identified by Dymond et al. (2006) focused on teaching mands and tacts to children with developmental disabilities, and concluded that “[a]lthough the invaluable clinical significance of this research is not questioned, this

Correspondence concerning this article should be addressed to Anna Ingeborg Petursdottir, Department of Psychology, Texas Christian University, Box 298920, Fort Worth, TX 76129. E-mail: a.petursdottir@tcu.edu

alone cannot sustain the reliance on *Verbal Behavior* as a conceptualization of human language.” (p. 204). Sautter and LeBlanc (2006) reached a similar conclusion, and also noted that all of the research had been published in a small number of behaviorally oriented journals. Nevertheless, additional support had emerged for at least some aspects of Skinner’s (1957) analysis, such as the conceptual validity and practical value of distinguishing between manding and tacting (Sautter & LeBlanc, 2006).

In the past decade, empirical research on verbal behavior has proliferated. Petursdottir and Devine (2017) found a substantially increased rate of citations to *Verbal Behavior* from 2005 to 2016 compared with prior review periods (Dymond et al., 2006; McPherson et al., 1984); an increase that was most evident in citations from empirical articles. In addition, Petursdottir and Devine reported more than a sixfold increase from Dymond et al. (2006) in the rate of publication of empirical studies in which a verbal operant was manipulated or measured, whether or not *Verbal Behavior* was cited. Following previous reviews (Dymond et al., 2006; Sautter & LeBlanc, 2006), the 369 studies that met this criterion in the 12-year review period were considered directly influenced by *Verbal Behavior*. Applied experimental analyses¹ accounted for 75% of these studies, basic experimental analyses for 23%, and observational studies for 2%. A majority of the studies appeared in behavioral journals and focused on improving the verbal repertoires of children diagnosed with autism spectrum disorder (ASD) or other neurodevelopmental disorders. The mand was overall the most studied verbal operant, although basic studies were more likely to address the tact or the intraverbal. These characteristics of the empirical database were similar to previous reviews (Dixon et al., 2007; Sautter & LeBlanc, 2006).

Petursdottir and Devine (2017) did not review specific topics of investigation or assess the contributions of recent additions to the literature to the advancement of a science of verbal behavior. The present article, therefore, provides an overview and discussion of the topics addressed in Petursdottir and Devine’s (Study 2) database of verbal behavior studies published between 2005 and 2016. The search methods, inclusion criteria, coding categories, and reliability procedures used to identify articles for

inclusion in this database are described in detail in Petursdottir and Devine (2017), but will be summarized briefly here: A PsycINFO search was conducted for peer-reviewed journal articles that contained verbal operant terms in their titles, abstracts, or keywords. Based on the authors’ reading of the abstracts, articles were included in the database if they (a) represented original empirical research, and (b) employed Skinner’s (1957) verbal operant terminology to describe at least one manipulated or measured variable. Both criteria were operationally defined in objective terms and interrater reliability found acceptable. To this database, we added a few articles that met criteria (a) and (b) and did not come up in the PsycINFO search but had previously been identified in the citation analysis portion (Study 1) of Petursdottir and Devine (2017), which utilized Thomson Reuters Web of Science along with manual searches of the reference lists of behavior analysis journals not included in Web of Science.

For the purposes of the present review, the 369 articles were categorized and subcategorized through several iterations of qualitative coding based on information contained in titles and abstracts, which were read in full by the author, and in some cases other portions of the articles. In contrast to the objective procedures used by Petursdottir and Devine (2017) to identify articles for inclusion and quantify major characteristics of the database, the present article deliberately used a subjective approach to identifying themes within the literature based on the author’s familiarity with the research topics and her assessment of how each particular study fit in with others. Thus, interrater reliability was not assessed on the categories represented by the subsections of this article. However, a list of the articles is available for independent analysis as an online supplement to Petursdottir and Devine (2017).

¹ Consistent with previous reviews, Petursdottir and Devine (2017) classified studies as applied if their primary goal was to improve some aspect of the participants’ behavior, regardless of whether or not they met additional criteria for applied behavior analysis as outlined by Baer, Wolf, and Risley (1968).

Acquisition of Mand, Tact, and Intraverbals Through Reinforcement Contingencies

Almost a third of the studies in the database (113 total, or 31%) focused on the acquisition or generalization of new mand, tact, and intraverbal relations through direct reinforcement contingencies. Most were classified as applied and included children with ASD as participants, but other populations represented included adults with dementia (e.g., Oleson & Baker, 2014) and typically developing children (e.g., Coon & Miguel, 2012).

Sixty studies evaluated the efficacy of a reinforcement-based procedure for establishing or extending antecedent control over a particular type of mand, tact, or intraverbal relation. The most common theme was procedures for teaching mands for information, which were evaluated in 14 studies. Methodological advances were evident in research on this topic throughout the review period, with more recent studies incorporating careful assessment of control by motivating operations (MOs; Laraway, Snycer-ski, Michael, & Poling, 2003) over the taught responses (e.g., Lechago, Howell, Caccavale, & Peterson, 2013; Shillingsburg, Gayman, & Walton, 2016). As an example of research on teaching tacts, earlier research on the use of matrix training procedures to assess and promote recombinative generalization (e.g., Goldstein, Angelo, & Moussetis, 1987) was translated into the language of *Verbal Behavior* and extended to teaching young children with ASD diagnoses to tact multiple aspects of stimulus displays (e.g., Frampton, Wymer, Hansen, & Shillingsburg, 2016). In the area of teaching intraverbals, previous research on using transfer of stimulus control procedures to teach intraverbal behavior (e.g., Braam & Poling, 1983) was extended to children with ASD diagnoses for the first time (Goldsmith, LeBlanc, & Sautter, 2007), and later studies demonstrated procedures for promoting discrimination of multiple components of a verbal stimulus (e.g., Kisamore, Karsten, & Mann, 2016; Ingvarsson, Kramer, Carp, Petursdottir, & Macias, 2016) and establishing complex intraverbal response chains (Valentino, Conine, Delfs, & Furlow, 2015). Other examples of research in this category included use of speech-generating devices (e.g., Carnett & Ing-

varsson, 2016; Lorah, Karnes, & Speight, 2015) and teaching children with ASD to direct mands at their peers (e.g., Paden, Kodak, Fisher, Gawley-Bullington, & Bouxsein, 2012).

Nine studies investigated differences between verbal response modalities. Eight studies aimed to identify an optimal mode of communication for minimally verbal individuals, using measures such as rate of mand acquisition, rate of use, and user preference (e.g., Lorah et al., 2013; Ringdahl et al., 2016). The remaining study (Vignes, 2007) was a laboratory investigation of topography-based and selection-based (Michael, 1985) verbal behavior, contributing to an existing line of verbal behavior research on this topic (e.g., C. T. Sundberg & Sundberg, 1990).

Finally, 44 studies systematically investigated the influence of procedural variations or participant variables (e.g., instructional history, Coon & Miguel, 2012; auditory-visual discrimination repertoires, Verbeke, Martin, Thorsteinsson, Murphy, & Yu, 2009) on the acquisition of mands, tacts, or intraverbals. In some cases, the primary research question pertained to discrete-trial instruction in general, and the selection of verbal operants as intervention targets was secondary to that aim. For example, Boudreau, Vladescu, Kodak, Argott, and Kisamore (2015) compared the effects of differential reinforcement procedures on acquisition and Haq and Kodak (2015) compared the effects of massed and distributed practice. Other studies addressed questions more specific to the type of antecedent control that defines a particular verbal operant. Examples included the effects of different prompt types on intraverbal acquisition (e.g., Ingvarsson & Hollobaugh, 2011), MO influences on mand acquisition and maintenance (e.g., O'Reilly et al., 2012), and the effects of the verbal stimuli "What is this?" and "What do you want?" on tact (Marchese, Carr, LeBlanc, Rosati, & Conroy, 2012) and mand (Bowen, Shillingsburg, & Carr, 2012) acquisition, respectively.

Overall, studies in this category were driven mostly by practical concerns and their major contributions lie in the area of optimizing and refining procedure for teaching language skills to children with language delays due to ASD or other disabilities. Nevertheless, this research should not be dismissed as unimportant to advancing the experimental analysis of verbal be-

havior. Some of the studies provided information of potential theoretical interest. For example, [Lechago, Carr, Grow, Love, and Al-mason \(2010\)](#) demonstrated that once a particular mand form has been acquired and reinforced with a specific consequence, it may generalize across different MOs of relevance to that consequence. In addition, studies in this category contributed substantially to the development of methods for establishing and verifying MO control over verbal behavior (e.g., [Gutiérrez et al., 2007](#)). These methodological advances may prove important, as the distinction between MO control and discriminative control was fundamental to [Skinner's \(1957\)](#) analysis.

Emergent Mand, Tacts, Intraverbals, and Listener Behavior

[Skinner \(1957\)](#) noted that the same response form can appear as part of different functional relations that operate independently of one another. For example, different reinforcement contingencies produce antecedent control over the vocal response “water” by water deprivation, by the sight or sound of water, and by the printed word “WATER.” From the point of view of this analysis, there is no reason to expect the reinforcement of a particular verbal operant (e.g., a tact) to yield additional sources of control (e.g., by an MO or a verbal stimulus) over the reinforced response form. Similarly, the analysis assumes that speaker and listener repertoires are produced by independent contingencies. Nevertheless, [Skinner \(1957\)](#) acknowledged (e.g., pp. 188–189, p. 193, 360, pp. 422–423) that for a variety of reasons, an antecedent stimulus or MO may sometimes come to evoke a particular response in the absence of a direct reinforcement history. A total of 83 studies (22%) assessed such emergent mand, tact, or intraverbal control, or the emergence of novel listener behavior as a result of reinforcing mands, tacts, or intraverbals. Approximately half of them were classified as basic investigations by [Petursdottir and Devine \(2017\)](#), and the other half as applied. Participants included typically developing children and adults, children and adults diagnosed with ASD and other developmental disorders, and children with hearing impairment (e.g., [Golfeto & de Souza, 2015](#)).

The functional independence of mands and tacts was addressed in 14 studies that followed up on [Lamarre and Holland's \(1985\)](#) seminal study on this topic. Some studies simply assessed the extent to which novel mands emerged following the establishment of tacts involving the same response form, or vice versa, under a particular set of conditions (e.g., acquisition of object names by children with autism; [Finn, Miguel, & Ahearn, 2012](#)), whereas others manipulated variables hypothesized to affect mand or tact emergence (e.g., modified contextual cues; [Egan & Barnes-Holmes, 2011](#)). This literature has been reviewed in detail elsewhere ([Gamba, Goyos, & Petursdottir, 2015](#)) and found to tentatively support the notion of the mand and the tact as functionally independent operants, but simultaneously bring to light a variety of methodological challenges in isolating sources of control over these operants.

Nine studies assessed the emergence of novel mand forms as a result of conditional discrimination training. For example, [Murphy, Barnes-Holmes, and Barnes-Holmes \(2005\)](#) taught children diagnosed with ASD to mand for two different types of tokens by selecting two different stimulus cards. Subsequently, the participants were found to mand for the same tokens using novel stimulus cards that, through an intervening training protocol, had entered into an equivalence class with the original stimulus cards. In general, this set of studies aimed to demonstrate transfer or transformation of evocative MO function through equivalence classes or other relational frames (cf., [Hayes, Barnes-Holmes, & Roche, 2001](#)).

The remaining 60 studies evaluated the emergence of novel tact, intraverbal, or listener relations. As with research on mands and tacts, a number of studies simply assessed the extent to which a particular learning experience resulted in the emergence of such relations. Examples include the emergence of new listener relations following establishment of tact and intraverbal responses ([Ingvarsson, Cammilleri, & Macias, 2012](#)), emergence of tacts (e.g., [Ribeiro, Elias, Goyos, & Miguel, 2010](#)) and intraverbals (e.g., [Smith et al., 2016](#)) after learning new listener relations, emergence of intraverbal relations after learning tacts (e.g., [Devine, Carp, Hiatt, & Petursdottir, 2016](#)), and emergence of intraverbal relations after learning other intraverbal relations (e.g., [Allan, Vladescu, Kisamore, Reeve,](#)

& Sidener, 2015). Collectively, these and other studies demonstrated that in spite of the functional independence of verbal operants implied by Skinner's (1957) analysis, the establishment of one or more verbal operants or listener relations often results in others emerging. Similar effects were even found in studies in which no relations were reinforced; for example, individuals with and without disabilities were found to emit novel tacts and intraverbals simply after repeatedly observing the contiguous presentation of visual and verbal stimuli (e.g., Carnerero & Pérez-González, 2014, 2015; Valentino & Shillingsburg, 2011).

Other studies showed, however, that such effects may not occur reliably under all circumstances (e.g., Perez-González, Herszlikowicz, & Williams, 2008; Petursdottir, Carr, Lechago, & Almason, 2008; Rosales, Rehfeldt, & Huffman, 2012). Thus, a number of studies attempted to identify influences on the emergence of novel tacts, intraverbals, and listener relations. Several studies assessed the relative efficiency with which the direct establishment of different relations produced a particular set of trained and emergent relations (e.g., Delfs, Conine, Frampton, Shillingsburg, & Robinson, 2014; Guerrero, Alós, & Moriana, 2015; Petursdottir & Hafliðadóttir, 2009) and generally found that direct establishment of tacts and intraverbals was more likely to produce emergent relations than the establishment of listener relations. Other studies evaluated the effects of instructional variations; for example, Zaring-Hinkle, Carp, and Lepper (2016) found that for college students, a one-to-many intraverbal training structure yielded more novel intraverbal responses than a linear series training structure, mirroring findings on stimulus equivalence (e.g., Arntzen, 2012). Yet others evaluated behavioral prerequisites for emergent stimulus control, such as how emergent intraverbal control is influenced by existing relations between nonverbal stimuli (Pérez-González & García-Asenjo, 2016) or existing intraverbal responses to elements of test questions (Belloso-Díaz & Pérez-González, 2015; Carp & Petursdottir, 2012).

Finally, numerous studies evaluated the effects of interventions hypothesized to boost the emergence of novel relations after a particular learning experience. Multiple-exemplar instruction (MEI) was the most commonly evaluated

intervention. In a typical MEI study, a particular learning experience initially results in limited emergence of untrained relations. After all possible relations are taught directly with a particular set of stimuli, subsequent instruction on a subset of the relations with new stimuli results in increased emergence of untrained relations. This effect was most commonly demonstrated on the emergence of tact and listener relations following exposure to contiguous presentations of verbal and nonverbal stimuli (e.g., Byrne, Rehfeldt, & Aguirre, 2014; Gilic & Greer, 2011), but other studies demonstrated, for example, effects on the emergence of intraverbals following establishment of other intraverbals (Pérez-González, García-Asenjo, Williams, & Carnerero, 2007). Results were generally positive, but failures to observe the effect were also reported (Dickes & Kodak, 2015; Lechago, Carr, Kisamore, & Grow, 2015). Other studies evaluated interventions that consisted of teaching participants to engage in collateral behavior during instruction or testing: an effect that would be consistent with some of Skinner's (1957) suggestions regarding sources of transfer between verbal operants. Petursdottir, Lepper, and Peterson (2014) evaluated the effects of requiring children to emit collateral echoic and tact emission during listener training, but found no increase in emergent tact and intraverbal responding. By contrast, positive results were found for teaching participants to engage in verbal problem solving (Sautter, LeBlanc, Jay, Goldsmith, & Carr, 2011) or visual imagining (Kisamore, Carr, & LeBlanc, 2011) in intraverbal test trials.

The large number of studies that evaluated emergent stimulus control over verbal responses is perhaps surprising, given that Skinner (1957) did not devote extensive attention to this phenomenon. Skinner's (1957) primary approach to explaining novelty in verbal behavior did not center on emergent stimulus control; rather, it emphasized the large number of nonverbal and verbal stimuli that come to exert antecedent control over verbal utterances through direct reinforcement contingencies, and the subsequent role of a dynamic physical and social environment in producing novel stimulus constellations that evoke novel utterances. In part, the burgeoning interest in emergent verbal relations may be less influenced by Skinner (1957) than by research on stimulus equiva-

lence (cf., Sidman & Tailby, 1982) and other derived stimulus relations, and subsequent interest in developing instructional technologies that maximize efficiency (Rehfeldt, 2011). But although perhaps not directly anticipated by *Verbal Behavior*, this work may be highly meaningful in the context of evaluating and advancing Skinner's (1957) analysis. Because a bare-bones operant analysis presumes functionally independent verbal operants, a theoretical account based on such an analysis needs to be capable of explaining what accounts for emergent mand, tact, and intraverbal control in the absence of a direct history of reinforcement. Doing so may be crucial for the ability to competently argue that a behavioral account has advantages over "in-the-head" representational views of language and cognition. Conceptual treatments of this issue include, along with Skinner's (1957) own suggestions, Horne and Lowe's (1996) naming hypothesis and relational frame theory (Hayes et al., 2001), and an influence of both was evident in the introduction and discussion sections of articles in this category.

Duplic and Codic Repertoires and Control by Textual Stimuli

Skinner (1957) described several types of verbal relations in which parts of the verbal controlling stimulus control parts of the response, such as the echoic, textual behavior, and dictation-taking. Michael (1982) proposed the umbrella terms *duplic* and *codic* to describe classes of such relations; the former referring to relations in which the response product bears physical similarity to the response (e.g., the echoic; copying a text) and the latter referring to those in which such similarity is absent but parts of the stimulus nevertheless correspond to parts of the response product. Eighteen studies (5%) had a primary focus on the acquisition of duplic or codic repertoires, or on control by textual stimuli over listener behavior (e.g., Sprinkle & Miguel, 2013). The specific topics of these studies were quite diverse and will not be discussed here. Applied studies evaluated, for example, techniques for establishing or improving echoic control over the vocal responses of children diagnosed with ASD (e.g., Tarbox, Madrid, Aguilar, Jacobo, & Schiff, 2009; Valentino, Shillingsburg, Conine, & Powell, 2012) and ef-

fects of instructional variables on the acquisition of textual behavior (e.g., Fabrizio & Pahl, 2007). A few studies examined strategies for teaching vocal or written spelling; for example, Aguirre and Rehfeldt (2015) found that the spelling performance of adolescents with learning disabilities was improved after they were taught to visually imagine printed words. Basic studies included demonstrations of the recombination of minimal units in textual behavior (e.g., Hanna et al., 2011) and musical reading (Perez & de Rose, 2010), and one study used eye-tracking technology to identify participants' problem-solving strategies while solving anagram puzzles (Endemann, Pessôa, Perez, & Tomanari, 2011). Although relatively few in number,² studies in this category provided both practical and theoretically interesting insights into variables that influence duplic and codic responding.

Autoclitic Control and Grammar

Skinner's (1957) analysis of grammar relied on the concept of autoclitic control, in which a verbal response is emitted because of its history of modifying or increasing the precision of the effects of other verbal responses on the listener. In addition to grammar, Skinner described the involvement of descriptive, qualifying, and relational autoclitics in various other aspects of verbal behavior. Eleven studies in Petursdottir and Devine's (2017) database were, for the purposes of the present article, considered to have a primary focus either on establishing or strengthening autoclitic control, or on teaching grammatical functions that were sometimes labeled autoclitic and sometimes not (i.e., the database included studies on grammar that did not make use of the term autoclitic but used other verbal operant terms to describe independent or dependent variables). Included in this category was the only study in the database that was conducted with nonhumans: Kuroda, Lattal, and García-Penagos (2014) trained pigeons to report on the strength of stimulus control over tactlike responses, analogous to such autoclitic

² As a reviewer pointed out, a large number of studies certainly exist on reading, writing, and so forth, outside of behavior analysis. These studies are not considered in this article due to not meeting inclusion criteria for the database established by Petursdottir and Devine (2017).

responses as “definitely” or “maybe.” Other examples included research on the effects of MEI on generalized use of prepositions (Luke, Greer, Singer-Dudek, & Keohane, 2011) and morphological inflection (Speckman, Greer, & Rivera-Valdes, 2012), and the effects of modeling on children’s use of the passive voice (Østvik, Eikeseth, & Klintwall, 2012; Wright, 2006). Although studies in this category comprised only 3% of the database, they are of interest in that some of them demonstrated, consistent with Skinner (1957), functional relations between grammatical and other referentially complex verbal behavior with environmental antecedents and consequences.

Role of Verbal Behavior in Derived Stimulus Relations

Eighteen studies (5%) aimed to evaluate the role of verbal behavior in derived stimulus relations. A majority were classified as basic and conducted with typically developing children or adults as participants, but children with ASD diagnoses were included in five studies. A majority of the studies aimed to assess predictions of Horne and Lowe’s (1996) naming hypothesis as it pertains to the role of verbal behavior in human performance in tests for stimulus equivalence. Several studies (e.g., Horne, Hughes, & Lowe, 2006; Kobari-Wright & Miguel, 2014; Lowe, Horne, & Hughes, 2005; Mahoney, Miguel, Ahearn, & Bell, 2011) demonstrated the establishment of stimulus classes through common naming, and others demonstrated a similar effect of establishing intraverbal relations between unique stimulus names (Ma, Miguel, & Jennings, 2016; Petursdottir, Carp, Peterson, & Lepper, 2015; Santos, Ma, & Miguel, 2015). Although some of the data were inconsistent with certain aspects of the naming hypothesis (e.g., Petursdottir et al., 2015), these studies collectively demonstrated that novel stimulus classes could be produced by directly establishing the verbal relations that Horne and Lowe (1996) hypothesized to arise spontaneously during equivalence training. As such, they may contribute to behavior-analytic work on categorization and concept learning in a broader sense.

Other studies examined, for example, performance consistent with analogical reasoning as a result of establishing verbal relations (Miguel et

al., 2015), influences on equivalence test performance by vocal tact acquisition (Howarth, Dudek, & Greer, 2015), and verbal stimuli present in test trials (Martins, Hübner, Gomes, Pinto Portugal, & Treu, 2015).

Rate and Variability of Verbal Behavior

Rather than focusing on antecedent control over particular response forms, 25 studies (7%) focused on altering the rate or form variability of verbal behavior. All but one of these studies were classified as applied: most were conducted with clinical populations. Several studies in this category evaluated strategies for reducing impractically high rates of manding (e.g., Sidener, Shabani, Carr, & Roland, 2006; Vladescu & Kodak, 2016) and others more generally evaluated the effects of reinforcement schedule parameters (e.g., Bernstein & Sturmey, 2008; Romani et al., 2013) or antecedent variables (e.g., Costa & Pelaez, 2014; Pérez-González, Pastor, & Carnerero, 2014) on rates of manding or tacting. Studies on increasing form variability addressed the variability of mands (e.g., Drasgow, Chezan, Wolfe, & Halle, 2016), tacts (e.g., Heldt & Schlinger, 2012), and intraverbal behavior (e.g., Carroll & Kodak, 2015; Contreras & Betz, 2016), using lag reinforcement schedules or other interventions. Although perhaps not germane to most of the topics Skinner (1957) addressed in *Verbal Behavior*, studies in this category contributed additional information pertaining to the sensitivity of verbal behavior to operant reinforcement contingencies. In addition, they suggested many novel solutions to practical problems related to developing verbal repertoires.

Other Practical Applications

A total of 83 articles (22%) addressed practical problems other than those mentioned previously. Procedures for increasing speechlike vocalizations of children with minimal vocal communication skills were evaluated in 14 studies. Participants were mostly children diagnosed with ASD, but typically developing infants participated in one study (Lee, Luke, & LeePark, 2014). Although this was not a topic addressed extensively by Skinner (1957), previous research on the use of stimulus-pairing procedures to induce novel vocalizations (e.g.,

M. L. Sundberg, Michael, Partington, & Sundberg, 1996) had been inspired by Skinner's speculation on the role of automatic reinforcement in shaping vocal repertoires (p. 58). Several studies in this category represented continued evaluation of stimulus pairing procedures (e.g., Yoon & Feliciano, 2007). Other studies evaluated the effects of nonvocal mand training (e.g., Carbone, Sweeney-Kerwin, Attanasio, & Kasper, 2010), extinction of existing nonvocal mands (Valentino, Shillingsburg, Call, Burton, & Bowen, 2011), and lag schedules of reinforcement (e.g., Koehler-Platten, Grow, Schulze, & Bertone, 2013).

The assessment of existing verbal repertoires was the topic of 13 studies. Lerman et al. (2005) developed a functional analysis model for assessing the emerging verbal repertoires of minimally verbal children, and the findings were later replicated by others (e.g., Kelley et al., 2007). Esch, Esch, McCart, and Petursdottir (2010) described a procedure for distinguishing between echoic and self-echoic repertoires, and Gross, Fuqua, and Merritt (2013) described procedures for assessing controlling variables in the verbal behavior of older adults. Along with some of the previously mentioned applied studies, this research contributed to the development of a methodology for identifying antecedent control over verbal behavior.

Effects of establishing verbal repertoires on other behavior were assessed in 36 studies: in most cases, within the context of functional communication training, in which a behavioral excess is replaced with an appropriate mand for the maintaining reinforcer identified in a functional analysis (e.g., Falcomata, Muething, Gainey, Hoffman, & Fragale, 2013). Similar to studies on the rate and variability of manding, some of the studies in this category contributed interesting information on the operant characteristics of communicative behavior: for example, information on the resurgence of extinguished mands (Berg et al., 2015).

Additional studies on language intervention for children with ASD or other developmental disorders addressed, among other topics, staff and caregiver training (e.g., Nigro-Bruzzi & Sturmey, 2010), effects of treatment integrity errors on mand acquisition (Pence & St. Peter, 2015), procedures for improving conversation skills (e.g., Peters & Thompson, 2015), and outcomes of packaged interventions (e.g., Mc-

Keel, Dixon, Daar, Rowsey, & Szekely, 2015). In a somewhat different area of application, several studies on equivalence-based instruction (EBI) in higher education incorporated verbal operant terminology to describe independent or dependent variables (e.g., O'Neill, Rehfeldt, Ninness, Muñoz, & Mellor, 2015). These studies are part of a larger literature on EBI that has emerged in recent years.

Miscellaneous Topics

The remaining 19 studies in the database addressed a miscellany of topics, some of which broke new ground or represented understudied areas in the analysis of verbal behavior. For example, Cruvinel and Costa Hübner (2013) collected observational data on the behavior of a typically developing toddler from the age of 17 to 24 months and classified child and caregiver vocalizations in terms of likely sources of control. Results were consistent with the notion that caregivers arrange contingencies supporting children's acquisition of verbal operants. Flores, Santos, Amadeu, and Dias (2013) similarly collected observational data on the verbal behavior of adults reading stories to children, which were also analyzed according to Skinner's conceptual system. Stocco, Thompson, and Hart (2014) conducted a laboratory study on the establishment of control by private events based on public accompaniment over tacting, and another laboratory study by Houtmanfar, Hayes, and Herbst (2005) modeled the dominance of first language over second language in a bilingual verbal repertoire.

Finally, one study on rule-governed behavior was included in the database (Wilson & Dixon, 2015). Many other basic and applied studies on rule governance were published during the review period but not included in the database because the variables measured and manipulated were not characterized as verbal operants. This may be a limitation of the inclusion criteria used by Petursdottir and Devine (2017) and previous studies (e.g., Sautter & LeBlanc, 2006), given that consideration of rule-governed behavior has been identified as important to the advancement of the experimental analysis of verbal behavior (e.g., Catania & Shimoff, 1998). The status of research on rule-governed behavior, however, must await future review.

Conclusions and Future Directions

The failure of Skinner's (1957) analysis of verbal behavior to gain status as a mainstream scientific theory of language has sometimes been attributed, in part, to its failure to generate a vigorous program of empirical research (e.g., Dymond & Alonzo-Alvares, 2010; Michael, 1984). It is clear that an experimental analysis of verbal behavior has now taken off with an exponential increase in empirical activity. As Petursdottir and Devine (2017) noted, these developments may be, in part, driven by the demand for behavioral interventions for children with ASD, the promotion of Skinner's work as a conceptual foundation of behavioral language interventions for this population (e.g., M. L. Sundberg & Michael, 2001), and a proliferation of behavior analysis graduate programs along with increased emphasis on verbal behavior in graduate curricula.

It may be reasonable to ask how much really has been learned about verbal behavior from this research, compared with what was already known decades ago; specifically, that verbal behavior is sensitive to social reinforcement contingencies and such contingencies can be utilized to teach language skills to individuals with disabilities. A large portion of the recent work reviewed in this article perhaps served primarily to contribute more demonstrations of these two points, along with refining intervention and assessment techniques and providing other practically important information. However, the sheer volume of practically oriented studies should not be used to divert attention from the fact that a large number of studies also addressed more fundamental questions regarding variables that influence verbal behavior. In addition, it should be kept in mind that Skinner (1957) considered the prediction and control of verbal behavior to be the ultimate aim of his analysis (p. 12) and suggested that one way to assess this aim was through the accomplishment of specific engineering tasks (p. 3). The large number of applied verbal behavior studies published in recent years have contributed a wealth of information on how to best accomplish at least one specific engineering task. That is, we now know a great deal more about effective strategies for establishing basic mand, tact, and intraverbal

control in developing verbal repertoires, such as those of children with language impairment due to ASD or other developmental issues. It may not be unreasonable to suggest that the achievement of practical control over developing verbal repertoires is a prerequisite to achieving practical control over more complex verbal behavior.

It is clear, of course, that much unexplored territory remains. Based on an analysis of articles published in the journal *The Analysis of Verbal Behavior* since its inception, Presti and Moderato (2016) concluded that although empirical studies were appearing in this journal at increasing rates, their contribution was mostly limited to the study of the acquisition of elementary verbal operants in isolation, while few studies had addressed complex topics such as multiple control and autoclitic behavior. The present analysis of a larger database confirms that current verbal behavior research primarily addresses Part 2 of *Verbal Behavior*, in which Skinner introduced the conceptual tools that he would use to expose the argument that relatively simple operant contingencies could fully account for the complexity of human language. Several studies addressed autoclitic control and grammar from Part 4, but little was done to address the topics of Parts 3 to 5, such as multiple control (but see Kisamore et al., 2011; Sautter et al., 2011), self-editing, and thinking. However, it may be premature to conclude that the absence of these topics suggests "methodological and theoretical limits of the operant analysis of verbal behavior that grew from . . . the animal laboratory" (Presti & Moderato, 2016, p. 13). Alternatively, perhaps the sudden proliferation of studies on elementary verbal relations represents the expansion of an empirical foundation for future work involving more complex problems. Recent annual convention programs of the Association for Behavior Analysis International include some indicators that such work may be beginning (e.g., Bergmann, 2017; Devine, 2016; Phelan, 2017). The introduction of the elementary verbal operants in Part 2 of *Verbal Behavior* made it possible to accomplish the analysis of complex verbal behavior presented in later sections of the book. It may be that, similarly, empirical validation of these fundamental concepts is what makes empiri-

cal application of the remaining content possible.

It should be noted that another behavior-analytic research program is already in existence that addresses adult cognition and mature verbal repertoires from the perspective of relational frame theory. Although a few studies that clearly rose from this tradition were included in Petursdottir and Devine's (2017; Study 2) database, it is likely that many more failed to meet the inclusion criteria for direct influence by *Verbal Behavior*, so the contributions of this literature will not be assessed here. It remains to be seen how future research modeled more directly on the later sections of Skinner's (1957) book might fit in with this existing work, and whether it will adopt the concepts of relational frames as higher-order operants or focus more on component repertoires in relational framing.

In a 1998 special issue of the journal *The Analysis of Verbal Behavior* (Schlinger, 1998), several researchers described their future visions for the analysis of verbal behavior. Among areas identified as needing future work were the integration of elementary verbal repertoires, as when the reinforcement of one relation alters another (Spradlin, 1998) and the relationship between verbal operants and stimulus equivalence (Hall, 1998). These seem to be the primary areas in which developments have occurred since then, as a majority of basic investigations in the last decade have been related to these topics. As noted previously, antecedent control in the absence of reinforcement is an issue that requires explanation in a behavioral account of language. A thorough discussion of the extent to which major conclusions can be drawn so far and where additional work is needed is beyond the scope of this article. However, whatever conclusions may ultimately be drawn, it should be kept in mind that Skinner's (1957) analysis of multiple causation and its role in complex verbal behavior is capable of accommodating a variety of reasons why an antecedent stimulus may have gained control over a response, as long as they are consistent with behavioral rather than mentalistic explanations.

Beyond addressing the additional content of *Verbal Behavior*, what are some reasonable future directions for the experimental analysis

of verbal behavior? Plenty of guidance can still be found in previous attempts to answer this question (e.g., Catania & Shimoff, 1998; Mabry, 1998; M. L. Sundberg, 1991), and only a few suggestions will be offered here. First, now that Chomskyan nativism has largely fallen out of favor in the area of mainstream psycholinguistics (e.g., Evans & Levinson, 2009; Romberg & Saffran, 2010; Tomasello, 2009), the time seems ripe to consider how behavior analysis may complement current environmentally based theories of language and its acquisition. In this context, non-human analogs (e.g., Epstein, Lanza, & Skinner, 1980; Kuroda et al., 2014) may provide important validation of the role of basic behavioral processes in verbal phenomena, along with human laboratory experiments and observational research on verbal behavior development (e.g., Cruvinel & Costa Hübner, 2013). Related to the last point, a great deal of recent research on infant development outside of behavior analysis has focused on the role of social contingencies in language acquisition (e.g., Goldstein & Schwade, 2008; Goldstein, Schwade, & Bornstein, 2009; Wu & Gros-Louis, 2014) and behavior analysts might do well to make a connection to this work. Second, it may be important to develop nonexperimental methodologies appropriate to answering questions that are not amenable to experimental analysis. Some developments in this area are already underway (Critchfield, Becirevic, & Reed, 2016). Third, current technologies afford new areas of application, or perhaps resurrection of old ones. In the area of artificial intelligence and robotics, there is currently a great deal of interest in the role of contingency learning in language (e.g., Lohan, Rohlfing, Saunders, Nehaniv, & Wrede, 2012) and increased contact with this area would likely be intellectually profitable. In addition, now that most people carry potential teaching machines (cf., Skinner, 1958) in their pockets, it seems reasonable to expect verbal behavior researchers to address questions related the development of educational software, perhaps building on existing foundations of programmed instruction and EBI. However, only time can tell exactly where the experimental analysis of verbal behavior will go from here.

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