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DISCUSSION/REVIEW ARTICLE

A Bibliographic Tribute to Jack Michael

Barbara E. Esch[1] · **John W. Esch**[1]

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Abstract *"In the late 1950's, Jack Michael, a bright but irritating young psychology instructor, moved from the Universities of Kansas to Houston to Arizona State. Along the way he befriended two nontraditional students, protected them through their Ph.D. programs, and turned them loose on the world: Teodoro Ayllon…and Montrose Wolf…*" (Risley, 2001, p. 267). So begins Risley's chapter on the origins of applied behavior analysis. For almost 50 years, Jack Michael provided a model for us to "talk like Skinner" and to analyze behavior as Skinner would. For this, he has been widely respected and revered. The purpose of this bibliography is to explain to new and familiar readers alike Jack's contributions to the field of behavior analysis in areas of his primary focus: (a) behavioral function taxonomy, (b) motivation, (c) reinforcement, (d) response topographies, (e) multiple control, (f) duplic and codic verbal behavior, and (g) teaching. Throughout, we weave his role in the field's history and his leadership in its expansion, as these have been additional areas of significant contributions. Above all, we wish to highlight Jack's work, in bibliographic and narrative form, in a way that expresses a heartfelt tribute on behalf of his students and others whom he influenced to learn about psychology as a natural science and to think and talk like Skinner.

Keywords Jack Michael · bibliography · verbal behavior · motivating operations · stimulus control

This bibliography is written in a somewhat informal style to give readers a sense of Jack's affability, yet also to highlight his precise attention to the details of our "verbal behavior about behavior." In fact, he was a stickler for these details. Former students will recall his frequent *NQR* ("not quite right") written in the margins of a quiz paper, leading many to examine their own intraverbal and transcriptive behaviors and

✉ Barbara E. Esch
besch1@mac.com

✉ John W. Esch
jesch1@mac.com

[1] Esch Behavior Consultants, LLC, PO Box 20002, Kalamazoo, MI, USA

then strive to follow his model. He devoted an entire chapter in *Concepts and Principles of Behavior Analysis* ("C&P"; Michael, 1993, 2004) to the correct pronunciation of *realtor*, *nuclear, picture*, and other commonly garbled words, as well as to the correct usage of *stimulus, evoke, illicit/elicit, effect/affect, accept/except, sit/set, lay/lie*, and he enjoined us to not confuse *casual* and *causal* in reading Skinner, and to immediately remove the word *irregardless* from our vocabulary.

These pet peeves represented his deep concern with "getting it right" when writing and talking about behavior analysis. We hope readers will be inspired to continue addressing areas that he so strongly emphasized throughout his career. In this paper, we discuss the areas of his primary focus: (a) behavioral function taxonomy, (b) motivation, (c) reinforcement, (d) response topographies, (e) multiple control, (f) duplic and codic verbal behavior, and (g) teaching. Throughout, we weave his role in the discipline's history and his leadership in its expansion, as these have been additional areas of significant contributions. Ultimately, the impact of Jack's impressive body of work will be evident in the bibliographies of others. His legacy is through all who learned from him and through the echoes of their own influence.

Identification of Resources

Literature Search

Primary sources for bibliographic entries were selected for maximum breadth to represent Jack's contributions. These included personal books, manuals, reprints, and letters; course syllabi, course objectives, lecture notes, and exams from Western Michigan University; published journal articles; newsletters and program books from the Association for Behavior Analysis International (ABAI); videotapes/DVDs from Dr. Alyce Dickinson (Jack's long-term colleague and wife) and from ABAI; audio and/or video presentations archived by Florida Institute of Technology and the Pennsylvania Training and Technical Assistance Network; and accessible online media. We initially listed and cross-referenced bibliographic items from Jack's website and curriculum vitae, adding entries yielded from database searches and other sources. We also searched the following databases: PsycINFO, Web of Science (Social Science Abstracts, Humanities Abstracts - online), Scopus, WMU Library Search, Google Scholar, PubMed (Medline), and SciELO Citation Index. In addition, if a presentation (e.g., workshop) was available in retrievable form, it was included. After omitting duplicate entries, this became the master list.

Results

No previous bibliographies of Jack's works were found so this appears to be the first. The bibliography includes scholarly works and newsletter contributions published in English, Spanish, Portuguese, and Polish. Course notes referenced throughout the narrative were not included in the primary-source bibliography as they are the authors' personal copies and are not electronically retrievable. Jack's book, C&P, is largely a

compilation of previously published scholarly articles and is so noted in the bibliography in two ways: first, the entry for C&P (2004) is followed by a list of the component chapters and articles from which they were modified or revised; second, each original article is listed separately in the bibliography. Both editions of C&P are listed (1993/2004). The C&P book references were included because (a) they contain original material (e.g., Chapters 1 and 2) and (b) Jack noted (Michael, 2004, p. ii) that modifications were made to many of the original articles that later were reprinted in the revised edition of C&P.

In the case of journal articles printed first in *VB News*, and later reprinted when that publication became *The Analysis of Verbal Behavior* (*TAVB*), we have listed the entry as it appears on the first page of the published article (see *TAVB* archives http://www.ncbi.nlm.nih.gov/pmc/journals/609/). This eliminated discrepancies in page numbers between the original publication and the reprinted *TAVB* versions of each article. This resulted in 109 primary-source bibliographic entries covering the years 1959 to 2014, with many of these entries also appearing in the References.

Conceptual/Taxonomical/Research Contributions

Above all else, Jack's writings emphasize his dedication to conceptual clarity and precision. Having been strongly influenced by Skinner's writings, particularly *Science and Human Behavior* (1953; Michael, 2004, pp. 122-129), Jack may have observed that some topics covered by Skinner (and others) were undeveloped or underdeveloped. Also, as a professor, he had ample opportunity to observe issues, points, and concepts that were easily misinterpreted by students. Starting with his paper on reinforcement (Michael, 1975b), he began to refine and clarify various topics relevant to the analysis of behavior, providing a model for our verbal practices regarding these issues and influencing their further conceptualization, research, and clinical applications.

Behavioral Function Taxonomy

> One might ask why it is of any value to be able to recognize and correctly name these various effects. I would answer that I have found…that I cannot understand some things unless I can talk about them clearly. I cannot think clearly about nonverbal events unless I have a consistent verbal repertoire regarding those events. Perhaps I should be more intuitive or contingency shaped and less rule governed, but my intuition tells me otherwise. (Michael, 1995, p. 284)

Conceptual relevance Jack presented his first taxonomy of behavioral functions in 1983, perhaps initially as a teaching tool, but certainly as a reminder to the field that these functions are important, separately distinguishable, and critical for inclusion within a contextual framework. Several modifications followed (Laraway et al., 2002, 2003; Michael, 1995, 2004). Table 1 depicts our adaptation of Jack's 2004 version, presenting the terms for behavioral functions of respondent and operant relations according to their *behavior-altering* and

function-altering effects. Behavior-altering effects refer to stimuli that immediately, but only *momentarily*, elicit or evoke behavior. By contrast, function-altering effects refer to *permanent* changes of a behavior-environment relation. The following is a description of these terms and Jack's recommendations for more precise verbal practices.

A respondent is a learned stimulus-response relation developed by pairing a neutral stimulus with an unconditioned stimulus for a reflex response (Michael, 2004). For example, in a classic respondent experiment, a food-deprived dog will salivate, an unlearned reflex, when an unconditioned stimulus (US) such as food powder is placed in its mouth. Further, a neutral stimulus (NS) paired with that US presentation would acquire some of the eliciting properties of the US. For example, if a tone is presented just before the food powder in a series of NS-US pairings, the next time the tone is presented, it alone will elicit salivation.

In the experiment described above, the single term, US, actually describes two distinct effects: behavior-altering (salivation) and, through pairing, function-altering (the tone now evokes salivation). To eliminate the ambiguity that could result when a single technical term refers to multiple effects, Jack recommended separate terms for each effect. He assigned the term *unconditioned elicitor* (UE, e.g., food/salivation) to denote unlearned behavior-altering effects (i.e., the momentary eliciting effects of the US) and the term *unconditioned conditioner* (UC, e.g., tone/food pairing) to refer to its function-altering effects following pairing (i.e., conditioning of the CS). In similar

Table 1. Taxonomy of Behavioral Functions

		Respondent	Operant
Behavior-Altering	Unlearned	UE	UMO
	Learned	CE	CMO-S CMO-R CMO-T $S^{D}_{(rfmt)}$ $S^{D}_{(pmt)}$
Function-Altering	Unlearned	UC	S^{R} S^{P}
	Learned	CC	S^{r} S^{p}

Respondent behavior-altering: UE (unconditioned elicitor), CE (conditioned elicitor)

Respondent function-altering: UC (unconditioned conditioner), CC (conditioned conditioner)

Operant behavior-altering: UMO (unconditioned motivating operation), CMO-S (surrogate conditioned motivating operation), CMO-R (reflexive conditioned motivating operation), CMO-T (transitive conditioned motivating operation), $S^{D}_{(rfmt)}$ (discriminative stimulus for reinforcement), $S^{D}_{(pmt)}$ (discriminative stimulus for punishment)

Operant function-altering: S^{R} (unlearned reinforcer), S^{P} (unlearned punisher), S^{r} (learned reinforcer), S^{p} (learned punisher)

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Michael, J. L. (2004). *Concepts and principles of behavior analysis* (Rev. ed.), Figure 20, p. 74.

Kalamazoo, MI: Association for Behavior Analysis International.

fashion, the CS was ascribed a separate term for each effect. The term *conditioned elicitor* (CE, e.g., tone/salivation) describes learned behavior-altering effects and the term *conditioned conditioner* (CC, e.g., tone/neutral stimulus) expresses learned function-altering effects.

Table 1 also displays two effects of operant relations. Cooper et al. (2007) describe an operant as "behavior whose future frequency is determined primarily by its history of consequences" (p. 31). For behavior-altering effects, Jack inserted subscript tags by type for discriminative stimuli, with S^{D}_{rfmt} based on reinforcement and S^{D}_{pmt} based on punishment (Michael, 2004). Other behavior-altering effects involve unconditioned motivating operations (UMO) and various conditioned motivating operations (CMO), described below.

Function-altering effects involve the pairing of unconditioned or conditioned reinforcement or punishment (S^{R}, S^{r}, S^{P}, S^{p}). Through this procedure, neutral stimuli paired during reinforcement can come to function as S^{D}s and CMOs (see Michael, 1995, p. 276). For example, consider the initial conditioning of a token to an instruction: "When you finish the puzzle and get your last token, you can play with the computer." New behavioral relations are developed upon finishing the puzzle by pairing delivery of the token and access to the computer. However, it is not until the next time these stimuli are present that the established behavioral relations are evident. That is, pairing the token with computer access alters the function of tokens from NS to a form of conditioned reinforcement (S^{r}). The stated contingency (*When you finish…*), having been paired with computer access, comes to function as a CMO that alters the value of tokens (S^{r}) and the function of finished puzzles (S^{D}). Similar analyses can be made for punishment contingencies. That is, pairing unconditioned stimuli with aversive events can establish those stimuli as S^{p}, S^{D}_{pmt}, and abolishing operations (AO).

Research impact The impact of Jack's taxonomy of behavioral functions as an instructional tool and in analyzing behavior is difficult to determine. Certainly Jack hoped it would have utility for the discipline (see Michael, 1995), but it does not appear to be in widespread use compared to other scientific references (e.g., chemistry's Periodic Table). However, recent changes may offer steps toward its improved usefulness. For example, Michael (1996) adopted Schlinger and Blakely's (1987) term, *function-altering effects,* to replace *repertoire-altering effects* to more precisely label the more permanent changes of stimulus events as the result of the pairing of neutral stimuli with effective stimuli or the unpairing of conditioned stimuli (e.g., delivery of tokens without backup reinforcement). Similarly, following recommendations by Laraway et al. (2003), Michael (2004) replaced the term *evocative effects* with a more inclusive term *behavior-altering effects* to describe the immediate but momentary effects of stimuli on behavior (i.e., abative, evocative, elicitive, and inhibitive).

With these unambiguous components of the taxonomy (learned/unlearned, operant/respondent, function-altering/behavior-altering effects), it may be time to consider updating the taxonomy, which may result in a more useful instructional tool for assessing and treating clinical problems as well as to sharpen our scientific verbal repertoire regarding difficult-to-explain phenomena. For example, like Skinner (1957), Jack gave verbal stimuli no special recognition in any versions of the taxonomy. But the discussion of function-altering verbal stimuli, such as those that specify a

contingency (see Blakely & Schlinger, 1987; Schlinger & Blakely, 1987), suggests that verbal stimuli could be a useful addition to the taxonomy (see Schlinger, 1993b). Special notations to discriminate behavior-altering and function-altering effects of verbal stimuli from non-verbal stimuli might be indicated if a case could be made that their separate functions are unique or deserving of separate notation. For example, Sundberg and Sundberg (2011) denoted VC^D to refer to verbal conditional discriminations. Other possible inclusions of verbal stimuli are discussed by Lotfizadeh et al. (2014).

Finally, using subscripts to denote the different behavioral effects of respondent stimuli (e.g., $_E$ for behavior-altering effects and $_C$ for function-altering effects) is a modest change that might be more acceptable. Thus, US_E and CS_E would indicate the elicitive effects of the US and CS, whereas US_C and CS_C would refer to the function-altering effects of the US and CS. For completeness, an updated taxonomy should include all function-altering effects of pairing and unpairing procedures. Jack mentioned several that were omitted, including unpairing operations (e.g., operant/ respondent extinction), pairing operations (e.g., producing conditioned reinforcers, S^Ds, CMOs), as well as other operations affecting behavior (e.g., blocking, overshadowing, observational learning, imprinting; see Schlinger & Blakely, 1994). Although organizing this type of taxonomy could be challenging, we believe it could offer important support to research design and clinical applications.

Motivation

> Our way of talking about operant stimulus control seems to include but fails to distinguish between two quite different forms of control. We might improve our verbal practices by adopting a new technical term for one of these forms of control. (Michael, 1982a, p. 149)

Conceptual relevance The traditional literature in psychology is replete with constructs of motivation as an inner mechanism related to other mental functions that are seen to affect behavior. Interestingly, "most introductory psychology textbooks have a whole chapter on motivation, but it is typically disconnected from the chapter…on learning" (Sundberg, 2013, p. 13). As a science that focuses on the observable effects of environmental events, behavior analysis and its literature has not been so encumbered. Nevertheless, the topic has presented conceptual difficulties for our field in a number of ways. First, explicit, fine-grained descriptions (i.e., molecular analyses) of how motivation influences behavior were lacking in our literature's early treatments of the topic (e.g., Keller & Schoenfeld, 1950; Skinner, 1938, 1953, 1957).[1]

[1] Skinner (1938, 1953, 1957) and Keller and Schoenfeld (1950) clearly saw motivation as a critical antecedent (see Sundberg's comprehensive discussion, 2013). However, the field of behavior analysis made little use of this information, leading Michael (1993) to observe that the "present failure to deal with the topic leaves a gap in our understanding of operant functional relations" (p. 191).

Also, Skinner's (1953) treatment of the term as biological deprivation (e.g., *wants, drives*) may have delayed a more complete analysis. In addition, pervasive cognitive descriptions of motivation and the term's everyday usage may have contributed to the lack of analytic scrutiny. Furthermore, descriptions vis-à-vis the three-term contingency (e.g., S^D-R-S^R) may have obscured alternative behavioral explanations for evocative effects of other antecedent stimuli. Consider the example of a child asking for a cookie. If one disregards motivation as a variable, it might be compelling to view the mand solely in the context of a discriminated response. That is, she asks (R-response) mom (S^D_{rfmt}) for a cookie due to a differential history of requesting and getting a cookie (S^R) only when mom is in sight (S^D). However, if motivation is indeed a variable, the explanation is not inaccurate, only incomplete. It is an easy oversight because the evocative effects correlated with *wanting a cookie* are confounded with the evocative effects of the S^D (sight of mom) correlated with *a history of cookie reinforcement*. Thus, a full account must consider all relevant antecedents and identify those that could be masked as discriminative stimuli.

The conceptualization of motivation as *establishing operations*[2] (Keller & Schoenfeld, 1950; Michael, 1982a) addressed this problem, introducing a 4th term into contingent relations, thus allowing more complete analyses of component and combined roles of these variables. Skinner (1953) and Keller and Schoenfeld (1950) had discussed motivation as an antecedent event, but Jack refined the analysis by distinguishing the separate roles of antecedent stimuli, namely those arising from *motivating operations* (establishing operations; EO, MO)[3] versus those correlated with a history of reinforcement (i.e., S^Ds). These separate roles are easily confused. Consider Jack's laboratory example of a shock-escape procedure (Michael, 2004, p. 33) in which the onset of shock evokes a lever press that results in shock offset. At first blush, it may seem reasonable to view shock as an S^D for subsequent responses that terminate the shock stimulus, but this would be an incorrect analysis because shock onset does not meet the definition of an S^D:

> A discriminative stimulus is a stimulus condition which, (1) given the momentary effectiveness of some particular type of reinforcement (2) increases the frequency of a particular type of response (3) because that stimulus condition has been correlated with an increase in the frequency with which that type of response has been followed by that type of reinforcement. (Michael, 1982a, p. 149)

The critical defining feature of the S^D is the correlation of a stimulus with *differential reinforcement* by an event, when that event is valuable. In the cookie example above, the child asks for a cookie (when cookies are valuable), because of a differential reinforcement history of doing so with mom in sight, but not in mom's absence.

In the case of Jack's shock example, understanding why shock is not an S^D centers on the importance of differential reinforcement in establishing an event as discriminative. In combination with an MO, an S^D evokes a response because that

[2] Also referred to as *motivating operations* or *motivating variables* (Laraway et al., 2002, 2003) and *motivative variables* (Michael, 2000, 2004, 2007).

[3] The acronym, MO, will be used throughout to denote environmental operations that function either as establishing (EO) or abolishing (AO) events.

response has been followed by MO-relevant reinforcement in the presence of the S^D *and not in its absence* (Michael, 2004, p. 61). With non-aversive stimuli, like cookies, it is easy to understand how a child learns to ask for them (when there's an MO for cookies) when mom is present and never asks for them when she is absent. That is, cookies are unlikely to be requested in mom's absence, because asking for them when mom is not in sight has never been followed by cookies, despite a strong cookie MO. The S^D learning paradigm requires that, in the presence of the S^D_{rfmt} (sight of mom), cookie requesting occurs and is followed by reinforcement. The response also must occur in mom's absence, S^{Delta}, and never be followed by reinforcement.

By contrast, shock onset is a stimulus that does not meet the defining features of an S^D_{rfmt}. If it were an S^D_{rfmt}, it would require a differential history of (a) reinforcement (i.e., shock offset) for lever pressing in the presence of shock and (b) no reinforcement for lever pressing in the absence of shock. The key point is that, in the absence of shock onset, shock offset cannot function as reinforcement. Thus, shock cannot be an S^D and must be explained by a different stimulus function.

Jack introduced the term that became *motivating operation* to account for this different type of evocative effect, one correlated with a particular event regardless of the differential availability of that event (Michael, 1982a). An MO is "an environmental event, operation, or stimulus condition that affects an organism by momentarily altering (a) the reinforcing effectiveness of other events and (b) the frequency of occurrence of that part of the organism's repertoire relevant to those events as consequences" (Michael, 1993, p. 192). That is, MOs (a) establish or abolish what is currently effective as reinforcement or punishment and (b) evoke or abate behavior that has resulted in that consequence in the past; furthermore, discriminative stimuli can be modified by these events (Laraway et al., 2003; Lotfizadeh et al., 2012).

In distinguishing MOs from S^Ds, additional examples may be helpful. A hot day at the beach is a stimulus event (MO) that (a) alters the reinforcing effectiveness of cold things or escape from the heat and (b) increases the frequency of behaviors related to obtaining cold things (e.g., buying cold drinks) or escaping from the heat (e.g., lying under a beach umbrella). In this case, a hot day is an MO that changes what is *valuable*, not what is available, as would be the case with an S^D. Cold drinks or beach umbrellas might be readily available at any time at the beach and mands related to these items may have been differentially reinforced in the past. However, one is unlikely to ask for them on a chilly, cloudy day because they are not valuable regardless of their availability. Under such conditions, a mand for cold drinks or sun umbrellas must be accounted for in another way. Consider another example: Upon seeing that the car's fuel gauge indicates full, one could, but does not, stop at a gas station (S^D). This is because, regardless of the availability of gas, it is not currently valuable (no MO for gas). But seeing an empty gas gauge (MO for gas), the gas station (S^D) will evoke behaviors that, in the past, have resulted in obtaining gas (S^r). Even if no gas station is present, the MO for gas would evoke the behavior of searching for a station. In other words, an MO may evoke responding related to a particular event or condition, but the MO alone does not guarantee reinforcement. That is, in the absence of a relevant S^D, the MO-evoked behavior may not be differentially reinforced.

Jack first talked about motivation as an unlearned *establishing operation* that had both repertoire-altering and evocative effects (Michael, 1982a). This terminology was modified over the years to more precisely describe various effects: (a) *establishing*

operation (EO) was changed to *motivating operation* (MO) and *conditioned establishing operation* (CEO) was changed to *conditioned motivating operation* (CMO), (b) *evocative effects* became *behavior-altering effects*, identifying the establishing or abating stimuli that immediately evoke or abate operant responses, and (c) *reinforcer-establishing effects* was replaced by *value-altering effects*, subsuming the reinforcer-establishing, reinforcer-abolishing, punisher-establishing, and punisher-abolishing effects of stimuli (see Laraway et al., 2002, 2003; Michael, 2004, p. 47; also see Klatt & Morris, 2001).

Table 1 shows two types of motivating operations, unlearned and learned, with behavior-altering effects. Unlearned (unconditioned) motivating operations (UMOs) are a function of certain biologically related events (e.g., hours without food) and establish specific stimulus conditions as reinforcement (e.g., food; Michael, 1995, 2004). When a UMO is paired with a neutral stimulus (NS), the NS becomes conditioned such that it now functions similarly to the original UMO. Jack described three such types of conditioned motivating operations (CMOs). The *surrogate* conditioned motivating operation (CMO-S) obtains behavioral effects and stimulus establishing effects of the UMO with which it was paired (Laraway et al., 2014; Michael, 2004; also Miguel, 2013). For instance, upon hearing the morning weather report that predicts a stormy day, one need not actually experience the rainstorm to pack an umbrella when leaving for work, given a history of seeing similar forecasts followed by actual rainstorms (see Tapper, 2005 for a discussion of CMO-S in appetite research). Another type of CMO, the *reflexive* conditioned motivating operation (CMO-R), is an event that establishes its own termination as a form of reinforcement. CMO-R operations are commonly called escape or avoidance. For example, the sight of a long line of cars backed up on the interstate establishes escape from that highway as a form of reinforcement, and, upon seeing an exit sign (S^D), evokes taking the next exit (a response that has been differentially reinforced in the presence of the exit sign when given relevant MOs). It should be noted, however, that the CMO-R is not restricted to obviously aversive stimuli like traffic jams. The CMO-R evokes the removal of any event, even one that may be commonly viewed as positive or pleasant. For instance, although most people may enjoy praise and attention, some people may find excessive flattery to be a CMO-R such that it evokes behavior that would terminate it. A third type of CMO, the *transitive* conditioned motivating operation (CMO-T), establishes a stimulus as reinforcement and evokes behavior to produce that stimulus because a second reinforcing event cannot be accessed without it. For example, the waiter brings your order of sushi, but no chopsticks. That situation (CMO-T) evokes asking the waiter (S^D_{rfmt}) for chopsticks; the waiter brings them (S^r/ S^D_{rfmt}) and now you can eat the sushi (S^R). For an in-depth review of Jack's conceptualization of all MOs, see Miguel (2013).

Research impact Jack's clarification of the separate roles of antecedent stimuli (i.e., MO, S^D; Michael, 1982a) focused our behavior-analytic lens in a way that greatly affected our research questions and how we teach (e.g., LaFrance & Miguel, 2014; Sundberg, 1991, 1993b, 2013; Sundberg & Michael, 2001). Among the first to recognize the applied impact of Jack's conceptualization were Sundberg (1993b) and Polson and Parsons (1994), who pointed out that the MO as an evocative stimulus expanded the three-term contingency to four terms (also see Schlinger, 1993a). These

discussions, coupled with Jack's initial work and subsequent refinements and extensions (e.g., Laraway et al., 2002, 2003; Michael, 1993, 2000, 2007) have generated conceptual and applied accounts of the role of motivating operations in a multitude of socially significant areas of human behavior, effectively spring-boarding behavioral designs across the expanse of our professional endeavors.

Perhaps foremost to benefit from the conceptual work in MOs is language acquisition research. Understanding the distinction between discriminative stimuli (S^Ds) and MOs is critical to effective mand training (Sundberg, 2004, 2007). In fact, Jack advocated for including the MO in the definition of a mand (Michael, 1988; also see Miguel, 2013). The temporary nature of an MO is of strong benefit in establishing conditions amenable to mand training; prevailing MOs can be captured or contrived and, thus, exploited to a learner's advantage. The reader will recall that this momentary effectiveness (i.e., value) of particular stimuli is central to the concept of the CEO-T[4] (Michael, 1993) in which some stimulus condition (S2) is dependent upon some other stimulus condition (S1), such that "the onset of S1 [as CMO-T] increases the reinforcing effectiveness of S2, and also causes an increase in the current frequency of all behavior that has been reinforced by S2" (Michael, 2004, p. 56). Jack's famous slotted screw example of CEO-T (Michael, 1982a, p. 152) is probably familiar to us all: a chain of responses (taking a faceplate off a wall) is interrupted by the absence of a certain stimulus (a flat-blade screwdriver) required for the next response to be emitted (removal of the slotted screw). This situation temporarily increases behavior (e.g., manding) that has obtained the missing item in the past. The electrician asks his assistant for the correct screwdriver, but not because the sight of the slotted screw is a discriminative stimulus signaling that the relevant screwdriver is more *available*; indeed, the electrician could have asked for it at *any* time, but he didn't. He asks for the screwdriver because of its increased value established by the MO (i.e., the sight of the slotted screw). That is, the electrician didn't need that particular screwdriver before, but now he does.

Such (CMO-T) situations are easy to contrive and have allowed the establishment of mand repertoires in many learners, including mands for information (e.g., Endicott & Higbee, 2007; Shillingsburg & Valentino, 2011; Sundberg et al., 2002). This is a common skill deficit in children with an autism diagnosis and both the reason and solution are related to the critical difference Jack articulated between the S^D and MO. Often, mand instruction fails to establish relevant MOs for a learner to request information precisely because the requisite antecedent conditions are not established, resulting in question-asking evoked solely by discriminative stimuli, such as an instruction (e.g., "Go ask Joey what color he likes"). Recall that discriminative stimuli are related to the *availability* of reinforcement, not the *value* of reinforcement (Michael, 1982a, 1993, but also see "a complication," Michael, 2004, p. 57). This distinction between these sources of control is often ignored in language program design, possibly because antecedent instructions and prompts are easier to provide than arranging effective motivating conditions. However, without a relevant MO (e.g., "After you find out what color Joey likes, come and tell me then you can pick out your own paint

[4] Arrangements employing CEO-T are often referred to as *blocked access* or *interrupted chain* procedures. Jack saw these CEO-T events as ubiquitous in maintaining typical everyday behavior (Michael, 1993).

color"), mands such as those for information are unlikely to become part of a learner's repertoire.

Fortunately, relevant S1 and S2 conditions described by Michael (see above) have been successfully arranged and reported in the literature. Carbone (2013) cites many such applications, including those "to assess the transfer of mands across EOs… and settings…, establish derived manding skills for adults with developmental disabilities …, and test for transfer across verbal operant categories following manual sign and PECS training" (p. 47). In addition, MOs have been manipulated to assess mand functions in older adults with dementia (e.g., Gross et al., 2013; Oleson & Baker, 2014), to teach mands for missing items (e.g., Albert et al., 2012; Sidener et al., 2010), and to promote peer initiations (e.g., Taylor et al., 2005). (See Sautter & LeBlanc, 2006 for additional applications.)

Applications to improve language acquisition may also benefit from within-MO manipulations (Sundberg & Michael, 2001). A review by Lotfizadeh et al. (2012) reported that varying levels of food deprivation (UMOs) increased the evocative effects of not only S^Ds, but of stimuli that shared similar characteristics to the S^Ds. These findings have implications for designing and analyzing language instruction by considering, for example, how MO variations could maximally impact the evocative effect of the discriminative stimulus. Clinicians could vary the value/deprivation level within CMOs and assess the impact of these variations on target acquisition. For example, they could vary the intervals between access to favorite toys and, when the MO is strong for a particular toy, tact training could be conducted for that item.

Skinner (1957) defined and described verbal relations separately, delineating the necessary and sufficient conditions to evoke "pure" mands, tacts, and other verbal responses. Furthermore, the functional independence of these operants has been demonstrated (e.g., Petursdottir et al., 2008; Sundberg et al., 1990). However, responses need not be, and often are not, evoked only by variable(s) that define these separate functions; in fact, "most functional relations involve both S^Ds and MOs" (Sundberg, 2013, p. 24). The combined effects of multiple stimuli at current strength can bring about particular verbal (or nonverbal) responses and, in so doing, can enhance a learner's repertoire (see Michael et al., 2011, particularly pp. 13-14). In tact training, establishing relevant mand relations (i.e., MO and specific reinforcement) has been shown to facilitate its acquisition[5] (e.g., Carroll & Hesse, 1987) and the interaction of the multiple controlling variables for these operants can foster the acquisition of either (e.g., Braam & Sundberg, 1991; Finn et al., 2012; Greer & Ross, 2008; LeBlanc et al., 2009; Ross & Greer, 2003). For related discussions of how contingencies may interact in establishing verbal and listener relations see Miguel et al., 2005; Petursdottir et al., 2005; Ribeiro et al., 2010; also see Grow and Kodak, 2010 for a review of this topic, as well as our later section on *Multiple Control*.

Manipulations of MOs can reduce the occurrence of problem behavior (e.g., Bowman et al., 1997; Brown et al., 2000; Winborn et al., 2002). Moreover, addressing the function of problem behavior (see Iwata, Dorsey, Slifer, Bauman, & Richman, 1982/1994), including influences by MOs, can help reduce those problem behaviors by replacing them with functionally equivalent verbal responses (e.g., *Functional*

[5] But see Gamba et al. (2015) for a research review of functional independence of mands and tacts and their discussion of why "the literature has become difficult to interpret" (p. 12).

Communication Training, Carr & Durand, 1985; Tiger et al., 2008). For further applications involving the role of MO in resolving problem behavior, the reader is referred to several reviews on the topic: Iwata et al. (2000); Langthorne et al., 2014; McGill (1999); Smith and Iwata (1997); and Wilder and Carr (1998). Also see the tutorial by Langthorne and McGill (2009).

Researchers have begun to address another language related repertoire, joint attention, which is, by definition, a socially mediated skill.[6] Isaksen and Holth (2009) investigated ways to modify the value of attention (JA) (i.e., the conditioned reinforcing value of social attention) in order to increase initiation of joint attention by children with autism. Others have evaluated requisite component repertoires to achieve and maintain joint attention (e.g., Carbone et al., 2013). However, bringing these social responses under natural contingencies (i.e., MO for social attention) can be challenging (see Whalen & Schreibman, 2003) and continued research in this area has been called for (e.g., Carbone, 2013; Dube et al., 2004; Taylor & Hoch, 2008).

Including MO in a behavior analysis of clinical problems (e.g., depression, PTSD) may facilitate their resolution by viewing cognitions and emotions as outcomes of MOs (Dougher & Hackbert, 2000), thereby allowing a more complete analysis of the contingencies maintaining these behaviors. Lewon and Hayes (2014) proposed that CMO is a more apt term for certain clinical events whose current descriptions invoke mental states (e.g., conditioned emotional responses). Tapper (2005) described the advantage of including MOs in conceptualizations of independent variables involved in research on food and drink intake (e.g., cultural, social, sensory, and physiological stimuli). Motivating operations also may be important to include in the analysis and treatment of drug abuse relapse (see Troisi, 2013). A review by Langthorne et al. (2014) focused on negatively reinforced problem behaviors with putative escape from demand (CMO-R), finding that, in some cases, these behaviors were influenced, not by escape from demand, but by biological variables, ambient noise, or escape from attention (e.g., social proximity, praise), conceptualized as MOs. Some of these stimuli may be subtle and idiosyncratic, requiring careful analysis by researchers. For example, Langthorne et al. reported that an instructional mand such as "Show me the X" evoked problem behavior, but a disguised mand "I wonder where X is" did not. In terms of MO, subtleties such as these are critical to identify in order to design successful treatment programs. Skinner (1953) described reinforcement related to being effective in one's social environment where "prestige and esteem are generalized reinforcers only insofar as they guarantee that other people will act in certain ways" (p. 79). Thus, a conceptual analysis of generalized reinforcers and punishers characteristic of specific verbal communities may help inform treatment in particular settings and contexts. For example, guilt, related to certain religious practices or family histories, may, as an MO, evoke or abate certain responses by an individual or group. A more complete understanding of human behavior would require the identification of this class of reinforcers and punishers, the MOs that establish these stimuli as effective consequences, and their evocative or abative effects related to the relevant verbal community (e.g., Dillenburger, 2007).

[6] Joint attention (JA) is generally characterized as shared gaze following between two or more people attending simultaneously to an external stimulus (see Holth, 2005 for an operant analysis of JA skills).

Human motivation is of inherent interest to the field of Organizational Behavior Management (OBM) and MO applications have been successful within those settings (e.g., Agnew, 1998; Fagerstrøm & Arntzen, 2013; Fagerstrøm et al., 2010). Yet, a review of OBM articles that included MO discussions (see Lotfizadeh et al., 2014) suggests difficulty with its analysis and subsequent applications within organizational frameworks. They reported that MO terminology has expanded beyond its original definition (e.g., discussing product displays in terms of UMOs) and suggest that expansion may have occurred because conceptual descriptions of MO fail to identify effective reinforcers (and the operations that establish them as such) applicable to organizational contexts. To the extent that this is the case, more accurate descriptions and analyses are required to define requisite MO parameters. For instance, feedback as a common business term could be operationalized to allow its assessment as a motivating operation, as a conditional verbal discriminative stimulus, and as a form of reinforcement. Ultimately, MO applications in OBM settings may require modification of Jack's taxonomy, and research has been called for to more fully "delineate and categorize the full range of MO subtypes in organizations" (Lotfizadeh et al., 2014, p. 92).

Finally, behavioral research findings that pre-dated Jack's conceptualization and writing on the MO may require some analysis, particularly those studies involving rules and verbal instructions (e.g., peer proximity during instructions; Hake et al., 1973). This may be a starting point for research on complex behavior that includes verbal MOs and MOs involving generalized reinforcement in social settings (e.g., cooperation, competition).

Jack's students have been at the forefront of the effort to support and disseminate his work on MOs, particularly as it relates to verbal behavior. It would be difficult to adequately assess the positive impact made by the hundreds of publications and presentations that former students (and their students, in turn) have produced on this topic, but a few examples suggest these contributions have been significant. A highly cited article that Jack co-authored with one of his students, Mark Sundberg, contains a detailed discussion of the MO as an appropriate and critical independent variable in language training, with considerations of its role in establishing mands, as well as other forms of verbal behavior (see Sundberg & Michael, 2001). Another student published the first and oft-cited review of mand interventions (see Shafer, 1994), possibly precipitating another frequently cited and more comprehensive review of behavioral interventions across several verbal functions (see Sautter & LeBlanc, 2006). A popular press book on child development by another former student (see Schlinger, 1995) heavily references Jack's publications on the EO/MO. Finally, a special section entitled "Motivating Operations and Verbal Behavior" recently appeared in *The Analysis of Verbal Behavior* (Volume 29, 2013), with one of Jack's former students providing the introductory editorial (see Petursdottir, 2013) and two students (also former editors of the journal) contributing topic articles (see Miguel, 2013; Sundberg, 2013). In his 2013 article, Sundberg notes:

> …it was Michael's strong interest in language and his extended contact with the content from Skinner's book *Verbal Behavior* that provided the source of information and inspiration for his systematic extension and refinement of motivative variables. Most of the 30 points [title of Sundberg's paper] about motivation

abstracted from *Verbal Behavior* were regular topics of discussion in Michael's classes, presentations, and writings. (p. 36)

Automatic Reinforcement

If complex verbal behavior is initially a function of contrived reinforcement and only through a rich conditioning history comes under the control of automatic reinforcement, then Skinner has provided a pragmatic framework to begin to study, analyze, and teach the behavior most difficult in understanding and developing. The analysis may be speculative, but it is nevertheless aimed at the right target, and automatic consequences may be an essential aspect of the interpretation. (Vaughan & Michael, 1982, p. 226)

Conceptual relevance Automatic reinforcement (AR) occurs when a response generates stimuli (response products) that serve to strengthen the response that produced them (Vaughan & Michael, 1982). Such a response is "automatically" (in the sense of "self") reinforced. In the case of nonverbal behavior, these responses include scratching an itch, blowing up a balloon, tuning an instrument, or playing a computer game. Examples of automatically reinforced verbal behavior include singing a well-loved tune or correctly pronouncing a foreign word.

Although Skinner used the term in many of his writings (e.g., Skinner, 1953, 1957, 1968, 1969), he did not conceptualize AR as a distinct technical subcategory (cf. intermittent, conditioned) but, rather, to emphasize instances where reinforcement was not mediated by others. Despite the term's persistence throughout Skinner's publications, it was not commonly referenced in behavior analytic literature, leading Vaughan and Michael to write their seminal paper (1982) in an attempt to "describe and clarify the role of automatic reinforcement in Skinner's writings in order to determine its importance in furthering the analysis of complex human behavior" (p. 218). The concept provides a behavioral basis for understanding the rapid and seemingly effortless way children learn language, in contrast to traditional explanations that credit the "phenomenon" to hypothetical constructs, innate structures, or processes (e.g., Chomsky, 1980/2005; Pinker, 1994).

Research impact Vaughan and Michael's (1982) critical examination of Skinner's notion of AR effectively served as a backdrop for a line of speech acquisition research that followed.[7] Sundberg, Michael, Partington, and C. A. Sundberg (1996) published the first application of stimulus-stimulus pairing (SSP) to increase vocalizations in children with delayed[8] speech and language. The study's rationale was based on

[7] Although Vaughan and Michael's 1982 paper primarily discussed AR in terms of complex human behavior (i.e., verbal behavior), their conceptualization undoubtedly made an impact on the assessment of nonsocially maintained problem behavior (e.g., Iwata et al., 1982/1994; also see Miltenberger, 2005).

[8] For SSP application with typically developing children, see Smith, Michael, and Sundberg (1996).

the hypothesis that automatic reinforcement might serve to strengthen vocal responses if the auditory stimuli produced by those responses had acquired reinforcing properties. By pairing highly preferred stimuli (i.e., already established unconditioned or conditioned reinforcers) with adult vocalizations (as those occurring in early caregiving with infants), it was possible that subsequent randomly produced vocalizations that were similar to those with the pairing history would be selected into the child's repertoire; that is, they would "sound right" and, as a result, any vocal response that produced those sounds would be automatically reinforced. The Sundberg et al. (1996) study generated much interest and many SSP investigations followed, warranting a recent review of the 13 papers to date in this line of research (see Shillingsburg et al., 2015). Conceptual analyses on the topic of automatic reinforcement have broadened the discussion from increasing speech in early or delayed speech learners to considerations of how linguistic consonance (e.g., grammatical constructions such as verb tense, passive voice, plurals) is acquired through *achieving parity* (see Donohoe & Palmer, 1994; Palmer, 1996, 1998). These analyses and discussions offer substance for applied work in this area and results are encouraging (e.g., Critchfield, 1993; Wright, 2006; Østvik et al., 2012).

Stimulus Change, Remote Contingencies, Positive/Negative Reinforcement

> A distinction is sometimes made between *reinforcer* and *reinforcement*...the former may be considered…a static stimulus condition, and the latter an operation involving such a stimulus condition. I argue that the terms ending in er are problematic, because only a stimulus change can have a behavior function, and I recommend not using them at all. (Michael, 2004, p. 32)

Conceptual relevance Jack asserted that some terminology with respect to reinforcement might interfere with accurate descriptions and analyses of behavior (Michael, 1975b). One difficulty is that the term reinforc*er* implies a static (unchanging) event. That is, behavior change may inaccurately be attributed to a particular stimulus and not to a change from one stimulus condition to another. The term reinforce*ment* better captures the behavior-relevant operation represented by changing stimulus conditions (Michael, 1979). Consider a stimulus change from having $100 (S1) to having $1000 (S2), a condition that defines reinforcement for any behavior producing that change. By contrast, a shift from having $100 (S1) to having $0 (S3) defines punishment for any behavior producing that change. Further, the absence of a stimulus change (having $100 to still having $100) would be a behaviorally neutral condition. Thus, it is not accurate to say that $100 is a reinforc*er* (or punish*er*). Its effect as reinforce*ment* (or punish*ment*) depends on the relative change in before-and-after stimulus conditions surrounding the behavior that produced it. In other words, reinforcement and punishment are defined by stimulus change and its parameters (e.g., duration, magnitude) relative to the pre-change condition.

When stimulus changes are delayed, Jack advised caution in ascribing their behavioral effects to reinforcement, noting that this term was established experimentally with nonhuman subjects where behavioral effects were demonstrated by direct-acting contingencies occurring within seconds (Michael, 1986, 2004). To accurately describe indirect-acting contingencies (for example, those related to a course grade), Jack advocated viewing these effects as analogs to reinforcement (see Michael, 2004, pp. 161-167).

With respect to the singular behavioral effect of reinforcement, the terms *positive* and *negative* are potentially confusing (Michael, 1975b) in several ways. For instance, the terms fall easily into common word associations: positive is equated with something good or pleasant (reward) and negative connotes something bad or unpleasant (punishment). One might talk about a reward as positive reinforcement, but what would negative reinforcement be? In fact, it is not uncommon for people to mistakenly interpret the term as punishment instead of as the removal of a stimulus that results in an improved condition. One might replace *positive* and *negative* with *present* and *remove*, respectively, but one would still need to assess the relative stimulus change within these operations: "The abbreviation is usually possible in the case of unconditioned reinforcements, although even here it must always be possible to infer the characteristics of both pre- and post-change conditions if we are to imply behavioral significance" (Michael, 1975b, p. 41). Due to these and other difficulties, Jack advocated dropping the terms positive and negative in the context of reinforcement.

Research impact Reinforcement, conceptualized as stimulus change, reveals many possible variables to study (e.g., magnitude, onset, duration, and the function-altering capacity of the stimulus change). For instance, animal research with self-injected addictive drugs reports differential responding to variables including different types and dosage levels of drugs, as well as to varied onset delays to drug action (Liu et al., 2005; Winger et al., 2002), as well as producing discriminated responses to one of two operanda (Bertz & Woods, 2013). In terms of clinical practice, developing *generalized* conditioned reinforcers is crucial and requires careful manipulations of stimuli according to their relative value (e.g., DeFulio et al., 2014).

Conceptualizing reinforcement as a stimulus change, instead of as specific, static items or events (i.e., reinforc*ers*), also may enhance instructional practices and condition naturally occurring stimulus changes as forms of reinforcement. For example, toy blocks or pennies may not be identified as particularly valuable for a child with autism, but they can become preferred as part of a task in which they must be inserted into a slotted container (e.g., a *put* task). The changing stimulus conditions, as the task is gradually completed, function as reinforcement for persistent responses to pull-off-and-put all the items into the container. Many activities with component parts (e.g., puzzles, sorting, match-to-sample grids) lend themselves to the development of this type of task completion as a form of conditioned reinforcement. Other stimulus changes can be easily incorporated into instructional tasks, and it would be interesting to compare acquisition rates with and without such designs. For example, many selection tasks start by presenting pictures face up in an array. Pictures could be presented face down instead, requiring the child to emit a differential observing response (i.e., turn the picture face up) to change the stimulus condition in order to respond to the selection instruction (e.g., *find pizza; where's backpack*). The stimulus change from no-picture to

picture would function as reinforcement for turning the card over (to the extent that there is an MO for the visual image on the card). We believe that conceptualizing reinforcement as a stimulus change could encourage the use of more interesting instructional activities that produce their own reinforcement (thus decreasing the use of edibles as artificial reinforcement in these settings). Related applications and discussions can be found in some of the research literature on gamefication (e.g., Morford et al., 2014).

Jack's discussion of the terms positive and negative reinforcement and his call to eliminate the distinction seems to have generated little terminological change and descriptions persist (e.g., Cooper et al., 2007), despite supporting research or theory to do so (see discussion by Baron & Galizio, 2005, 2006; also Michael, 2006). The terms might be useful, however, in a practical way (see Langthorne et al., 2014). Certainly, they allow more succinct, if not precise, communication. Nevertheless, it may be beneficial to use terms that are not easily misconstrued, as is negative reinforcement, where negative is commonly confounded with punishment.

Response Topographies: Selection-Based, Topography-Based, and Manded Stimulus Selection

> There are differences between these types of verbal relations; these differences would be expected to be of special significance when verbal behavior is being developed in those whose verbal repertoires are seriously deficient, and it is important not to overlook them. (Michael, 2004, p. 210)

Conceptual relevance Jack's cognizance of the stimulus control exerted over disparate response forms was key to the Pigeon Parlance Project (PPP; see Michael et al., 1983; also Sundberg, 1985), a "language training program" in which pigeons were taught to emit 3 types of analog tacts[9] (Skinner, 1957) within a paradigm of verbal behavior that included *topography-based* (TB) responding, *selection-based* (SB) responding, and *manded stimulus selection* ("two kinds of verbal behavior plus a possible third," Michael, 2004, p. 207). To establish *topography-based* responding, the birds were trained to emit unique response forms (e.g., head thrust, walking in circle) in the presence of corresponding nonverbal stimuli. Thus responses were analogous to vocal or signed tacts in which specific stimuli evoke different response forms that are topographically based (i.e., each component of a response has point-to-point correspondence with its response product). The task became the basis for a recurring exam question in Jack's Verbal Behavior course (see Michael, 2004, pp. 208-209): describe an analog system for color naming by a pigeon that resembled as much as possible the human "color naming" repertoire. Interestingly (but perhaps to no surprise), many students described not a topography-

[9] In addition to tact analogs, the PP Project illustrates response analogs to intraverbal, duplic, and mand operants. See Michael (1984) for analysis and critique of related animal research.

based tact response (e.g., head bob, peck 3rd right toe), as would occur with human vocal or signed responses (e.g., saying *cat* requires different tongue movements than saying *noodle*), but rather, they described a response in which the pigeon emitted the same topographic response (e.g., peck) to select a verbal icon (word or other verbal symbol) when presented with a color card or similar stimulus. This arrangement, of course, accurately describes the tact (a verbal response evoked by a nonverbal stimulus), but the response is not one that is analogous to typical human vocal responding (i.e., different topographies). Students found (to the detriment of their quiz points) that they had described, instead, *selection-based responding*, by having the pigeon emit the same response topography each time.

Analog tacting by stimulus selection (*selection-based* verbal behavior) involved teaching the pigeon to "select" (peck) from an array a specific verbal stimulus when presented with a particular object. Selection responses were topographically similar (i.e., pecking); the difference was in terms of the verbal stimulus selected, conditional upon the presentation of another stimulus (i.e., multiple control; see Michael et al., 2011). This type of selection-based responding is analogous to pointing to a symbol/picture[10] board (e.g., PECS, Bondy & Frost 1994; Yerkish [lexigrams], Rumbaugh et al., 1977; von Glasersfeld, 1974; also see Sundberg, 1996).

Although the PPP may have been of questionable value for the pigeons' communication needs, it made clear the relative differences between the two kinds of verbal behavior, including the requirements of conditionality and scanning for selection-based responding (for discussion of other differences, see Michael, 2004; Sundberg, 1993a; C. T. Sundberg & Sundberg, 1990). Jack emphasized the burden of conditionality on acquiring a repertoire of selection-based responding (over topographic responding) by pointing to factors such as ease of acquisition, establishing MO control, and the possibility of "interference by similar functional relations" (Michael, 2004, p. 209).

Jack described a possible third kind of verbal behavior, *manded stimulus selection* (commonly referred to as *receptive language*), in conjunction with the previous two (Michael, 1985; Michael et al., 1983). Quite possibly he included this topic, not because of its utility to the learner, but because of its priority by language teachers: "This type of instruction is quite popular with [teaching] the developmentally disabled, even to the neglect of other verbal relations, such as the mand and the intraverbal, which seem to be more directly valuable to the learner" (Michael, 2004, p. 210). In the PPP (Michael et al., 1983), manded stimulus selection (also termed "mand compliance with respect to a stimulus," p. 6) was programmed for reinforcement when the pigeon selected an object (a nonverbal stimulus) in an array upon presentation of a specific verbal stimulus (e.g., it pecked a red ball when a particular lexigram was presented). In this type of listener behavior, "the repertoire developed by such training is, in a sense, the opposite of a selection-based tact repertoire….Both of these relations involve joint control by a nonverbal and a verbal stimulus, thus both are clearly conditional discriminations" (Michael, 2004, p. 210; also see Lowenkron, 1991). However, the joint control that evokes responding as a result of simple conditional discrimination

[10] Nonverbal evocative stimuli (e.g., pictures) would not define tact responding, but may be involved in mand or intraverbal relations under multiple control.

training (as when your puppy can "get the ball") is demonstrably different[11] than the joint control that evokes listening responses by verbally competent speakers (i.e., *mediated stimulus selection*, Schlinger, 2008a; also see our later section on *Multiple Control*).

Research impact Jack's identification of topography-based and selection-based responding has had significant benefit for human language training in terms of understanding the parameters for evaluating and selecting particular communication response forms, as well as analyzing acquisition of these targets (Adkins & Axelrod, 2001; Petursdottir et al., 2009; Potter et al., 1997; Shafer, 1993; Sundberg, 1993a; Sundberg & Partington, 1998; Vignes, 2007; also see Carr & Miguel, 2013). An added benefit is the ability to design language programs that are not dependent on, nor reflective of, "cognitive interpretations in which internal choice [words selected from an inner source] is used as an explanation of external differential responding" (Michael, 2004, p. 208).

Jack's inclusion of manded stimulus selection as verbal behavior provided a behavioral framework for discussions of multiple stimulus control in the analysis of listener-as-speaker behavior (e.g., Michael, 2003; Michael et al., 2011; Schlinger, 2008a). In extending the descriptive edges of a listener repertoire, Schlinger (2008a) describes its active (i.e., verbal) role:

> …the listener also behaves verbally when he or she is said to be listening. Because much of listening is covert, it is easy to believe that the listener really does passively receive and process information from the speaker. In a behavior-analytic account, however, a listener is not the passive receptacle implied by such expressions as 'receptive language'; a listener is constantly active, behaving verbally with respect to other speakers as well as to him- or herself as a speaker. This is especially apparent when we consider that as individuals become speakers they simultaneously become listeners to both others and to themselves. As Skinner pointed out, the speaker and listener reside in the same skin. This fact of verbal behavior means that, in this regard, distinguishing between speaking and listening may be specious (p. 149; also see Greer & Speckman, 2009).

Analyses of speaker-listener repertoires (sometimes viewed as listener-only tasks as in *Find a city on the map that's near Tuscon*), reveal the convergence of multiple controlling variables (e.g., textual, tact, echoic/self-echoic, mimetic/self-mimetic; see Causin et al., 2013; Tu, 2006) that are at strength individually and en masse to ultimately evoke an appropriate response. Describing these component repertoires and their controlling variables holds exciting opportunities for further research, albeit the proposed explanations are as diverse as the questions (e.g., Miguel & Petursdottir, 2009; Miklos & Dipuglia, 2015; also see Petursdottir & Carr, 2011).

One of these explanations was proposed in 1996 by Horne and Lowe as the concept of naming, "a higher order bidirectional behavioral relation that combines conventional speaker behavior and listener functions…" (p. 207). These combined repertoires were described as consisting of "listener behavior, echoic and self-echoic behavior, tacting, and conditioned effects" (Lowe & Horne, 1996, p. 317). Several commentaries

[11] If in doubt, try asking your dog to "go get the big key on the bottom hook in the laundry room."

followed the Horne and Lowe paper, many calling for a more complete analysis (e.g., Dugdale, 1996, p. 273; Pilgrim, 1996, p. 286; Stemmer, 1996, p. 247). In his own commentary, Jack affirmed his preference for a *molecular analysis* of the separate and combined functions of the requisite component repertoires:

> Horne and Lowe might say that [in providing examples of alternative accounts for naming behavior] my use of separate repertoires is simply elaborating the implications of the naming concept. However, until the function of the separate repertoires is understood in each instance of verbal behavior, any reference to naming is incomplete, and once they are understood it is not clear what is added by reference to naming. (Michael, 1996, p. 298)[12, 13]

Multiple Control

> How much of what we call "intelligence" can be more concretely explained as a sensitivity to concurrent variables or as a skill in manipulating them for strategic purposes? (Michael et al., 2011, p. 20)

Conceptual relevance The extended discourse on naming is but one example of ongoing efforts by Jack and others to offer parsimonious accounts for speaker-listener repertoires that comprise verbal behavior under the control of multiple stimuli. In 2011, Jack Michael, with co-authors Dave Palmer and Mark Sundberg, published "The Multiple Control of Verbal Behavior," a paper that captures the breadth of Jack's priority topics[14] with respect to the analysis of verbal behavior. Their discussion provides a comprehensive, molecular analysis, based on known behavioral principles, of complex verbal phenomena. Complexity can be defined variously (e.g., topographic, linguistic), but the paper calls our attention to the evocative interaction of multiple controlling variables, complexity as the synergy, but not necessarily the symmetry, of multiple stimuli that influence effective verbal behavior.

Skinner's analysis (1957) has been criticized for its inadequacy to account for complex and emergent verbal behavior (e.g., Hayes et al., 2001), such as repertoires of matching, following directions, categorization, problem solving, recall, inference, satire, and humor, among many others. However, these "phenomena" are, indeed, addressed throughout the book, notably in its chapters on multiple control (9 through 11) and autoclitic relations (12

[12] Lowe and Horne (1996) responded that, in fact, naming is not easily nor appropriately reducible in its description (see pp. 315-340).

[13] Although Jack may have been critical of the concept of naming as a higher-order operant, he saw the importance of the interaction of the repertoires described by Horne and Lowe (i.e., echoic, listener, and speaker) in the development of complex language to the point of publishing experimental work in this area (see Miguel et al., 2008; also see Miguel in this issue).

[14] Jack often remarked that Skinner's placement of this topic in the latter half of *Verbal Behavior* (as well as Jack's similar arrangement in his VB course) may have inadvertently minimized the importance of the topic and the ubiquity of multiple control in everyday verbal interactions.

through 14), as well as in the introductory material (e.g., Chapter 1, p. 11; Chapter 3, p. 42). Fundamental to these verbal repertoires is the evocative influence of *convergent* and *divergent* multiple stimulus control, at times separately identifiable but probably more often, intertwined (e.g., see Michael et al., 2011, Figure 3, p. 8). Contextual flexibility of interacting variables is key. The adaptive value that concurrent stimuli exert over our verbal behavior is central to its power in our combined roles of speaker and listener, allowing a "welter of interacting variables" (Palmer, 2006a, p. 209) to rearrange and recombine as new sets of controlling variables, according to an infinite number of changing conditions (Michael et al., 2011).

Convergent stimulus control occurs when several stimulus events exert control over a single response, allowing, for example, a correct response to *Find/Draw/Name some animals that live in water* or to *How are you* versus *How old are you*. All relevant stimuli (including MO) must be salient in their convergence to evoke a single discriminated response (e.g., Michael et al., 2011, Figure 2, p. 6). These distinctions are often difficult for many individuals with a diagnosis of autism, likely due, at least in part, to weak component repertoires (e.g., tact: *animal* vs *plant*; autoclitic: *some* vs *an*; or listener discriminations: *find, draw, write*).

Divergent stimulus control occurs when a single stimulus event evokes multiple responses. For example, in the presence of a ball, you might throw, kick, or hit it, or you might ask for a different one (*I wanted the* basket*ball, not the* volley*ball*). Errors with this type of multiple control are often observed when rote responses have been reinforced. For example, when asked *Tell me something red*, a child might only say *apple* and be unable to name other red things or to answer *What else is red.* Similar rote-learning errors are seen when arbitrary sequences do not vary (e.g., *pig-horse-dog* in response to *Name some animals*). In these instances, as well as those involving convergent stimulus control, a specific operant (e.g., autoclitic) may be weak, but also, repertoires requiring component skills (e.g., problem solving to scan the room for red things) may not have been developed and other sources of control may be transitory (e.g., MO) or not yet established (e.g., audience relations).

A single stimulus event, regardless of whether it occurs in a respondent or operant paradigm, can produce near-immediate and momentary behavior change (thus, behavior-altering, or *evocative*, effects) as well as producing effects that alter the function of stimuli to evoke future responding (i.e., *function-altering* effects) (see Table 1; also see Michael, 1983, 1986, 2004; Schlinger & Blakely, 1994). The distinction between these types of effects is critical. Conceptually, it speaks to the strength of Skinner's analysis to account for complex verbal behavior. Clinically, its empirical elaboration could inform effective applications: "One of the biggest problems of failing to distinguish between evocative and function-altering effects of verbal stimuli is that there has been no research into the provenance of function-altering effects" (Schlinger, 1993b, p. 17). Behavior-altering and function-altering effects are not restricted to a single stimulus event. Multiple stimuli involving convergent and divergent control can produce these effects as well, by exerting formal control (e.g., echoic, imitative) and thematic control (e.g., MO, tact, audience) (see Skinner, 1957; also the discussion by Michael et al., 2011). In the case of distal contingencies, the effects of multiple control are seen when relevant stimulus events are cumulative (e.g., *when you are finished, raise your hand*).

The task is to describe *how* complex verbal stimuli condition the behavior of a speaker-listener. That is, how do verbal events alter the function of other stimuli to evoke responding, verbal or nonverbal, at some future time, in the absence of

identifiable operant or respondent conditioning? In 1987, two of Jack's former students began to address this in discussions of *rule-governed behavior* and *contingency-specifying stimuli* (CSS; Skinner, 1969; see Blakely & Schlinger, 1987; Schlinger & Blakely, 1987).[15] Since then, numerous refinements have been put forth, pinpointing and clarifying critical issues in how verbal stimuli come to affect responding by altering the function of other stimuli (e.g., Palmer, 1991; Schlinger 1993b, 2008a; Schlinger & Blakely, 1994).[16]

The work by Jack and others cited throughout this paper does much to offer interpretive and analytic support for a Skinnerian explanation of complex behavior of speakers-listeners, but empirical questions remain (see those suggested by Palmer's entertaining example, 2005). Schlinger offers one proposal to inform the conceptual analysis:

> …all of the processes that produce the long-term behavior change that lead us to speak of learning can be called function altering. A function-altering classification scheme may permit all conditioning processes, the verbal events that mimic them, and other seemingly unrelated learning phenomena (e.g., imprinting) to be considered in a more unified manner, and may well suggest a common underlying mechanism of behavior change. Not only does such a scheme have important implications for how behavior analysts talk about their subject matter, but it also enables them to answer more effectively charges by some cognitively oriented psychologists (e.g., Brewer, 1974; Chomsky, 1959) that behavior analysis is unable to account for complex behavioral processes, especially those involving language. (1993b, pp. 21-22)

Understanding how stimuli engender function-altering effects has implications, not only clinically, but also, for much of our everyday behavior and the verbal stimuli that influence it. Applications could range from improvements in self-management on a small scale to the influence of advertising and public policy more broadly (see next section on *Research Impact*; also Michael, 1986, p. 14; also Schlinger & Blakely, 1994, pp. 48-49).

Research impact Skinner's conceptual analysis of multiple stimulus control appears to be receiving increased attention in research and application. A quick Google Scholar™ search recently revealed more than twice as many hits for the term *multiple control* in papers submitted to *The Analysis of Verbal Behavior* between 2000 and 2016 (n = 23) compared to the period between 1982 and 1999 (n = 10). Although Jack may not be directly responsible for this increase, as a standard-bearer for Skinner's *Verbal*

[15] For additional discussion of *rules* and *rule-governed behavior*, see Ribes-Iñesta (2000) and Vaughan (1985, 1987). Also see Schlinger's discussion (1990) of non-empirical work on rule-governed behavior and his call for behavioral interpretations of "complex verbal and social behaviors…using principles induced from an experimental analysis" (Schlinger, 2004, p. 281). See Michael (1986) for further discussion regarding the temporal requirements of contingencies and their effects (including issues related to molar explanations of these types of relations, e.g., Baum, 1973).

[16] Explaining these effects may be informed by research on equivalence and the formation of equivalence classes (e.g., Sprinkle & Miguel, 2012; Wulfert et al., 1991; also see Miguel & Petursdottir, 2009).

Behavior, he has certainly made a significant contribution directly or through others writing on the topic.

This attention has generated research that spans many topics regarding the multiple control of complex and emergent verbal behavior. We discuss the empirical work in a few of these areas: joint control, problem solving, matrix training to develop conditional discriminations, and multiple exemplar training. In addition, we briefly present Jack's perspective on humor and rhetoric as examples of the role of multiple control in everyday discourse.

Joint control, as hypothesized by Lowenkron (1984, 1991, 1998, 2006) occurs when two stimuli, arising from different verbal operants (e.g., tact, self-echoic, textual), both control the same response topography and, in doing so, generate a new discriminative stimulus that evokes a response. Because the relations arise from verbal behavior, the listener also becomes his or her own speaker (see Horne & Lowe, 1996; Miguel et al., 2008). For example, one may be asked to look at some objects and "find the big blue square." While scanning the array, tacts are evoked by the various objects (e.g., "little green circle," "big red square") at the same time that the self-echoic ("big blue square") is occurring. Eventually, a response will occur that is under the joint control of the self-echoic ("big blue square"), the tact of the object ("big blue square"), and the non-verbal stimulus (big blue square). At this point, the response products, as evocative stimuli, will produce a selection response (i.e., a *selection-based* [descriptive] *autoclitic*, Lowenkron, 2006) with respect to the big blue square.

Lowenkron's account of joint control has occasioned descriptions and experimental analyses of the repertoires involved (e.g., Causin et al., 2013; DeGraaf & Schlinger, 2012; Esch et al., 2010; Esch et al., 2013; Gutierrez, 2006; Sidener & Michael, 2006; Tu, 2006; Wright, 2006; also see Palmer's review, 2006a and Sidener's tutorial, 2006). Although tact and self-echoic repertoires are often exemplars of joint stimulus control, other relations may be similarly evocative (e.g., Palmer, 2006a, pp. 212–213) and future research identifying effective combinations will be critical to add substance to current interpretations. Within those interpretations, the speaker-listener's judgment of joint control, the recognition that joint control has occurred, warrants consideration as the variable of interest over stimulus properties of identity itself (Palmer, 2010):

> That is, we are not responding to a quality of *identity*; rather, we judge identity according to our responses to the stimuli…I am arguing that a judgment of identity is controlled, not by a stimulus property of *identity*, but by a common behavioral effect of the two stimuli, that is, that identity is marked by joint control. (p. 41)

Multiple control is essential for the development of strong intraverbal repertoires to support *problem solving* (and recall as a "special case;" Michael et al., 2011, p. 11). Problem solving, by contrast to trial-and-error learning or the "appearance of a solution" (Skinner, 1953, p. 248), is a process of actively recruiting stimuli, verbal or nonverbal, to make a response more likely.[17] Because problem situations vary, any resemblance to an already-trained relation must evoke responses that yield appropriate

[17] Some responses require no problem solving, because they are discriminated operants that are immediately evoked by relevant discriminative stimuli (i.e., rote, such as 2x2=?).

supplementary stimuli to allow effective action (see Michael et al., 2011; also see Skinner, 1957, pp. 293-309). Skinner (1953) refers to "the marshaling of relevant information" (p. 250) and manipulating or rearranging stimuli, thus "encourag[ing] the emission of a response which may prove to be a solution" (p. 249).

> As the solution progresses, some stimuli become increasingly remote, some are more recent…The cumulative effect…is to strengthen the target response and weaken competing responses. Eventually the target response becomes the prepotent response and is emitted, satisfying the contingency posed by the problem. (Donohoe & Palmer, 1994, p. 273)

A body of recent research on problem solving has focused on teaching children this process of recruiting and manipulating stimuli (i.e., establishing multiple control) in previously failed tasks. Procedures have involved strategies that generated a (precurrent) supplemental stimulus, including visual imagining (Aguirre & Rehfeldt, 2015; Kisamore et al., 2011; Mellor et al., 2015; Sautter et al., 2011), heuristic techniques (Neef et al., 2003), and mnemonic strategies (Wood et al., 1998).

Multiple control research also has addressed the challenge of establishing *conditional discriminations* (C^Ds), particularly verbal conditional discriminations (VC^Ds; Sundberg & Sundberg, 2011) for learners with developmental disabilities. In an effort to better pinpoint the fracture points in divergent and convergent stimulus control among conditional verbal stimuli, Sundberg and C. A. Sundberg designed an intraverbal assessment subtest[18] that can serve as a guide for program planners in selecting appropriate targets. For example, if "is/is not" questions were answered incorrectly on the subtest, this discrimination can be targeted for training. One promising model for such training is presented in Axe's (2008) review on the topic of conditional discriminations. "Matrix training is a generative approach to instruction in which words are arranged in a matrix so that some multiword phrases are taught and others emerge without direct teaching" (Axe & Sainato, 2010). Earlier reports of similar training arrangements termed the process *recombinative generalization* (e.g., Goldstein & Mousetis, 1989, p. 246). Matrix training has supported the acquisition of conditional discriminations by children learning, for example, to perform an action to a picture (e.g., *underline pepper, circle stapler*; Axe & Sainato, 2010), to tact kitchen items and relative (prepositional) position of items (e.g., *whisk above box*; Pauwels et al., 2015), and to tact subject-verb-object from videos (e.g., *Jack throws block*; Kohler & Malott, 2014).

Another line of research on multiple control, *multiple exemplar instruction* (MEI), reflects the influence of Horne and Lowe's (1996) account for the emergence of untrained verbal and nonverbal behavior (i.e., *naming* as a higher-order verbal operant; see earlier discussion). For example, Greer and Ross (2008) developed MEI protocols specific to the deficit components in the naming repertoire (e.g., naming completely missing; only listener component missing; see pp. 150-158; also see Greer et al., 2005). The order of these instructional arrangements may not be crucial. Petursdottir and Carr (2011) reported lack of strong evidence for the efficacy of traditionally sequenced

[18] This subtest supplements a more comprehensive assessment of intraverbal and other "milestone" skills, as well as repertoires that can be barriers to learning (see Sundberg, 2008/2014).

language training in which listener behaviors (e.g., matching, selecting) are taught before mand, tact, and intraverbal responses. Subsequent research supported the notion that varied instructional sequences could produce untrained operants. Delfs et al. (2014) compared the emergence of untrained listener versus tact responses resulting from instruction in the opposite direction. They found that tact instruction was more likely to produce emergent listener behavior than listener-to-tact acquisition. Other research illustrates emergence following other-operant training: tacts (including tact features) of untrained visual compound stimuli through listener training (Ribeiro et al., 2015); feature, function, class listener responses following intraverbal instruction (Kodak & Paden, 2015); listener behavior following tact training (Davis et al., 2016), and tacts following mand training (Egan & Barnes-Holmes, 2009). Within-operant emergence also has been demonstrated (i.e., intraverbal to reverse intraverbal; see Allan et al., 2015). These reports clearly demonstrate that multiple control involving intraverbal, tact, and listener behavior can produce emergent behavior different from that of the trained operant. However, functional independence (i.e., non-emergence) of verbal operants also has been demonstrated (e.g., Hall & Sundberg, 1987; Twyman, 1996) and future research should explicate the critical differences that account for instances of emergence or the lack thereof (see Gamba et al., 2015; Grow & Kodak, 2010; Lechago et al., 2015; Nuzzolo-Gomez & Greer, 2004). Some have called for more clearly specifying participant characteristics, including instructional histories and prerequisite repertoires, especially verbal and non-verbal skills (e.g., Delfs et al., 2014; Petursdottir & Carr).

Our discussion of multiple control closes with Jack's perspective on humor and rhetoric as examples in which multiple control is key for enjoyment, influence, and expedience of our verbal behavior. "A biology class is about to dissect a fetal pig. The instructor says, 'Today we will start dissecting the organism. I realize that this may seem difficult, but go ahead and take a stab at it'" (Michael's VB course notes, 2003; exam answer from a 1997 student). We can laugh without understanding the multiple control that makes such a statement funny, but Jack taught his students how to construct a pun to increase our appreciation (i.e., analysis) of the skill it takes to make it work. Michael et al. (2011) discuss this and other puns in detail (see pp. 9-10), so we will only add to that by presenting an adapted form of Jack's *Job Aid for Pun Analysis* (Michael, 2002 course notes on "Good" and "Poor" Puns, Unit 11, p. 4): Recognizing that a good pun must have both main and secondary thematic sources of control, follow these steps: (a) Give background information (biology class, dissection task) so the main and secondary sources are clear and plausible; (b) Identify the carrier source; in this case, it is auditory, an echoic independent variable; (c) Identify the critical response (*take a stab at it*) and make sure it has two sources of control; (d) Identify the main thematic source (*take a stab at it* is like saying *give it a try*); (e) Identify the secondary source (the dissection task with scalpel) and make sure it is intrinsic to the situation. Note: Readers may be interested in further discussions of this pun analysis (see Hübner et al., 2005; Michael et al., 2011).

Wording things just right has more than merely entertainment value, of course. It can promote communication, influence political action (for good or ill), and encourage consumer behavior (wise or imprudent). For example, Michael et al. (2011) describe the coaction of divergent and convergent stimuli controlling a response *bruise* versus *contusion* (p. 9). Whether we know it or not, multiple control is similarly at work when we say

no to a pushy salesperson but *opt out* of a friend's dinner invitation. Motivating operations and audience variables can enter into multiple stimulus control of both verbal and nonverbal behavior as politicians, advertisers, and clergy well know (Michael, 1982a, 1993; also see Luntz, 2007) and altruism is easily disrupted. For instance, people often express opposing views to opinion poll questions that are variously stated but inherently the same (e.g., *Are you in favor of Federal handouts to people who don't work?* versus *Do you think we should help people who are hungry?*).

These examples of humorous and influential verbal behavior are but a few of those that Jack regularly analyzed in his class discussions. Others dealt with feedback, satire, audience control, impure tacts, and tact extensions. These verbal complexities are admittedly difficult areas for research and require scrutiny of both speaker and listener behavior. Nevertheless, Jack and others (e.g., Miguel, 2011) have encouraged the field to tackle them. Schlinger (2006) concurs, identifying a yet-to-be explored area: "The development of these verbal behaviors [predicting and inferring the mental states, i.e., private stimuli, experienced by others] in children would be an area ripe for behavior analysts to mine for the role of basic verbal operants, multiple control, and autoclitics…" (p. 7). In Jack's Presidential address to ABAI in 1980, he observed that the marketplace requires a multitude of skills and offered "Essential Topics for Success in Behavior Analysis." Fluency with the variables that control complex verbal behavior is evident in the list that includes systems and market analysis, consumer satisfaction research, staff training, influencing others, and public speaking (see Michael, 1980a; also see Bailey, 2000; Poling, 2010). As behavior analysts, we need to participate in the explanatory conversation. "Outside the laboratory, behavior is commonly the product of many interacting variables, and our interpretations of behavior must be correspondingly complex" (Michael et al., 2011, p. 3). Scrutiny of the separate and collective effects of certain environmental events (i.e., multiple stimuli entering into contingent relations) will lead us to better understand how these complex (and typically not directly trained) repertoires are acquired, which may help account for verbal behavior currently being explained in other ways (e.g., Hayes et al., 2001).

Duplic and Codic Verbal Behavior

> The suggested terminology is an instance of the general effort to eliminate ambiguity from technical and scientific language, an effort that is often initiated and possibly most keenly appreciated by those who spend most of their time teaching others to use that language. (Michael, 2004, p. 207)

Conceptual relevance Avoiding terminological confusion and redundancy is emphasized throughout Jack's writing and teaching, illustrating his uncompromising commitment to parsimony, clarity, and sufficiency in our scientific discourse. Noting that Skinner "almost named" (Michael, 2004, p. 203; also see Michael, 1982b) two other types of verbal behavior in addition to his elementary verbal operants (see Skinner, 1957, pp. 67-68, 70), Jack assigned the terms *codic* and *duplic* (Michael, 1982b; also see Wraikat et al., 1991) to verbal relations that encompassed Skinner's *taking dictation* and *copying a text*, respectively. But Jack observed that other similar relations existed that, at best, were only

awkwardly subsumed under these specific examples. By expanding the terminological umbrella to include *codic* and *duplic* relations, he achieved five "mutually exclusive and collectively exhaustive groupings" (Michael, 1982b, p. 1). These new categories aided in understanding Skinner's discussion of these functional relations and supported analyses of additional types of coded and duplicated verbal behavior.

In the case of the codic relation, a verbal stimulus controls a response whose product has point-to-point correspondence, but no formal similarity (i.e., similarity in form) with the evoking stimulus (Michael, 2004). Thus, in addition to taking dictation, codic verbal behavior includes reading aloud (*textual*) and emitting certain sign language responses. Examples include fingerspelling-to-vocal, fingerspelling-to-written (although this relation can also be duplic, as when a finger-spelled letter closely resembles its written form, e.g., "o"), reading Braille aloud, and writing in Braille what is heard. As with codic relations, a verbal stimulus evokes duplic responses as well. However, duplic response products have formal similarity with the controlling stimulus and thus, point-to-point correspondence. Echoic responses and non-vocal imitation of sign and fingerspelling (also called "mimetic" responses; Vargas, 1982) are examples of duplic responses, in addition to copying a text.

Jack's addition of the terms codic and duplic resulted in groupings that captured both parsimony and clarity. Now, Skinner's elementary verbal operants (i.e., *mand, tact, intraverbal, codic, duplic*) permit a further account of "all of the common forms of verbal behavior in terms of important defining properties, as well as to classify immediately any new form that develops" (Michael, 2004, p. 205).

Research impact Precision in our technical and scientific language can point us more readily to potential investigations and applications of behavior analysis in ways we may have overlooked. The role of sign language as verbal behavior is one such example. "Michael's broadening of Skinner's categories [codic/duplic] allows us to include such verbal relations as reading written sign language[19] (Stokoe et al., 1965) and reading Braille" (Sundberg, 1983a, p. 304). Certainly the terminological revision satisfied Jack's (probably mild) unease with what he considered an insufficient mechanism to classify particular verbal operant relations involving sign language. But this clarification and its forerunners via university lectures and other presentations (e.g., Sundberg, Michael, & Peterson, 1977; also see Sundberg & Partington, 1982, 1983 reference lists) surely served to enhance the design and analysis of applied programs that incorporated signed responses as the dependent variable form to teach a wide variety of individuals with language deficits, (e.g., Braam & Poling, 1983; Hall & Sundberg, 1987; Stafford et al., 1988; Sundberg, 1983a). For additional discussions of critical program considerations influenced by Jack, see Sundberg (1980, 2008/2014), Sundberg et al. (1980), and Sundberg and Partington (1998). Sundberg (2013) writes, "it was Michael's interest in the communication difficulties faced by deaf individuals and others with developmental disabilities that gave him opportunities to apply and test Skinner's analysis of verbal behavior and motivation (e.g., Meyerson & Michael, 1964; Sundberg, Michael, & Peterson, 1977)" (p. 14).

[19] There is no commonly used codic system currently for signs, but Stokoe et al. (1965) developed a dictionary form of such a framework.

The genesis of this interest in sign language vis-à-vis Skinner's (1957) analysis of verbal behavior, as well as applied work in the area of developmental disabilities, may have been his collaboration with University of Houston colleague, Lee Meyerson, a relationship that proved productive (see Meyerson et al., 1965; Meyerson, Kerr, & Michael, 1967; Meyerson et al., 1961). The impact of Skinner's *Verbal Behavior* (1957) on Jack and on many of his students is chronicled in two important reference lists that highlight the body of work that ensued (see Sundberg & Partington, 1982, 1983; entries are catalogued according to "Conceptual," "Experimental," and "Applied" references).

Teaching Contributions

> My main contribution has been as a teacher. I have written a number of journal articles, a few of which have had some influence. (Michael; www.jackmichael.org)

Ripples of Jack's influence on the understanding and teaching of behavior analysis abound in the repertoires of his students, colleagues, and so many others whose teaching, research, and writings are based in large part on his own. With Skinner's *Science and Human Behavior* (1953) and *Verbal Behavior* (1957) as a theoretical foundation, Jack's conceptual analyses influenced behavior analysts to such a degree that it triggered a new area of professional literature (*The Analysis of Verbal Behavior*, the flagship journal for publications on this topic) and had a strong impact on diverse venues of dissemination. Perhaps foremost among these are the university courses in verbal behavior (e.g., Caldwell University; Chicago School of Professional Psychology – Los Angeles; Endicott College; Florida Institute of Technology; University of Kansas; University of São Paulo, Brazil; Western Michigan University; Western New England University), with others offering verbal behavior (VB) coursework augmented by VB research labs (e.g., California State University Sacramento, Simmons College, Texas Christian University, University of Houston Clear Lake). Some of these classes are based on Jack's own shared course notes.[20] A listing, periodically updated, of universities offering behavior analysis courses appears on the website of the Verbal Behavior Special Interest Group (see http://verbalbehaviorsig.org/university-programs.html). Another list was published in the 1980's (see Johnson, 1982) indicating university bookstores that had stocked Skinner's *Verbal Behavior* (1957). This list is likely outdated, but it does provide historical reference for the evolution of the courses currently being offered in various locations. Jack's writings also have influenced the development of textbooks and instruction

[20] One source for these notes is the VB course packet of Dr. Ed Morris, University of Kansas; he draws on materials from Jack Michael (WMU) and Joseph Pear (University of Manitoba). "These 'discussion objectives and questions' are now so intermingled that I do not know which are Jack's and which are Joe's, but they are included in each week's/topic's syllabus where Skinner (1957) is part of the assigned reading" (E. Morris, personal communication, March 11, 2016). This course packet has been archived through The Association for Behavior Analysis International (see https://www.abainternational.org/media/6201/absc_931.pdf).

manuals (e.g., Greer & Ross, 2008; Sundberg & Partington, 1998) and those in the popular press (e.g., Bailey & Burch, 2006; Barbera, 2007; Burch & Bailey, 1999), clinical assessments (e.g., McGreevy et al., 2012; Partington, 2006; Sundberg, 2008/2014; Sundberg & DMTD, 2014), and hundreds of worldwide workshops given by Jack's protégés.

Jack provided a model for scientific collaboration with students and colleagues by recognizing their influence and crediting them publicly (e.g., Michael, 1979, 1982a). His ABAI Presidential address exemplifies these tributes (see Michael, 1980a, p. 1). Collaborations with some of his early students and colleagues yielded several important publications, including one of the field's seminal papers in applied behavior analysis (Ayllon & Michael, 1959). Other papers (Michael, 1979, 1980a, b, 1982a) came from the regular Sunday morning meetings with his WMU students (many of whom are acknowledged in these publications). "He really didn't like to write and do formal research; he liked to teach. Our Sunday meetings with Jack were primarily to get him to write" (M. Sundberg, personal communication, December 1, 2015). Sundberg continues:

> Note that in the 1979 acknowledgements he thanks us for 'setting up the contingencies responsible for writing the paper' (it was Marge [Peterson Vaughan] who started the Sunday group to get Jack to write). We sometimes called it 'Sunday with Father Michael'. (M. Sundberg, personal communication, March 15, 2016)[21]

> Jack began teaching a verbal behavior applications course around 1976. He and I and Norm Peterson published a sample of the topics covered in that class in the first WMU psych dept. Behavioral Monograph Series [see Sundberg et al., 1977]. We used this as a workshop handout…That document contained my first version of the "VB intervention program" [see Sundberg & Partington, 1998] with Jack writing the basic elementary operants part (chapter 1). (M. Sundberg, personal communication, December 1, 2015)

> Jack taught [a VB course] at his house in Scottsdale on Saturday mornings…a couple of undergrads like me snuck in. There were no course materials or study guides, we just sat on the couch or floor and took notes like crazy as he talked in his rapid-fire way he did when he was excited. (J. Bailey, personal communication, February 29, 2016)

Others have chronicled, in some detail, Jack's teaching history (e.g., Mabry, 2016; Sundberg, 2013, 2016; Wolf, 2001). Briefly, he taught at University of Kansas (1955-1957), University of Houston (1957-1960), Arizona State University (1960-1967), then moved to Western Michigan University where he taught from 1967 until his retirement in 2003. His verbal behavior course started informally in 1955 at KU where he made use of Skinner's early material on verbal behavior (i.e., the Hefferline notes and

[21] See Sundberg (in press) and Wolf and Willhite (2000) for additional history of these collaborations and their effects on the field of applied behavior analysis. Also see Morris et al. (2013) for a history of applied behavior analysis through its publications.

William James lectures). After Skinner published that material as the book *Verbal Behavior* (Skinner, 1957), Jack taught a class in verbal behavior "almost every academic year" (Sundberg, 2013, p. 14). Although Skinner apparently did not cite Jack's work, he recognized the work of Jack's students (see Skinner, 1968 [*Technology of Teaching*] references for Ayllon & Azrin, 1965; Ulrich, Stachnik, & Mabry, 1966; Wolf, Mees, & Risley, 1964).

Commitment to his students' success is evident in Jack's *Concepts and Principles* chapter, "A Behavioral Perspective on Teaching" (see Michael, 2004). Observing that most students spend little time studying, he wrote:

> It is customary to locate the problem within the student as a lack of intellectual ability, a lack of motivation, or possibly both. An alternative approach would inspect the environmental contingencies that are supposed to maintain class attendance and effective out-of-class study. What follows is an analysis of these contingencies and some suggestions for improving them. (Michael, 2004, p. 211)

The material in this chapter highlights the design of his long-standing College Teaching course at WMU, emphasizing the importance of effective contingencies to promote student success (e.g., weekly essay exams to offset the *procrastination scallop*; see p. 218). His commitment to effective teaching and learning was also evident in his *Box Diagrams of Behavioral Procedures* (Michael, 2004, pp. 79-92). As he often did, he credited colleagues and students for their involvement in developing these types of visual aids (see footnote, p. 80; also see Michael & Shafer, 1995a, b). His "Rat Lab" book (Michael, 1963), published while he was at ASU, was another example of his effort to make course material understandable and accessible to students: "The primary purpose of the laboratory is to bring each student into contact with behavior as an orderly experimental subject matter"… [and if it were not for my many colleagues and students] "I would not have become interested in writing a laboratory manual" (p. v). A few years later, he published another laboratory guide (Michael, 1975a; see Karsten & Carr, 2008 for an annotated reference to that publication).

Jack's positive influence on his students has been memorable. Karl Minke recalled Jack's class (Arizona State University, circa 1960-1962) on how to wire operant conditioning racks. Jack had students work out the wiring on paper first, using stencils to represent components such as timers, steppers, and relays: "made me an 'expert' by the time the course was over" (Personal communication, February 19, 2016).

Mont Wolf described his own entry into behavior analysis at the University of Houston. He was initially skeptical about the teaching skills of a flip-flop clad Jack Michael, who was asked to leave the University of Kansas for teaching Skinner, and "to make matters worse, Jack announced that the class would concentrate on animal research!...[eventually we became converts and a group established] which met in Jack's living room and planned how to save the world through behaviorism" (2000, pp. 6-7).

Another of Jack's students, Grayson Osborne, recalled that Mont Wolf and John Mabry followed Jack from Houston to Arizona, along with Lee Meyerson, Jack's colleague and co-author on several papers (see Bibliography). Meyerson "was

adventitiously deaf and a masterful lip reader....[he] made a successful teaching film [of the use of operant conditioning with humans]" (From Osborne's address to ABAI 2005 upon receiving a Distinguished Career award from the Experimental Analysis of Human Behavior SIG; G. Osborne, personal communication, March 15, 2016). Jack's collaboration with Meyerson in his work with children with developmental disabilities no doubt strongly influenced Jack's interest in autism:

> The autism VB movement would not have occurred without his teachings, direction, guidance, and contingencies; for example, he once asked me to sketch out for him how all types of autoclitics would work in sign language. I probably put in 50 hours trying to figure that out (circa, 1976). (M. Sundberg, personal communication, December 1, 2015)

In 1977, an informal meeting was held during the conference of the Midwestern Association for Behavior Analysis (MABA; now Association for Behavior Analysis International). The group consisted of people who were teaching Skinner's book (*Verbal Behavior,* 1957):

> Scott [Wood] and Jack stood up front the whole time; the room was packed, it was filled with the field's *Who's Who*: Skinner, Keller, Day, Cook, over 200 people. The Hefferline notes and [William] James lectures were available, along with Jack's objectives. Someone suggested a newsletter or journal; I was Jack's grad student so he assigned me to the newsletter; the first issue [as *VB News*] came out in 1982. Kent [Johnson] and I were co-editors. (M. Sundberg, personal communication, February 5, 2016)

Two volumes of *VB News* were published (1982, 1983).[22] The second volume (1983) contains a 1-page report by the SIG's Chair and identifies the primary need for a journal: "Most professors agreed that it was difficult to teach from the book partly due to the complexity of the issues, but also due to a lack of instructional materials and supporting research" (Sundberg, 1983b, p. 24). In 1985, the 3rd volume was published under the name *The Analysis of Verbal Behavior* (*TAVB*). Much of the professional literature that has emanated from Jack's work is currently being published in this journal, where Jack served as Editor from 2004 through 2007. Several subsequent editors have discussed the journal's trends and impact factor as well as improvements, changes, and direction for its future (e.g., Luke & Carr, 2015; Miguel, 2011; Petursdottir, 2013; Petursdottir et al., 2009).

The 1977 meeting at MABA that led to the founding of *TAVB* also effectively established the Verbal Behavior SIG (verbalbehaviorsig.org) as an affiliate of the organization Jack helped found (ABAI; see Peterson, 1978). In some ways, the VB-SIG provides a surrogate format of the one that Jack held with students in his living rooms over the years by offering a Student Research Resource Center in which SIG student members present articles of interest, providing both critical review and rationale

[22] Early papers (1977 through 1983) on verbal behavior appeared as Western Michigan University Monographs, the first from Sundberg et al. (1977). This paper and several others are available for download at marksundberg.com.

for their choice of papers to discuss. The SIG is active at ABAI's conventions and annually bestows the *Jack Michael Award for Outstanding Contributions in Verbal Behavior*. Created in 2012, the award first honored Jack Michael himself. Subsequent recipients were Mark Sundberg (2013), Dave Palmer (2014), Hank Schlinger (2015), and Barry Lowenkron (2016).

Jack's influence on the teaching of verbal behavior may be measured, in part, by sales of Skinner's (1957) *Verbal Behavior*, whose foreword in the 1992 re-publication of the book was co-written by Jack and Ernest Vargas (see bfskinner.org). According to the B. F. Skinner Foundation, "*Verbal Behavior* is our best-selling title and the sales have been growing every year since 1998. We do not have all the data from 2015 yet, but we know that e-book sales alone more than doubled compared to 2014" (B. F. Skinner Foundation, personal communication, February 9, 2016). The Foundation reports 2014 sales at 1134 books and 270 electronic copies (also see Schlinger, 2008 a, p. 145).

In addition to professional publications, Jack has presented his work at conventions, meetings, workshops, and similar settings. In this bibliography, we have included Jack's presentations for which there is searchable and retrievable material. A few of these are of special note. One was a co-presented lecture (see Carbone, 2011) at the National Autism Conference, sponsored by Pennsylvania Training and Technical Assistance Network (PaTTAN). The topic was applied behavior analysis research in autism. "I can tell you the students loved hearing his insider remarks about important historical events and people that they had only read about, e.g., Dicky, Ferster, Lovaas, Keller, etc" (V. Carbone, personal communication, March 2, 2016). PaTTAN also has archived a 2008 award ceremony that honored Jack's contributions to ABA (see Michael & PaTTAN, 2008). Jack's frequent presentations at ABAI (and MABA before that) are listed in ABAI's archived program books (see abainternational.org). In addition, ABAI has two archived videotapes of Jack's presentations, one on the topic of motivation and early language training (Michael, 2002) and the other on multiple control (Michael, 2003).

Limitations and Future Directions

There are other models for bibliography, including the comprehensive and detailed chronicle of the works of B. F. Skinner by Morris and Smith (2003). Their personal and enumerative bibliography, for instance, streamlined entries by omitting re-publications, which we did not. They excluded interviews, which we chose to include, if searchable and retrievable. They also used a much larger source of citation indexes and electronic databases. However, given the relative difference in the number of known publications (and categories within these) of our respective subjects (i.e., Skinner, Michael), we believe the search sources we used to be sufficient for the purpose of providing an initial bibliography of Jack's work.

We hope this bibliography provides a starting off point for additional descriptions of Jack's contributions to the field of behavior analysis. It would be helpful, for example, to have an annotated bibliography. Another variation would be to arrange the entries according to topics (e.g., motivating operations, automatic reinforcement) and publish these separately or as a group. The current bibliography also could be divided, then expanded, in such a way to include publications of others that emanated from Jack's

specific areas of focus. There are several iterations that might be possible, including those capturing the extensive applied work of Mark Sundberg. Another type of "co-bibliography" might trace particular conceptual perspectives involving verbal behavior; these might encompass topics of multiple control (e.g., the work of Michael, Palmer, and/or Sundberg), speaker-listener behavior (e.g., the work of Michael, Palmer, and/or Schlinger), and emergent language (e.g., the work of Michael, Miguel, and/or Petursdottir). Each of these (and many other unnamed collaborative combinations) would constitute both provenance and foundation to further document our field's behavior-analytic interpretations in these areas. In addition, it is likely that additional bibliographic sources (e.g., recorded workshop presentations, online course lectures) may be identified and could be added to an updated bibliography when those materials have been archived in retrievable formats.

Conclusion

We close this bibliographic tribute to Jack by briefly noting a colloquium that was held at Western Michigan University in 1978 (see Michael & Western Michigan University, 1978). The topic was current perspectives on the science of language and the linguist Noam Chomsky had been invited as the main speaker. Participants included faculty from the Departments of Linguistics, Philosophy, and Psychology (represented by Jack Michael). The general format was for each panelist to pose various questions to which Chomsky would respond. Jack posited three points for Chomsky's reply, all centering around Chomsky's assertion that a *theory of action* (i.e., a mechanism that relates stimulus conditions to behavior) is unattainable, a "mystery." If this were the case, Jack reasoned, this would impose severe limitations on scientific knowledge. Furthermore, operant conditioning itself represents such a "theory" in that its independent variables are stimulus conditions that increase or decrease the probability of a response. As such, this evidence seems incompatible with Chomsky's view that our science-forming capacities are limited.

> *Michael*: "Most of the people I know, that talk about science, talk about it, not in terms of specific capacities that would be limited, but rather in terms of increasing effectiveness on the part of the verbal repertoire of the scientific community, which gets better as it gets better…The notion that, just by chance, certainly not for evolutionary bases, …we happen to have been born with science-forming capacities in the area of physics but, say, not in other areas, and that we are forever doomed to not know about these other areas is a very peculiar notion and I would like to hear Dr. Chomsky elaborate on that a little bit."
>
> *Chomsky*: "I quite agree with you that it's a peculiar notion, …but I still think it's true…I think we should recognize its truth if we can get over a sort of a traditional hang-up, which is not only empiricist, but is rationalist as well, and that is the hang-up of thinking of ourselves as universal instruments in the Descartes sense…[This is like] the problem of language learning. We have a certain amount of evidence, like when you were six years old…your task was to throw away a lot

> of that evidence…and to find some kind of a grammar, which would predict infinitely, including the evidence that you decided to keep. That's very much like science formation and that is only possible if you have a very high restriction in advance as to the class of theories that you're allowed to look at. If you're allowed to imagine any possible theory, then you can't select anything. It's a simple fact of logic that there are infinitely many theories inconsistent with one another but consistent with [particular] evidence – we can't argue logic."
>
> *Michael*: "But we're talking about behavior, not logic."
>
> *Chomsky*: "But that doesn't matter…what I said is simply a point of logic. Therefore, it follows that there's got to be some device, if learning ever takes place…if we do select out of the infinite class of possibilities, only a small set… it's because we're somehow predesigned to do it. It's obviously true in the case of language."

The exchange is compelling, particularly given that Jack had yet to publish his work on motivating operations. One perhaps can intuit some overlapping kernels of compatibility in their views (the existence of an evolved human physiology, for example) but the interaction is disparate, and, logic arguments aside, seems to lack cohesion at its core. Perhaps Jack's assertions needed more explanatory heft, but it is doubtful that persuasive inroads were going to be made, given Chomsky's dismissive reaction to Skinner's *Verbal Behavior* (1957; Chomsky, 1959; also see his subsequent interview with Virués-Ortega, 2006; also see MacCorquodale, 1970; Palmer, 2006b; Schlinger, 2008b, p. 329).

The Chomsky-Michael exchange illustrates challenges then and now for behavior analysts, starting with the fundamental task of conceiving adequate (i.e., explanatory) behavioral analyses. Within a few years of that 1978 colloquium, we would have Jack's conceptualization of motivational variables (Michael, 1982a) and his taxonomy of behavioral functions of environmental events (Michael, 1993, 2004), analytic tools that moved us forward exponentially to ever-increasing applications of our technology in clinical, educational, and corporate arenas.

However, the task requires multiple skill sets and it is easy to get derailed in the analytic process. To support perseverance and success, Jack often reminded his students to "take it back to the Skinner box" for analysis when real-world behavior change was difficult to achieve or to interpret. Many of Jack's examples that have helped us better understand CMOs in language training, for instance, are not applied, but rather experimental (e.g., behavioral chaining; avoidance-escape and warning stimuli; see Michael, 2004, pp. 68-71). There is no disconnect here. Behavioral language training (i.e., "the verbal behavior approach") *is* behavior analysis. It is simply the application of already existing behavioral principles to verbal behavior. It is the analysis of functional contingencies with respect to these responses (function) and their topographic variations (form within function). Jack reasoned that if we could design effective programming at the basic science level, we would better understand how to apply it to socially significant behaviors, most notably verbal behavior and the problem behavior that often accompanies weak verbal repertoires.

Although Jack has long advocated for the application of behavior analysis, we think he would champion our continued efforts to conceptualize, analyze, and articulate our work at the experimental level.

> Behavior analysis has been successful at building a theory of behavior, but much work remains to be done. There are fundamental questions about the nature of behavioral processes and even behavioral units that remain unanswered. By supporting basic behavioral work, we can continue to build a theory on which we can base further extensions and applications. (Pietras, Reilly, & Jacobs, 2013, pp. 146-147)

Ultimately, the critical mass of this experimental evidence, and the interpretations that follow, will provide the vehicle for more persuasive arguments to substantiate our science.[23] In the meantime, we can try to talk like Jack, who, in his 1978 interaction with Chomsky characterized one of Chomsky's notions as "peculiar" instead of "unacceptable" or "incomprehensible." The difference is subtle, but it illustrates Jack's sincere attempts to understand the verbal behavior of those expressing conflicting views and to find conceptual congruence wherever possible. The sentiments expressed by Pietras et al. (2013) were both anticipated and underscored in Jack's conclusion to Chapter 4 of *Concepts and Principles* (Michael, 2004), so we think it is a fitting conclusion to this bibliographic tribute as well. It captures the essence of all that he tried to teach us. Thanks, Jack.

> The approach to the prediction, control, and understanding of human behavior that has been described above should not be thought of as static. Behavior analysis is constantly changing in little ways, and every once in a while a big change—a breakthrough—occurs. It is a deterministic view that sees human behavior as the inevitable product of innate endowment and environmental events taking place during the person's lifetime. In many respects, it is scientific method applied to all aspects of behavior.
>
> This view is not concerned only with operant conditioning. It does not exclude private stimuli and covert behavior from scientific consideration. It does not insist that behavior can change only as a result of direct exposure to contingencies, but readily acknowledges behavior change by instruction, and by the description of contingencies. It is not antiphysiological, antigenetic, or antitheoretical (except with respect to inferred inner explanations). It is the science and technology of behavior. (p. 120)

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[23] "I should like to see a closer association with the other so-called behavioral sciences – sociology, economics, political science, and the rest. Their data are almost exclusively behavioral, if historical, but their formulations are still largely mentalistic" (Skinner, 1993/2014).

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