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HUMAN SIMULATIONS IN BEHAVIOR ANALYSIS (1987-2010): FACILITATING RESEARCH IN COMPLEX HUMAN BEHAVIOR

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ABSTRACT: The authors reviewed human empirical studies from 1987-2010 in the Journal of the Experimental Analysis of Behavior (JEAB), Journal of Applied Behavior Analysis (JABA), Journal of Organizational Behavior Management (JOBM), and Psychological Record (PR). Out of 2286 empirical studies, the authors classified 45 as simulation research, which fell into 4 main categories including organizational, gambling, financial, and other. JOBM contained over half of the simulations, while JEAB contained two. A subsequent citation analysis found that the original simulations informed 15 service-delivery articles, across five journals. In addition, the original articles also informed 35 other behavioral simulations across 19 journals. Simulation research could be ideally placed between theory and application to facilitate empirical research and applications in complex human behavior and the development of an empirically validated, comprehensive, system of behavior analysis.
KEYWORDS: simulation, analogue, behavioral systems, cultural analysis

The history of behavior analysis is marked with persistent internal critics whose origins, ironically, stem from its early recognition as a powerful technology of behavior change. Skinner (1938) originally intended his science to become a comprehensive, empirically-validated account of all of psychology (also see Hayes, 2001; Hayes, Barnes-Holmes, & Roche, 2001). However, early applied successes changed the largely "simple to complex" research strategy into a "basic to applied" approach which created a relative void of basic human research (Hake, 1982). Though recent work indicates the empirical void is beginning to fill, the critics still remain (Catania, 2008; Dymond & Critchfield, 2001, 2002; Geller, 2001, 2002; Hayes & Berens, 2004; Johnston, 1996). The general consensus among these critics can be interpreted as a concern that the

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original scientific aims of Skinner (1938) were lost in the applied success of the field (Hayes, 2001).

In an effort to further promote the empirical study of human behavior in its full complexity, the current paper seeks to investigate the role of simulation-based research in behavior analysis, which can be regarded as a component of the "complex to simple" approach, espoused by Epling and Pierce (1986). In contrast to the original "simple to complex" approach characteristic of early behavior analysis (Epling & Pierce; Hake, 1982), this approach draws on naturalistic human settings as the primary source of research questions, yet simplifies aspects of those settings in a controlled laboratory preparation. We offer a definition of simulation-based experimentation, contrast that approach with non simulation-based human research, and categorize 45 behavior analytic experiments conducted between 1987-2010 that appear to fit the current definition. From this, we will begin to build a picture depicting the state of simulation-based research in behavior analysis and suggest specific avenues for the continuation of such work as one possible research methodology towards the analysis of human behavior in its full complexity.

In order to fully appreciate why Epling and Pierce (1986) advocated for the complex-to-simple approach, which acts as a general conceptual guide for the current paper, one must consider the history of behavior analysis as a whole. The following sections provide a sketch of that history, which measures the evolution of the field at various stages in relation to Skinner's (1938) original aims to develop a comprehensive science of psychology.

Early Success Breeds Division

In 1938, with the publication of *Behavior of Organisms,* Skinner set out to establish a program of research upon which a comprehensive and naturalistic psychology would eventually arise (also see Hayes, 2001). Though the book described his animal-based research, Skinner cautioned against interpreting his animal work as interest in animal behavior *per se.* Rather, "the importance of a science of behavior derives largely form the possibility of an eventual extension to human affairs … the reader should be as able to make applications as the writer" (Skinner, 1938, pp. 441-442).

According to Skinner, after initially investigating animal behavior in an inductive fashion, the data would yield basic principles to eventually allow a more focused and fruitful analysis of complex human behavior than the hypothetico-deductive method (Skinner, 1969, pp. 82-83, also see Sidman, 1960). Hayes, Barnes-Holmes, and Roche (2001) note that this approach "was certainly the long way around, but the hope was that a knowledge base would be formed that was

more stable than if complexity were taken head on, with so many ways to get it wrong" (p. xi). Remarkably, Skinner's "simple to complex" strategy (Epling & Pierce, 1986; Hake, 1982) quickly came to bear fruit.

Effective applications to human affairs followed soon after the creation of the *Journal of the Experimental Analysis of Behavior* (JEAB) (e.g., Ayllon & Michael, 1959). Basic human research appeared early on as well (e.g., Azrin, 1958; Bijou, 1958; Flanagan, Goldiamond, & Azrin, 1958; Holland, 1958). Two studies even investigated applied human problems in the laboratory related to noisy work environments (Azrin, 1958) and "operant stuttering" (Flanagan et al., 1958) using concepts and procedures taken directly from the animal lab. At the same time, Skinner (1957) produced his ambitious theoretical treatise *Verbal Behavior* to deal with the complexities of human language.

Times were good for behavior analysts through the 1960s, which witnessed the expansion of the applied domain with the creation of the *Journal of Applied Behavior Analysis* (JABA) in 1968. During this period there was much overlap between basic and applied behavior analysts. Most behavior analysts received relatively homogenous training in basic principles and the philosophy of radical behaviorism and all typically fell under the label "operant conditioner" (Epling & Pierce, 1986). Eventually, however, the practical techniques of these "operant conditioners" generated a demand for applied positions requiring quick and effective solutions to behavior problems (Epling & Pierce, 1986). As discussed by Epling & Pierce (1986) practitioners became less concerned with analysis and increasingly focused on problem solving while the basic researchers increasingly focused on abstract theoretical questions at the expense of investigating socially significant behavior. It was here that the seeds of long-standing internal criticisms of behavior analysis were sown.

In the following sections, we will briefly outline the evolution of these criticisms from the standpoint of both basic and applied behavior analysts. In that regard, we will provide a history that can be described as a breaking away from Skinner's (1938) original scientific aims of a comprehensive science of behavior followed by efforts to return to these goals. Finally, we will advocate for, and offer a review of, the use of simulation-based research as one approach to further the "complex to simple" research agenda set forth by Epling and Pierce (1986) to facilitate the comprehensive study of human behavior in its full complexity.

Concerns within Behavior Analysis

On the basic side, one of the first criticisms came from the Interbehaviorists. For instance, Kantor's (1970) "Analysis of the Experimental Analysis of Behavior" applauded the naturalistic and objective approach of behavior analysis,

but with caution. He felt behavior analysis had an overreliance on non-human subjects and a resultant over-simplification of psychological events. Kantor predicted that continuing on such a course, which ran contrary to Skinner's (1938) original aims, would leave an empirical void in the realm of complex human behavior that was rapidly being filled by psychologists from different philosophical orientations (Galizio, 1987). Seven years later, Ribes (1977) echoed Kantor's assertions with a call to develop an empirically-based understanding of complex human social and verbal behavior in order to develop a sophisticated behavioral technology to deal with complex human problems. In this regard, he felt existing data on such matters were "not of the kind nor of the depth we would prefer….that which we do have lacks an adequate base in theory" (p. 419). The "adequate base" was lacking, according to Ribes, due to the heavy reliance on animal data for the construction of behavioral principles.

In 1982, Hake's assessment of basic human research to-date confirmed Kantor's (1970) original fears. What started with Skinner (1938) as the "simple to complex" approach, whereby animals were used as a strategic precursor to complex human behavior, turned into a "basic to applied" approach. Animal preparations were seen as the primary basic preparation while humans were designated to the applied domain. Left in the middle were basic data concerning complex human verbal and social behavior (Hake, 1982; Hayes, Barnes-Holmes, & Roche, 2001). This created a situation in which basic journal editors viewed much human operant research as too applied for their outlets while applied editors viewed the same work as too basic (Hake, 1982). If humans were used in basic research, it was primarily for the purposes of extending animal lab data, as opposed to investigating uniquely human phenomena (Baron, Perone, & Galizio, 1991; Hake, 1982). Baron and Perone (1982) note that, given the applied values of behavior analysis, it is surprising that such a discrepancy existed between such goals and the actual empirical data upon which behavioral constructs were built.

During the same period, a decade after JABA came into existence, criticisms appeared regarding the technical basis for applied behavior analysis (Dietz, 1978, 1987). It was felt by some that practitioners were simply applying existing knowledge to socially significant issues without contributing to the knowledge base of behavior analysis through the analysis of these new types of behavior problems (Dietz, 1978, 1987). Many behavior analysts at the time felt that "analysis"—a pillar of applied behavior analysis, as outlined by Baer, Wolf, and Risley (1968)—was missing from applied work.

The Experimental Analysis of Human Behavior

The 1980s witnessed a marked shift in the field influenced by Hayes, Rincover, and Solnick's (1980) declaration of a "technical drift" (p. 293) in applied behavior analysis. Their empirical review of data published in the first 10 volumes of JABA confirmed the increasingly "cure" oriented approach suspected by others that left the "analysis" of applied behavior analysis lacking (Dietz, 1978). By 1982, it seemed that Kantor's (1970) original critique had been heard and behavior analysts had begun warming up to the analysis of uniquely human phenomena (Baron & Perone, 1982; Hake, 1982). Behavior analysts recognized more than ever the pervasiveness with which human social and verbal behavior is found in naturalistic settings and the degree to which these types of behavior are involved in many mainstream psychological topics (e.g., imagining) (Dietz, 1987; Hake, 1982). Hake (1982) dared to say that for such behaviors "basic animal laboratory research may not be the best place to begin" (p. 25) particularly if the species is not biologically prepared to engage in the complex behavior of interest. In 1982, *The Analysis of Verbal Behavior* was founded toward this end.

These shifting perspectives seen in the early 1980s were quickly followed by a number of articles dealing explicitly with issues in basic human research (Buskist, 1987; Dietz, 1987; Galizio, 1987). The atmosphere of behavior analysis was changing, as seen in the Dietz' (1987) statement: "we should do what we can do but we need to remember always how much we do not yet know" (p. 31). Buskist (1987) noted that the percentage of human experiments published in JEAB, between 1981-1985 was almost double the percentage from 1958-1980. Moreover, the percentage of human articles pertinent to social and verbal behavior from 1981 to 1985 was four times that of 1958-1980. Furthermore, conclusive data emerged indicating that verbal humans do, in fact, respond differently to schedules of reinforcement than do animals or preverbal infants (Buskist, 1987; Galizio, 1987; Lowe, Beasty, & Benthal, 1983).

Soon, behavior analysts began speaking of a new area called the Experimental Analysis of Human Behavior (EAHB) (Buskist, 1987; Dietz, 1987; Galizio, 1987) that served to fill the void in complex human behavior that originated in the early divergence of basic and applied behavior analysts, which was originally predicted by Kantor (1970) and confirmed by Hake (1982). In 1987, Dietz loudly proclaimed that EAHB "does not exist to replicate work in the non-human animal laboratory" (p. 32). This new area was created to lend a degree of analysis to human behavior that was missing in applied behavior analysis, though it was regarded as a conceptual trademark (Baer, Wolf, & Risley, 1968). At the same time, EAHB served to depart from the traditional animal-based

Experimental Analysis of Behavior (EAB) with an emphasis on uniquely human phenomena.

By the mid-1990s, it was clear that the void was filling. Johnston (1996) noted significant increases in research pertaining to verbal behavior, particularly stimulus equivalence. Similarly, Dymond and Critchfield (2002) noted consistently increasing trends in human research publications in JEAB and *Psychological Record* (PR) throughout the 1980s and 1990s in at least five different content areas. At the turn of the 21st century a book-length treatment of the empirically-based account of human language and cognition known as Relational Frame Theory appeared (Hayes, Barnes-Holmes, and Roche, 2001), which aimed to supplement Skinner's (1957) *Verbal Behavior*.

The 21st Century: Creating Demand for the Complex to Simple Approach

The turn of the 21st century witnessed a growing demand for laboratory-based human research coming from two diverse groups. One group may be characterized as coming from a more basic science perspective. For example, some have alleged that JEAB is too animal oriented for their tastes (Dymond & Critchfield, 2001; Hayes & Berens, 2004) and that JEAB should take verbal behavior into greater consideration (Catania, 2008). Related to this concern, Hayes (2001) asserted that behavior analysis risks "becoming a subfield of developmental disabilities" (p. 61) instead of an empirically-validated psychology concerned with topics traditionally dealt with by mainstream psychologists.

The second group offers a more applied perspective, particularly focused on social phenomena in Organizational Behavior Management (OBM), cultural analysis, and their common bond, Behavioral Systems Analysis. For example, recent authors in OBM, have cited dramatic contrasts in popularity between traditional I/O psychology programs in comparison to OBM, and have called for expanding the content of the field, to include more traditional psychological topics (Geller, 2002; Hayes, Bunting, Herbst, Barnes-Holmes, & Bond, 2006). In a related fashion, Geller (2001) commented that behavior analysts have not realized Skinner's (1953, 1971) original dream of large-scale behavior change. While behavior analysts have had some success in applications to relatively complex community, social, and organizational issues, Geller suggests that most are short-lived. What are needed are more long-term and larger-scale interventions to complex social issues. Geller suggests that we need to reach out to non-behavior analysts who have a greater interest in such applied topics, even if their perspectives are different.

To a certain extent, however, several behavior analysts interested in organizational and cultural issues have reached outside of behavior analysis to

incorporate concepts particularly relevant to social complexities, most notably via Behavioral Systems Analysis (see, e.g., JOBM vol. 29, issues 2-3). Though there is a presence of applied systems work in the organizational and cultural arenas (e.g., Biglan, 1995; Gordon, Biglan, & Smolkowski, 2008; Mihalic & Ludwig, 2009), Mattaini (2006) cautions that "there is a real risk that without strong, progressive programs of empirical research, those within behavior analysis with interests in cultural level phenomena will become increasingly marginalized" (p. 74). The latter echoes Johnston's (1996) concern that a basic empirical knowledge of human social behavior was, and still has, "yet to blossom into an identifiable and multifaceted area of basic research" (p. 38).

As the before-mentioned history illustrates, the successes of behavior analysis as a field are noteworthy but the field itself contains a lineage of critiques from within that, collectively, seek to bring the field into ever-increasing levels of human complexity. While signs of progress are currently seen in the domain of verbal behavior, behavior analysts in the 21st century are increasingly concerned with the analysis of human behavior relative to its social contexts, the latter of which necessarily requires a sophisticated analysis of verbal behavior. It is within this context that the case for Epling and Pierce's (1986) complex to simple research agenda is made.

The Complex to Simple Approach

Given the preceding discussion, the human research agenda within behavior analysis may benefit from the "complex to simple" approach advocated by Epling and Pierce (1986). Using what they describe as analogue research, Epling and Pierce suggest that behavior analysts may be better prepared to encounter uniquely human phenomena with uniquely human principles. Though the traditional "simple to complex" approach has served behavior analysts well in animal and human research, and has created a pragmatic technology of behavior change, such an approach may ultimately hinder the development of a basic understanding of human behavior (Hake, 1982).

Though behavior analysts can change a wide variety of behavior with a few powerful tools and principles (Hayes, 2001), we also need to understand how human behavior in its myriad of social and verbal features, develops in a naturalistic way. The complexities of the naturalistic world can serve as a rich source of many new and complex research questions that deal with uniquely human phenomena. Johnston (1996) calls this approach "applied research" (p. 38) and distinguishes this area from "service-delivery" (p. 38). The former is characterized by research with "a basis in fundamental principles…directly driven by applied issues and problems but not compromised by the practical limitations

or the immediate service interests of applied settings" (p. 38). Service-delivery, however, is synonymous with the implementation of an empirically-sound technology toward behavioral solutions in naturalistic settings. In Johnston's view, separating research from service-delivery facilitates the development of both areas. On one hand more basic researchers can pursue fundamental questions pertinent to socially-significant behavior, while on the other hand service-delivery practitioners are left to apply their technology without the burdens of conducting research.

Analogue research has been mentioned periodically throughout the history of behavior analysis, but used in different ways. In a general sense one may say that Skinner viewed all basic research as analogue research. For example, his before-mentioned remarks in *Behavior of Organisms* concerning "an eventual extension to human affairs" (Skinner, 1938, p. 441) makes clear that Skinner viewed animal research not as an end in itself, but as a strategic starting point to understand the complexities of human behavior. Nearly 20 years later, Skinner (1953) stated "a demonstration of basic behavioral principles under simplified conditions allows us to see these processes at work in complex cases even though they cannot be treated rigorously there" (p. 435). Lastly, Interbehavioral researchers hold that all methods of investigation are analogue since one necessarily investigates particular functional relations pertinent to a psychological event while ignoring others (Kantor, 1958, pp. 88-91).

Sidman (1960), in his classic methodological treatise *Tactics of Scientific Research*, also touched on analogue research but dealt with the matter in a more specific way than Skinner (1953) or Kantor (1958). For instance, he speaks of "finding new behavioral processes to bring into the laboratory" (p. 25) one source of which can reside in the complex naturalistic settings within which human behavior occurs daily. His definition, therefore, closely resembles the complex to simple approach advocated by Epling and Pierce (1986) and Johnston (1996). The examples Sidman uses are wide ranging, from the use of animal preparations to model human psychoses, to more practical uses such as training military personnel using a laboratory "display" of sorts.

Given the lack of discussion and explicit definition of analogue research, the current study sought to lend a degree of conceptual clarity to this methodology. In particular, the current study served three purposes. First, we distinguished between analogue research and simulation-based research such that the latter is a subset of the former. Secondly, we reviewed JEAB, JABA, PR, and the *Journal of Organizational Management* (JOBM) from 1987-2010 to assess the degree to which simulation research has been conducted. These journals were chosen based on their historical prominence in the field of behavior analysis. In the case of

JEAB and JABA, this is also exemplified by sponsorship by the Society for the Experimental Analysis of Behavior (Society for the Experimental Analysis of Behavior, n.d.). *Psychological Record* was founded in the 1930s by the prominent interbehaviorist J. R. Kantor with B. F. Skinner serving as the experimental editor at that time (*The Psychological Record*, n.d.). In addition, publication trends indicate that PR is considered a primary outlet for human operant research (Dymond & Critchfield, 2002). Finally, JOBM is the only journal devoted specifically to Organizational Behavior Management (OBM) and is the official journal of the OBM Network (*Journal of Organizational Behavior Management*, n.d.). Taken together, these four journals offer a diverse sampling of the behavioral literature, though they do not constitute the whole of the field.

Lastly, we conducted a citation analysis of those studies classified as "simulation-based" to assess the degree to which such studies have informed service-delivery articles and other simulations both within and outside of behavior analysis. The citation analysis was conducted to determine the extent to which the topographical definitions provided in the current paper are functional research categories in the sense of influencing future research and the development of behavior analysis more generally.

Method

Analogue Experimentation

Since behavior analysis seems to lack a clear definition of analogue experimentation, we offer a definition below. We further distinguished simulation-based research from analogue research such that the former is a subtype of the latter. Each of the following definitions is based on two factors: (a) whether or not the researcher explicitly attempts to extrapolate his/her findings as an explanation for events found in naturalistic settings, and (b) whether or not the physical features of the experimental apparatus, were designed to recreate particular features of a particular naturalistic setting.

An *analogue experiment,* which includes simulations and non-simulations, is one in which the researcher explicitly attempts to extrapolate his/her findings as an explanation for events found in naturalistic settings (i.e., "a" above). What is "analogous" in any type of analogue is the behavioral process found after the researcher examines his/her data. As discussed below, simulation and non-simulation analogues differ regarding the methods used to produce the analogous process (i.e., "b" above).

Non Simulation-Based Analogue Experimentation

A *non simulation-based analogue experiment* is, first, an analogue study, meaning the process found as a result of the study is explicitly extrapolated as an explanation for events found in naturalistic settings. Secondly, this type of study is not a simulation, meaning the physical features of the experimental apparatus were not designed to recreate any features of a naturalistic setting. As a result of the latter, the naturalistic settings to which non simulation-based analogues are extrapolated tend to be much less specific. As an example of a non-simulation based analogue, Kohlenberg, Hayes, and Hayes (1991) conducted an experiment utilizing a stimulus equivalence procedure involving male and female names. Near the end of the article, the authors then mention "the relevance of these findings to events existing outside of the laboratory are worth noting" (p. 517) and go on to discuss how their procedure and findings may resemble cases of social stereotyping as it relates to bigotry, discrimination, and war. The procedures and apparatus of Kohlenberg et al. were not meant to reproduce features of any particular context in which social stereotyping may come about.

Simulation-Based Analogue Experimentation

A *simulation-based analogue* experiment is, first, an analogue study in that the process found as a result of the study is explicitly extrapolated as an explanation for events found in naturalistic settings. However, the process that is extrapolated from a simulation-based analogue was produced with an apparatus whose physical features were designed to recreate particular features of the naturalistic setting to which the process is extrapolated. As an example of simulation-based analogue experimentation, Bennett and Samson (1991) investigated alcohol tolerance from a classical conditioning perspective using a laboratory room that was furnished to resemble a naturalistic bar setting. Furthermore the authors extrapolate their findings to naturalistic cases of drinking in a bar context.

Lastly, a simulation-based analogue may utilize verbal scenarios of naturalistic situations in that such scenarios are designed to verbally recreate particular features of a naturalistic setting. If the results of such a study are explicitly extrapolated as an explanation for events found in the same types of naturalistic settings to which the apparatus was designed to recreate, then this would be a simulation-based analogue.

Non-Analogue Experimentation

Lastly, any experiment in which the researcher does not explicitly extrapolate his/her findings as an explanation of events in naturalistic settings is not an analogue, even if the apparatus used was designed to recreate features of a naturalistic setting. For example, Bernstein and Michael (1990) constructed a laboratory apartment setting in which participants lived for up to a month. Though the stimuli and tasks engaged in by the participants resembled those of naturalistic tasks, the researchers were not seeking to understand processes involved in naturalistic living conditions. Rather, they were investigating the correspondence between verbal descriptions and behavior without explicitly extrapolating their findings as explanations of description-to-behavior correspondence within actual living conditions.

Procedure

The first author and research assistants reviewed JEAB, JABA, JOBM, and PR. Using the PsychINFO database, the search parameters for each journal were restricted to "human," and "empirical" studies spanning the years 1987-2010. Articles were immediately eliminated if participants were described as having a clinical diagnosis or included any of the following descriptors: diagnosis, disability, disorder, syndrome, handicapped, delayed, retardation, impairments, deficits, or dementia.

Also eliminated were service-delivery articles (see earlier discussion in relation to Johnston, 1996). Service-delivery articles consisted of experimental interventions designed to improve socially important behavior of non-arbitrary participants in naturalistic settings (Baer, Wolf, and Risely, 1968). Two particularly illustrative examples include Neef, Trachtenberg, Loeb, and Sterner (1991) who utilized video-based "simulation training" procedures in the training of respite-care providers, and Neef, Parrish, Hannigan, Page, and Iwata (1989) used "simulation training" with dolls to train girls with urinary problems how to self-administer catheters. Though the procedures were conceptualized as "simulation training" by their respective authors they did not meet the criteria for simulation-based experimentation as defined herein. Furthermore, these studies did not discuss their interventions as ways to understand a naturalistic phenomenon. Rather, these studies were purely applied in focus.

The before-mentioned definition of simulation-based analogue experimentation was then applied to the remaining articles. From these, articles were further eliminated that did not adhere to a behavior analytic perspective in the interpretation of results, which only applied to experiments found in PR, and

required that the results were interpreted using principles derived from operant or classical conditioning.

Seventy-one percent of resultant articles were distributed to research assistants who provided interobserver agreement on their status as simulation-based analogue experimentation. The number of agreements was divided by the sum of agreements plus disagreements and multiplied by 100. Interobserver agreement was 100%.

Results

Figure 1 shows the cumulative number of simulations per year for each journal. Forty-five articles were classified as simulations, 22 of which were from JOBM, 12 from JABA, 9 from PR, and 2 from JEAB. Note the sharp increase in frequency from 2009-2010. Twenty-four percent (11/45) of all the simulations obtained in this study were published during this time. This is accompanied by increased frequency from all four journals, with the most pronounced spike coming from JABA which accounts for over half of the increase (6/11).

Figure 2 shows the total number of simulations as a percentage of human empirical studies per journal in order to control for differing overall publication rates across journals. As depicted in Figure 2, JOBM has the highest percentage at 14% (22/155 articles), PR is a distant second at 2% (9/523 articles), while JEAB is at 1% (2/286 articles) and JABA is at 1% (12/1286 articles). When comparing Figures 1 and 2, note that JOBM remains most prevalent and JEAB least prevalent. However, JABA is more prevalent than PR in terms of frequency (Fig. 1), while PR is more prevalent than JABA when calculated as a percentage of overall empirical studies (Fig. 2). The specific simulations per journal are indicated in Tables 1-4.

Simulation Categories: 1987-2010

Figure 3 depicts the cumulative publication rates according to four categories of simulations, which are: (a) organizational, (b) gambling, (c) financial, and (d) other. Organizational simulations were the most frequent at 23/45. Simulations were categorized as organizational if they dealt with issues directly related to the work place. The organizational simulations found in the present study dealt primarily with pay contingencies, performance, productivity, leadership, quality control, and safety. As shown in Figure 4, the organizational

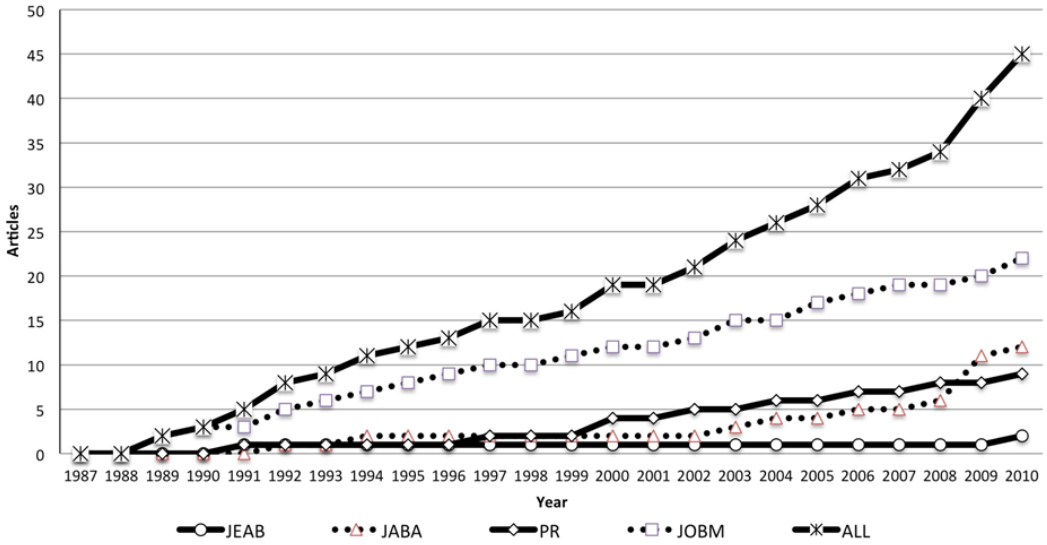

Figure 1. Cumulative simulations per journal (1987-2010).

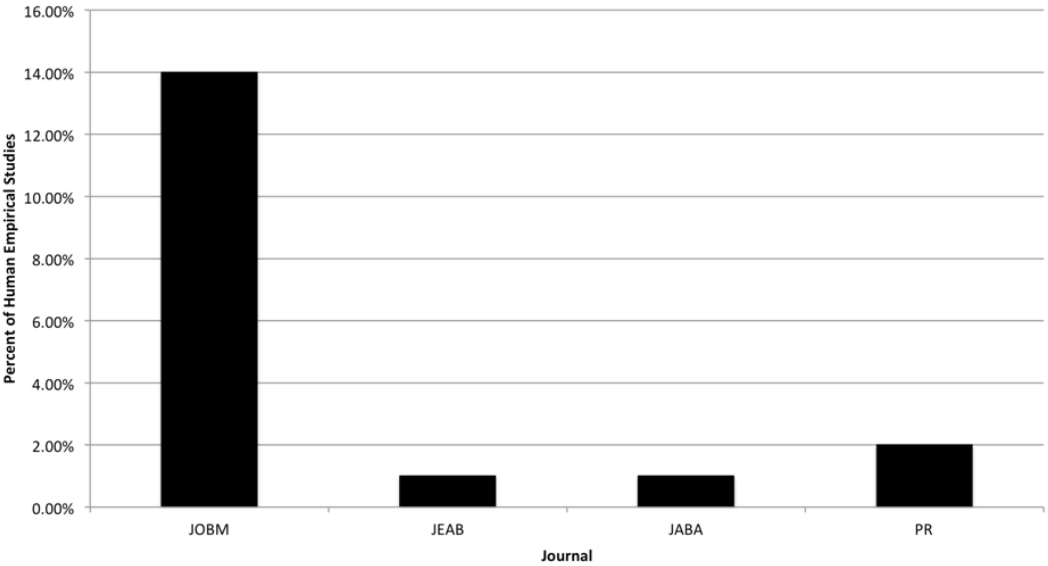

Figure 2. Simulations as a percentage of human empirical studies per journal (1987-2010).

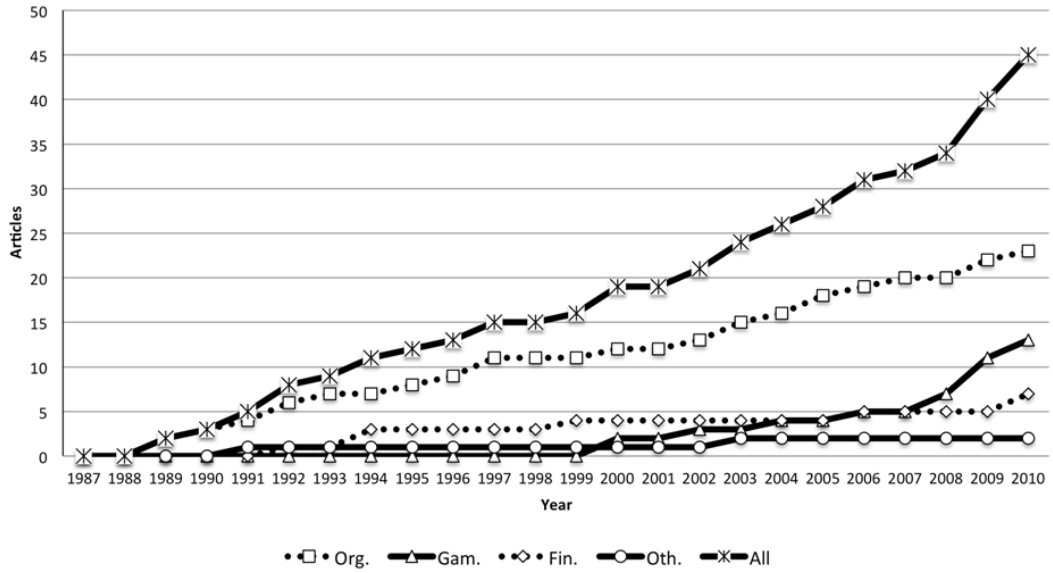

Figure 3. Cumulative simulations by category (1987-2010).

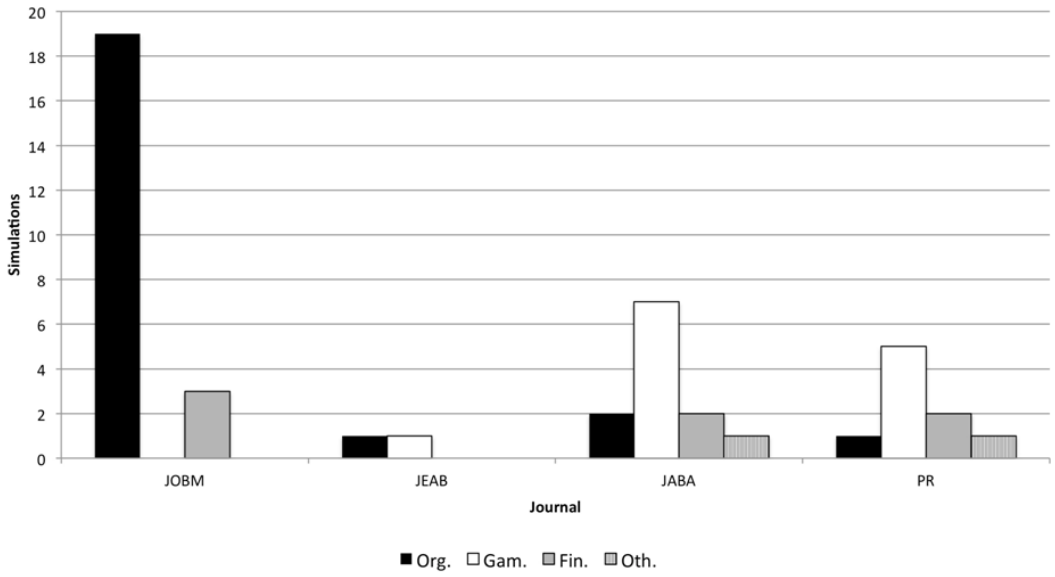

Figure 4. Simulation categories per journal.

Table 1. *Simulations in the* Journal of Applied Behavior Analysis

Category	**Reference**
Organizational	Alvero, A. M., & Austin, J. (2004). The effects of conducting behavioral observations on the behavior of the observer. *Journal of Applied Behavior Analysis, 37,* 457-468.
	Wine, B., Wilder, D. A. (2009). The effects of varied versus constant high-, medium-, and low-preference stimuli on performance. *Journal of Applied Behavior Analysis, 42,* 321-326.
Financial	Goltz, S. M. (1992). A sequential learning analysis of decisions in organizations to escalate investments despite continuing costs or losses. *Journal of Applied Behavior Analysis, 25,* 561-574.
	Hantula, D. A., & Crowell, C. R. (1994). Behavioral contrast in a two-option analogue task of financial decision making. *Journal of Applied Behavior Analysis, 27,* 607-617.
Gambling	Dixon, M. R., Nastally, B. L., Jackson, J. E., & Habib, R. (2009). Altering the near-miss effect in slot machine gamblers. *Journal of Applied Behavior Analysis, 42,* 913-918.
	Hoon, A., Dymond, S., Jackson, J. W., & Dixon, M. R. (2008). Contextual control of slot-machine gambling: Replication and extension. *Journal of Applied Behavior Analysis, 41,* 467-470.
	Johnson, T. E., & Dixon, M. R. (2009). Influencing children's pregambling game playing via conditional discrimination training. *Journal of Applied Behavior Analysis, 42,* 73-81.
	Johnson, T. E., & Dixon, M. R. (2009). Altering response chains in pathological gamblers using a response-cost procedure. *Journal of Applied Behavior Analysis, 42,* 735-

	740.
	Nastally, B. L., Dixon, M. R., & Jackson, J. W. (2010). Manipulating slot machine preference in problem gamblers through contextual control. *Journal of Applied Behavior Analysis, 43,* 125-129.
	Weatherly, J. N., Thompson, B. J., Hodny, M., & Meier, E. (2009). Choice behavior of nonpathological women playing concurrently available slot machines: Effect of changes in payback percentages. *Journal of Applied Behavior Analysis, 42,* 895-900.
	Zlomke, K. R., & Dixon, M. R. (2006). Modification of slot-machine preferences through the use of a conditional discrimination paradigm. *Journal of Applied Behavior Analysis, 39,* 351-361.
Other	Doepke, K. J., Henderson, A. L., & Critchfield, T. (2003). Social antecedents of children's eyewitness testimony: A single-subject experimental analysis. *Journal of Applied Behavior Analysis, 36,* 459-463.

Table 2. *Simulations in the* Journal of the Experimental Analysis of Behavior

Category	**Reference**
Organizational	Rao, R. K., & Mawhinney, T. C. (1991). Superior-subordinate dyads: Dependence of leader effectiveness on mutual reinforcement contingencies. *Journal of the Experimental Analysis of Behavior, 56,* 105-118.
Gambling	Habib, R., & Dixon, M. R. (2010). Neurobehavioral evidence for the "near-miss" effect in pathological gamblers. *Journal of the Experimental Analysis of Behavior, 93,* 313-328.

Table 3. *Simulations in the* Psychological Record

Category	Reference
Organizational	Honeywell, J. A., & Dickinson, A. M. (1997). Individual performance as a function of individual and group pay contingencies. *The Psychological Record, 47,* 261-274.
Financial	Kawashima, K. (2006). The effects of inflation and interest rates on delay discounting in human behavior. *Psychological Record, 56, 551-568.*
	Lie, C., Hunt, Maree, Peters, H. L., Veliue, B., & Harper, D. (2010). The "negative" credit card effect: Credit cards as spending-limiting stimuli in new Zealand. *Psychological Record, 60,* 399-412.
Gambling	Brandt, A. E., & Pietras, C. (2008). Gambling on a simulated slot machine under conditions of repeated play. *Psychological Record, 58,* 405-426.
	Dixon, M. R. (2000). Manipulating the illusion of control: Variations in gambling as a function of perceived control over chance outcomes. *The Psychological Record, 50,* 705-719.
	Dixon, M. R. (2000). Manipulating the illusion of control: Variations in gambling as a function of perceived control over chance outcomes. *The Psychological Record, 50,* 705-719.
	Dixon, M. R., Hayes, L. J., Aban, I. B. (2000). Examining the roles of rule following, reinforcement, and preexperimental histories on risk-taking behavior. *The Psychological Record, 50,* 687-704.
	Dixon, M. R., & Schreiber, J. B. (2002). Utilizing a computerized video poker simulation for the collection of data on gambling behavior. *The Psychological Record, 52,*

	417-428.
	Dixon, M. R., & Schreiber, J. E. (2004). Near-miss effects on response latencies and win estimations of slot machine players. *The Psychological Record, 54,* 335-348.
Other	Bennett, R. H., & Samson, H. H. (1991). Ethanol-related cues and behavioral tolerance to ethanol in humans. *Psychological Record, 41,* 429-437.

Table 4. *Simulations in the* Journal of Organizational Behavior Management

Category	**Reference**
Organizational	Stoneman, K. G., & Dickenson, A. M. (1989). Individual performance as a function of group contingencies and group size. *Journal of Organizational Behavior Management, 10,* 131-150.
	Rawlins, C. (1989). The impact of teleconferencing on the leadership of small decision-making groups. *Journal of Organizational Behavior Management, 10,* 37-52.
	Frisch, C. J., & Dickinson, A. M. (1990). Work productivity as a function of the percentage of monetary incentives to base pay. *Journal of Organizational Behavior Management, 11,* 13-34.
	Mason, M. A., & Redmon, W. K. (1992). Effects of immediate versus delayed feedback on error detection accuracy in a quality control simulation. *Journal of Organizational Behavior Management, 13,* 49-83.
	Oah, S., & Dickinson, A. M. (1992). A comparison of the effects of a linear and an exponential performance pay function on work productivity. *Journal of Organizational Behavior Management, 12,* 85-123.

Dickinson, A. M., & Gillette, K. L. (1993). A comparison of the effects of two individual monetary incentive systems on productivity: Piece rate pay versus base pay plus incentives. *Journal of Organizational Behavior Management, 14,* 3-82.

Cole, B. L., & Hopkins, B. L. (1995). Manipulations of the relationship between reported self-efficacy and performance. *Journal of Organizational Behavior Management, 15,* 95-135.

Sundby, S. M., Dickinson, A., & Michael, J. (1996). Evaluation of a computer simulation to assess subject preference for different types of incentive pay. *Journal of Organizational Behavior Management, 16,* 45-67.

Smoot, D. A., & Duncan, P. K. (1997). The search for the optimum individual monetary incentive pay system. *Journal of Organizational Behavior Management, 17,* 5-75.

Matthews, G. A., & Dickinson, A. M. (2000). Effects of alternative activities on time allocated to task performance under different percentages of incentive pay. *Journal of Organizational Behavior Management, 20,* 3-27.

Beal, S. A., & Eubanks, J. L. (2002). Self-report bias and accuracy in a simulated work setting: Effects of combined feedback on task and self-reported performance. *Journal of Organizational Behavior Management, 22,* 3-31.

Bucklin, B. R., McGee, H. M., & Dickinson, A. M. (2003). The effects of individual monetary incentives with and without feedback. *Journal of Organizational Behavior Management, 23,* 65-94.

Kang, K., Oah, S., and Dickenson, A. (2003). The relative effects of different frequencies of feedback on work performance: A simulation. *Journal of Organizational Behavior Management, 23,* 21-53.

	Johnston, M. R., & Hayes, L. J. (2005). Use of a simulated work setting to study behavior-based safety. *Journal of Organizational Behavior Management, 25, 1-34.*
	Mawhinney, T. C. (2005). Effective leadership in superior-subordinate dyads: Theory and data. *Journal of Organizational Behavior Management, 25,* 37-79.
	Sasson, J. R., Alvero, A. M., & Austin, J. (2006). Effects of process and human performance improvement strategies. *Journal of Organizational Behavior Management, 26,* 43-78.
	Tittelbach, D., Fields, L, & Alvero, A. M. (2007). Effects of performance feedback on typing speed and accuracy. *Journal of Organizational Behavior Management, 27,* 29-52.
	Hogan, L. C., Matthew, B., & Olson, R. (2009). A preliminary investigation of the reinforcement function of signal detections in simulated baggage screening: Further support for the vigilance reinforcement hypothesis. *Journal of Organizational Behavior Management, 29, 6-18.*
	Johnson, D. A., & Dickinson, A. M. (2010). Employee-of-the-month programs: Do they really work? *Journal of Organizational Behavior Management, 30,* 308-324.
Financial	Hantula, D. A., & Crowell, C. R. (1994). Intermittent reinforcement and escalation processes in sequential decision making: A replication and theoretical analysis. *Journal of Organizational Behavior Management, 14,* 7-36.
	Goltz, S. M. (1999). Can't stop on a dime: The roles of matching and momentum in persistence of commitment. *Journal of Organizational Behavior Management, 19,* 37-63.
	Fagerstrom, A. (2010). The motivating effect of antecedent stimuli on the web shop: A conjoint analysis of the impact of antecedent stimuli at the point of online purchase. *Journal of Organizational Behavior Management, 30, 199-220.*

category was the only one present in all four journals, while JOBM contained the overwhelming majority with 19/23.

The gambling category was the second most frequently published simulation at 13/45 (Fig. 3). All of the simulations in this category aimed to better understand gambling behavior primarily through the use of laboratory slot machines or roulette wheels. As shown in Figure 4, gambling simulations were present in 3 of the 4 journals with the most published in JABA (7/13) and none published in JOBM. In addition, Fig. 3 shows that gambling simulations accounted for a majority of the articles involved in the before-mentioned spike in frequency with 8 of the 13 simulations published between 2008-2010.

The financial category was the third most frequently published simulation at 7/45 (Fig. 3). The simulations in this category all involved purchasing or monetary investments directly related to stock markets, inflation, interest rates, and managerial decision-making. As shown in Figure 4, financial simulations were present in 3 of the 4 journals with the most published in JOBM (3/7) and none published in JEAB.

The fourth and final category was classified as "other" and contained two simulations (Fig. 3). One study investigated factors influencing eye-witness testimony (Doepke, Henderson, & Critchfield, 2003), while the other study in this category utilized a simulated bar setting to investigate effects of alcohol on behavioral tasks (Bennett & Samson, 1991). As shown in Figure 4, simulations in this category were published in JABA and PR only.

Citation Analyses: 1987-2010

As mentioned previously, citation analyses were conducted to empirically assess the function of the original 45 simulations in terms of the degree to which they are contributing to future work. Specifically, two types of citation analyses were conducted. The citation analyses reported here were not restricted to behavior analysis, but included any article involving any human population from any branch of the behavioral sciences that fit with the before-mentioned category.

The first analysis attempted to assess the impact of the original simulations on service-delivery articles. As mentioned previously, service-delivery articles were defined as those consisting of experimental interventions designed to improve socially important behavior of non-arbitrary participants in naturalistic settings. Figure 5 depicts the cumulative impact of the original simulations on

service-delivery articles in terms of the journals in which the original simulations were published. The total number of service-delivery articles that cited the original simulations is 15, with a sharp increase in 2009-2010 with 7/15 (47%) of the citations occurring during this time. Note that citations did not begin until 1994 and remained at zero until the burst of activity in 2003 that continued unabated through 2010 with JABA and JOBM carrying the overwhelming majority of citations (14/15; 93%) which may be expected given the applied nature of the journals. Table 5 lists the specific service-delivery articles by category. As shown in this table, the organizational category contained the overwhelming majority with 12/15 (80%), followed by the financial category at 2/15 (13%) and 1 (7%) in the "other" category, which consisted of an intervention related to developmental disabilities.

Table 7 depicts the journals in which the service-delivery articles that cited original simulations were published. While 59% (9/15) of these articles come from JOBM and 20% (3/15) from JABA, the remaining 21% is dispersed among three novel journals: *Behavioral Interventions* (7%; 1/15), the *Journal of Consulting & Clinical Psychology* (7%; 1/15), and the *International Journal of Aviation Psychology* (7%; 1/15). The reader should note that this analysis is in terms of unique articles, not duplicates. In some cases a service-delivery article cited multiple simulations within one of the four original journals. In these cases the service-delivery article was only counted once. Service-delivery articles were also searched across the four journals to exclude duplicates in the total count and none were found.

The second citation analysis sought to assess the impact of the 45 original simulations on other simulations. Like the first citation analysis, this analysis was not restricted to behavior analysis, but included any article involving any human population from any branch of the behavioral sciences that fit with the before-mentioned definition of simulation-based analogue experimentation. As shown in Figure 6, the original 45 simulations have informed 35 other simulations. Citation impact on simulations did not begin until 1998 and progressed steadily until a spike in activity in 2003, which has increased in rate through 2010. Note that the 2003 spike coincides with the 2003 spike in citation impact on service-delivery articles from the previous analysis.

Overall, PR, JABA, and, JOBM are closely matched in terms of impact at 16/35 (46%), 15/35 (43%), and 13/35 (37%) respectively, while JEAB impacted 1/35 (3%) simulation. The reader should note, however that the overall count of 35 is less than the sum of the four journals due to the exclusion of duplicates. For example, an article might cite one of the original simulations from JOBM and another from JABA. While this simulation would be counted once for JOBM and

once for JABA, it would not be counted twice in the overall number. In other words, the overall count of 35 simulations refers to 35 unique simulations and not duplicates. The same process was also applied within each of the four journals in order to exclude duplicates. If, for example, an article cited two of the original JOBM simulations, the article was only counted once for JOBM.

Table 8 depicts the journals in which the 35 simulations that cited the original simulations were published. 16/35 (46%) of the simulations found in the citation analysis were published in JOBM (7/35), JABA (6/35), JEAB (1/35), or PR (2/35). Thus, these are instances in which the simulations found in the original review cite other simulations found in the original review. However, the majority of the simulations (19/35; 54%) do not fall into this category and are spread across 15 diverse journals. The specific citations published outside the original four journals are listed in Table 6. Out of these 19 simulations, the majority fall into the gambling category at 11/19 (58%) followed by the financial category at 5/19 (26%) and the organizational category at 2/19 (11%).

Discussion

To some extent, behavioral research with humans already has a simulation-based element. In our review of the literature we found 45 articles that met our definition of simulation research from 1987-2010. Furthermore, our data indicate that this could be a functional category of research in that this work has informed 15 service-delivery articles across five journals and 35 other simulations across 19 journals.

Regarding service-delivery, the vast majority of the impact is in the organizational domain, which may be expected given that the organizational category contained most of the original simulations. In that regard, simulation research may function as a useful methodology to translate basic research findings into real-world applications even though the scope of this translation is narrow (see *The Behavior Analyst* vol. 34 #1). With respect to the impact on other simulations, perhaps the most noteworthy finding is the sheer variety of journals that cite the original simulations. If the four original journals are removed from the analysis, 15 novel journals remain that constitute the majority of the citation impact. However, like the impact on service-delivery the impact on other simulations is rather narrow in scope, with gambling studies constituting the majority of citations, though the impact is shared a bit more with another category, the financial category, than is the case in the service-delivery analysis.

It is encouraging to note that both citation analyses revealed a spike in activity in 2003 and continue at an increasing rate through 2010. In addition, the overall publication rate of simulations in the four original journals spiked in 2009

and continues at an increasing rate through 2010. If this pattern continues, the future looks promising both for simulation research and its impact on the field and real-world problems of social concern.

It should be noted, however, that only four behavioral journals were examined in this study. Thus, the degree to which the current findings represent the whole of behavior analysis seems questionable. It may be the case that journals such as *The Analysis of Verbal Behavior, Behavioural Processes,* and the *European Journal of Behavior Analysis* contain additional simulations that were not included in the current analysis. In addition, the current study only examined the years 1987-2010. It may be the case that simulation-based research was prevalent in earlier years as well which could reveal an even larger impact on the field and real-world problems of social concern.

Future Research

As we look to the future of behavior analysis, simulation research could play an important role in the analysis of increasingly complex behavioral phenomena. The analytic and socially-relevant nature of simulation research is well suited to answer some of the previously discussed internal criticisms of behavior analysis related to the void of empirical data on complex human social and verbal behavior, as well as the supposed "technical drift" of applied behavior analysis. The present work, coupled with future analyses of simulation research, could help articulate the characteristics of simulation research and examine ways to maximize the potential benefits of this research strategy for the field and larger society.

In this vein, one factor to consider is the fidelity or "realness" of a simulation. For example, in the human factors literature, Brehmer (2005) notes that fidelity may not always be necessary in simulations, but may be dependent on the type of task being simulated. For example, if the task is largely verbal in nature, such as a simulation used to train fire chiefs to allocate resources in relation to fire characteristics (e.g., information regarding wind speed and direction), a high-fidelity simulation may not be necessary. On the other hand, if the simulation involves fine-motor skills (e.g., simulated surgery) then a greater degree of fidelity may be necessary. After all, in many physical activities, one may have all the rules they need to govern their behavior but still need direct experience with the task in order to train the physical movements of their body. Skinner (1974, pp. 138-149) discussed a similar issue with his distinction between rule-governed and contingency-shaped behavior. Many times, rules, according to Skinner, do not completely describe a given situation and require exposure to direct-acting

contingencies in order to promote idiosyncratic behavior patterns more fine-tuned to the particular situation.

An interesting simulation-based research question, therefore, concerns the determination of when various degrees of fidelity are necessary to have applied value. If one finds that many situations do not require the time and money invested to build an expensive high-fidelity simulation, such findings would be highly attractive to businesses and government agencies (e.g., the Federal Aviation Administration, and the U.S. Navy) who utilize simulations to train personnel. However, training-based simulations are merely one type of simulation (i.e., an applied simulation). As we have seen in the current literature review, simulations can inform applications without being training-based. Whereas training-based simulations largely adhere to Baer, Wolf, and Risely's (1968) applied criteria of non-arbitrary populations and responses, the 45 original simulations catalogued in the current study, as well as the simulations catalogued in the citation analysis, were not applied. These simulations utilized preparations designed to reproduce features of naturalistic settings in a way that served to better inform the researchers about processes operating in those particular settings. The extent to which fidelity is important in the latter types of simulations has yet to be empirically determined. An investigation into such matters can perform a valuable service to simulation-based research by developing criteria by which the potential applied value of a simulation can be predicted beforehand.

Conclusion

In conclusion, the analysis of complex phenomena in behavior analysis is largely driven by demands for applications to behavioral problems. Behavior analysis has an unlimited potential for such analyses as seen in such areas as behavioral economics (Takahashi, Masataka, Malaivijitnond, & Wongsiri, 2008), behavioral systems analysis (Abernathy, 1996; Malott, 2003; Malott & Martinez, 2006), and cultural behavior analysis (Biglan, 1995; Glenn, 2004; Glenn & Malott, 2004; Malott & Glenn, 2006; Houmanfar, Rodrigues, & Ward, 2010; Ward, 2009; Ward, Eastman, & Ninness, 2009).

Some of these areas are largely theoretical. For example, a central component in Skinner's (1981) concept of cultural selection is the notion that innovations (e.g., behavioral techniques or technological products) spread within and across populations based on their ability to solve people's problems. However, not much behavioral research exists on this process, which seems to be pervasive in the networked information age of the 21st century. Simulation research could further promote socially significant experimental research in this area to examine factors that influence the spread of such innovations.

However, other areas in this domain have seen applications. For example, Anthony Biglan has a long history of applied behavioral research related to drug, alcohol, and tobacco use (Biglan, 1995; Biglan & Hinds, 2009). More recently, Biglan (2009b) has proposed methods to change corporate practices and policies aimed at reducing the effects of harmful corporate byproducts such as pollution and associated health risks. Biglan (2009c) is also working to extrapolate concepts from Acceptance and Commitment Therapy to increase sustainable practices and reduce punitive civil punishment. In addition, Abernathy's (1996, 1998, in press) *Total Performance System* (TPS) describes a technology that combines goal setting and pay-for-performance via a performance scorecard system. TPS has been shown to significantly improve performance in a wide variety of organizations including manufacturing, publishing, retail, distribution, and banking (Abernathy, 1998).

The field of behavioral systems analysis more generally has seen interventions of enormous complexity, such as that of Malott and Martinez (2006) who successfully improved the functioning of a Mexican university with simultaneous interventions at the administrative level, in curriculum development, and in local literacy programs to impact enrollment and graduation rates. Simulation research could play a role in clarifying some of the processes operating in these complex settings. For example, simulations involving leadership decision making could inform processes involved in the university administrators that participated in Malott and Martinez' (2006) study as well as investigate leadership processes relevant to Biglan's (2009b) work on sustainable corporate policies.

In conclusion, simulation research may be ideally placed between theory and application to help facilitate the analysis of complex behavioral phenomena. On one hand, simulation research could help expose a largely theoretical area to socially significant laboratory experimentation. On the other hand, simulation research could supplement existing applications by bringing aspects of particular complex settings into the laboratory to better understand the processes at work. In short, simulation research has the potential to take advantage of the entire field of behavior analysis (i.e., basic, applied, and theoretical domains) to help expand a basic human knowledge base in socially significant areas that can contribute to novel applications in previously-unexplored areas of complexity.

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