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COMMENTARY: Process Safety: Look Looking Beyond Personal Safety to Address Occupational Hazards and Risks

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> "A controlling agency, together with the individuals who are controlled by it, comprises a *social system* … and our task is to account for the behavior of all participants."
>
> —B. F. Skinner in *Science and Human Behavior*, 1953, p. 335

Industrial disasters have the potential for grave consequences, not only for the personal well-being of the workers involved, but also for the well-being of the environment and its other inhabitants. Industrial organizations, despite their reliance on advanced engineering feats and highly mechanized or automated operations, are social systems comprised of individuals behaving in service to both organizational and personal interests. I believe the emergence of process safety management as a method for preventing industrial disasters is in part a realization that safety is a behavioral phenomenon. One only needs to peruse the investigation reports from recent high-profile industrial disasters (e.g., Chernobyl, Texas City and Deepwater Horizon) to see that combinations of human error, unsafe actions, poor decision making, and poor safety cultures are invariably cited as major causes (CSB, 2007, 2016; IAEA, 1992). Also evident from these reports is an apparent refocusing of the safety lens from the actions and events most proximal to the incident to include any and all upstream factors in the causal chain of events, such as the actions and decisions of contractors, supervisors, managers, executives, and any other individuals with organizational leadership responsibilities. It is perhaps no coincidence then that the term "accident" as a generic label for occupational safety failures has fallen out of favor among safety experts precisely because such failures are now seen to be wholly preventable (Mathis, 2013).

Therefore, I applaud the editors of the *Journal of Organizational Behavior Management* (*JOBM*) and its contributors for offering this special issue on *process safety* and encouraging researchers and professionals in the field of behavior analysis to answer the petrochemical industry's call for behavioral solutions to their process safety challenges (see Ludwig, 2017-a). The

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collection of articles survey and illustrate the variety of ways in which concepts, principles, and methods of behavior analysis can contribute toward the establishment and implementation of effective process safety programs. In hearing the industry's call for process safety solutions, I actually discern three desires: (a) clarification of concepts, (b) recommendations for practical and effective interventions, and (c) additional research.

A call for clarification

The U.S. Occupational Safety and Health Administration promulgated the standard titled Process Safety Management of Highly Hazardous Chemicals (PSM) in 1990 to prevent the catastrophic release of hazardous chemicals (OSHA, 2000). The standard emphasized the management of hazards and established a comprehensive management program that integrated technologies, procedures, and management practices. PSM established programmatic requirements across 14 different elements, such as hazard analysis, training, prestartup safety reviews, compliance audits, incident investigations, and emergency planning, to name just a few. Characteristic of many governmental regulations, the PSM standard specifies *what* elements or outcomes are needed in a PSM program, but not necessarily *how* to achieve them. Although various guideline documents exist to aid employers and safety professionals in implementing process safety management systems (e.g., AIChE, 2016; OSHA, 1994), these guidelines offer few specific or actionable solutions for addressing process safety challenges, particularly challenges associated with identifying, establishing, and maintaining the necessary behavioral supports necessary to achieve the desired PSM outcomes—enter behavior analysis.

Illustrating some of the basic behavioral processes that account for process safety failures is one way to establish the relevancy of behavior analysis to process safety. Toward this end, Hyten and Ludwig (2017) and Lebbon and Sigurdsson (2017) show how the basic concepts of habituation, positive reinforcement, negative reinforcement and avoidance, rule governance, stimulus control, and other higher-order behavioral processes can account for many behaviors that are either supportive or detrimental to process safety. The design of effective behavioral change interventions requires a thorough understanding of behavioral principles; however, these basic topics are not covered in most safety-related training manuals or curricula for safety professionals. Accordingly, Gravina, Cummins, and Austin (2017) recommended developing and testing a comprehensive safety leadership training curriculum that includes teaching the fundamentals of behavioral science.

Behavioral science can also help to identify the relevant causal variables contributing to safety failures. McSween and Moran (2017) provided a useful reconceptualization of the often-cited Heinrich's (1931) safety triangle, which describes the relationships among major injuries and fatalities, minor

injuries, and near misses. McSween and Moran echo some of the criticisms of the triangle (e.g., Manuele, 2014), such as the lack of empirical evidence and predictive utility, but they also provide a potentially useful expansion and reconceptualization of the triangle to aid safety professionals in pinpointing at-risk behavior and its precursors, which include the leadership and system failures at different levels of an organization.

Another concept that still causes confusion is safety culture (and the related safety climate). In the wake of high profile industrial disasters, many organizations in high risk industries have placed a greater priority on conducting assessments of safety culture and implementing programs intended to create or foster a positive safety culture. Indeed, establishing a positive safety culture is considered a prerequisite for an effective PSM program (Kumar, 2014). Despite an appreciable increase in the number of published articles on safety culture in the last 25 years (Glendon, 2008), and arguably some progress in establishing its utility (Hofman, 2017; Schneider, 2017), safety culture is still not well defined nor well understood by industry leaders and safety professionals.

By illustrating the complex behavioral contingencies that can account for safety-related performances and decisions throughout an organization, Ludwig (2017-b) and Gravina et al. (2017) exemplify how behavior analysis can shed some much needed light on current conceptualizations of safety culture. Indeed, the behavioral analyses of cultures has received thoughtful analysis since B. F. Skinner initially provided a unified scientific theory of selection by consequences in which he illustrated the role of behavioral contingencies (e.g., reinforcement) in developing and maintaining cultural practices (Skinner, 1981). Behavioral interpretations of the origins and maintenance of cultures, and, notably, introduction of concepts such as metacontingencies and interlocking behavioral contingencies (Glenn, 1988; Glenn & Malott, 2004), provide a coherent framework that extends a behavioral analysis beyond the individual to the collective actions of social groups, societies, and cultures. Ludwig (2017-b) and Gravina et al. (2017) extend this framework convincingly to occupational safety, illustrating its descriptive power in identifying the behavior-based complex interpersonal, social, and cultural dynamics pertaining to occupational safety. Unfortunately, these concepts and framework have not yet permeated the mainstream safety culture literature. Linking behavioral accounts of cultural practices with process safety, which inherently goes beyond personal safety, is a good opportunity for academics, researchers, and professionals in the behavioral sciences to make important contributions to how safety culture is conceptualized, assessed, and influenced.

A call for effective solutions

Ongoing debates over the proper definitions of concepts, such as safety culture notwithstanding, safety professionals and industry decision makers mainly seek practical and effective solutions, and the articles in this special issue provide numerous examples. Readers of this journal are already familiar with the foundations and elements of behavior-based safety (BBS; also known as behavioral safety) as one effective approach. From its earliest inception and demonstrations (e.g., Komaki, Barwick, & Scott, 1978), BBS was intended to be an application of basic behavioral principles to positively affect not only worker behavior but also environmental conditions, system failures, and leadership decisions (McSween & Moran, 2017).

Unfortunately, the growth and evolution of BBS has resulted in some unrecognizable forms of BBS—some with unscrupulous practices—that have been meet with skepticism and criticism (e.g., Howe, 2001) in part because these approaches have focused too much on personal safety surrounding individual workers. For example, incentive systems, featuring great prizes and celebrations, were heralded as effective and efficient ways to promote safe behavior and discourage unsafe and at-risk behavior of workers. However, these practices were often implemented without regard to other organizational factors or other effective methods to eliminate or mitigate hazards and risks. Furthermore, by establishing rewards for achieving safety outcomes (i.e., fewer injuries), some ill-conceived incentive schemes function only to reinforce undesirable consequences, such as underreporting of injuries and, consequently, violating whistleblower and recordkeeping rules (OSHA, 2012). Although behavioral safety tends to focus on monitoring and reinforcing safe behavior of workers to achieve improved safety outcomes, long-term success requires comprehensive understanding and accounting of the roles of all other individuals in the organization, including coworkers, supervisors, managers, and executives.

As Ludwig (2017-a) explains, it is true that there are important differences between the contexts of personal safety and process safety; however, this does not mean necessarily that a fundamentally different foundation or approach is needed for PSM. Behavior analysis has already provided the intervention technologies necessary to make important contributions to PSM. For example, effective tools used for behavioral risk identification, such as PIC/NIC analysis (Agnew & Daniels, 2010) and the Performance Diagnostic Checklist (Austin, 2000; see also Martinez-Onstott, Wilder, & Sigurdsson, 2016, for a safety version) can be easily adapted to help safety professionals pinpoint critical process safety behaviors, including those behaviors and decisions of supervisors, managers, and executives. Rodriguez, Bell, Brown, and Carter (2017) and Hyten and Ludwig (2017) also show how behavioral training

methods, such as fluency building, can be used to enhance skills and competence to reduce human error in performance and decision making.

As many of the articles in this special issue document, these behavioral methods are not entirely novel, and they have been known to be effective in many different organizational settings. Furthermore, as illustrated by Rodriguez et al. (2017) behavioral systems analysis and BBS approaches are synergistic with more traditional safety approaches (e.g., human factors) to reduce human error. An important common theme across several articles in this special issue is that these behavioral solutions are potentially useful not only for addressing workers' safety-related performance, but also for addressing the various roles of supervisors and other leaders within an organization.

McSween and Moran (2017) further describe how the components of a well-designed BBS program, which includes the components of pinpointing, observation, analysis, feedback, and reinforcement, already provides the tools and methods to address process failures with the same systematic rigor. Likewise, in their analysis of the behavioral contingencies that govern leadership safety-related decisions and actions, Gravina and Austin (2017) illustrated other examples of how a behavioral science approach to safety, including the tools and methods of BBS, can be expanded to address leader performance. Another good example is Zohar's (2002) study, which demonstrated the applicability and effectiveness of BBS practices to increase the frequency of supervisors' safety-related communications in what has been called "leader-based safety" (Kines et al., 2010).

Another promising intervention approach that is novel (at least among mainstream safety training practices) is teaching the principles of behavioral science to organizational leaders. Gravina et al. (2017) describe the benefits of a well-educated and coached leader through a "consultant workshop model," which gives leaders the knowledge and skills needed to create the behavioral supports necessary to sustain an effective PSM program. This approach goes beyond more traditional and common safety training approaches by focusing on analyzing and managing the behavioral aspects of leadership performance, which is considered throughout this special issue as being the main driver of process safety.

A call for research

Despite the strong scientific foundations of behavior analysis and proven successes in improving the human condition in many different arenas, greater efforts are needed to conduct more research and disseminate the findings to the wider occupational safety community. Lebbon and Sigurdsson (2017) identify several other important research opportunities for those working in the field of behavior analysis to address some process safety challenges. In my opinion, one of the most promising areas for impact is

behavioral economics. Lebbon and Sigurdsson make a strong case for the relevance of delay and probability discounting and other behavioral economic theories of decision making in understanding factors that influence safety behavior in occupational settings, and they specify several avenues for continued research. Reward discounting by the consequence dimensions of delay and probability has been studied extensively in behavior analysis, but unfortunately these contributions, despite their relevance to occupational safety (see Reynolds & Schiffbauer, 2004), have not yet made their way into the mainstream safety literature.

Finally, Wirth and Sigurdsson (2008) provided a comprehensive research agenda surrounding many topics germane to the elements and practices of behavioral safety. For example, sample research questions were proposed in various categories including risk analysis and pinpointing, goal setting, training and prompting, observation and measurement, feedback, and rewards and incentives. Additional research topics were provided for methodological issues, safety culture and climate, and the integration of behavioral safety with other safety initiatives (e.g., PSM). Because appreciable overlap exists between behavioral safety and process safety, as demonstrated throughout this special issue, the research topics detailed by Wirth and Sigurdsson remain timely and relevant to PSM.

Final thoughts

The collection of articles in this special issue on process safety illustrates the many ways in which the field of behavior analysis offers a set of scientifically tested principles and technologies that can provide a solid framework for guiding research, practice, and policymaking in occupational safety and health. I have attempted to highlight a few specific topics raised by the contributors that I believe can be addressed uniquely and expertly by behavior analysis; however, success will depend on empirically validating the concepts, principles, and methods. Behavioral safety experts and consultants will play a vital role in this success. As evidence of their demonstrated successes over time, these professionals have established many positive and lasting relationships with workers, other safety professionals, and business leaders across many different industry sectors. The trust and cooperation gained can be leveraged into expanded partnerships with behavioral researchers in academia and government to conduct well-designed and well-executed applied research studies. Furthermore, these partnerships will allow access to the extensive data collected by companies on safety outcomes and other metrics associated with personnel, organizational, and environmental factors. These largely untapped data sources may prove to be a gold mine of important empirical evidence of tried and tested intervention approaches

and, as Wagner (2014) pondered, suitable for predictive analytics and related approaches help predict when injuries or disasters are eminent.

One note of caution: Although the articles in this special issue present a wealth of information on the applicability of behavior analysis principles and methods to process safety, much of it may be inaccessible to the wider audience of professional and academic safety experts, not to mention workers and their employers. The jargon of behavioral science is highly technical, and many of the complex behavioral concepts and processes might not be readily understood by individuals without further education or training in behavior analysis. It behooves our field to consider ways to repackage this material and disseminate it to a broader audience of industrial hygienists, safety engineers, business leaders, and other occupational safety and public health experts to better promote the use of behavioral science and technologies in process safety programs.

On the other hand, this special issue will serve as a nice introduction to the topic of process safety for individuals with a strong background in behavioral sciences. The collection of articles demonstrates that the field of behavior analysis, well-established with scientifically validated behavioral principles and intervention technologies, can help bridge the gap between theory and practice on matters related to process safety. The successes of behavior analysis in improving the human condition in many different arenas suggest similar promises for improving the safety and well-being of workers.

Author note

The findings and conclusions in this report are those of the author and do not necessarily represent the views of the National Institute for Occupational Safety and Health.

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