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Including physiological data in a science of behavior: A critical analysis

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Abstract

The position of behavior analysts on the inclusion of physiological data in behavior analysis varies. David Schaal, a contemporary behavior analyst, addressed advantages of such inclusion to behavior analysis with four arguments: (a) identification of retention mechanisms of operant conditioning; (b) physiology provides explanations when descriptions are not sufficient; (c) elucidation of cellular and neural mechanisms of reinforcement; and (d) characterization of degenerative alterations in the brain. The present paper provides further discussion of these points as to whether they truly represent an advantage to behavior analysis. It is argued and exemplified that behavior analysis and neuroscience are not mutually exclusive. Finally, the conditions under which the inclusion of physiological data in behavior analysis represents an advantage to the field are delineated.

Keywords: Behavior analysis, Neuroscience, Physiological data, Reductionism.

The most recent special issue of the Journal of the Experimental Analysis of Behavior (JEAB, Volume 84 November 2005 Number 3) deals with research on the relation between behavior and neuroscience. This relation can be considered an emerging consequence of our current *zeitgeist*. Some characteristics of our present historic period that directly influence the scientific enterprise of psychology are: (a) a strong history of Cartesian dualism which leads to an emphasis on the study of the mind, (b) a scientific tendency to reduce complex processes into simpler constituents, and (c) the fact that economic funds are predominantly allocated in neuroscientific research (Machado, 1999).

The decade of 1990-2000 has been referred to as *the era of the brain* (Borenstein, 2000), and more recently, the incoming millennium has been considered a time for *the mind to meet the brain* (Borenstein, 2001). The previous statement, based on the study of the mind as an internal entity, does not fit the conceptual framework of the science of behavior (hereafter behavior analysis) which holds that behavior is a function of environmental events. Still, neuroscientists represented by the members of the Society for Neuroscience, approximately 37, 500, outnumber behavior analysts represented by the 4, 700 members of the Association for Behavior Analysis (Timberlake, Schaal, & Steinmetz, 2005). The previous figures are evidence of a growing area of neuroscience and a minority, not as popular group of behavior analysts.

On the one hand, the pervasiveness of neuroscience in the field of behavior analysis, particularly nowadays, is unavoidable. On the other hand, behavior analysis has also permeated the field of neuroscience mainly by providing operant conditioning terminology and technology (Thompson, 1994). Moreover, since the origins of behavior analysis and despite the changes in Skinner's ideas

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throughout time (Parrott, 1983) there has been an ongoing interest for physiological variables to reach an ideal completion of the understanding of behavior (Skinner, 1974).

How is the relation between behavior analysis and neuroscience understood? For the purposes of the present paper, the relation is basically driven by the inclusion of physiological data in behavior analysis. Physiology is a science concerned with the functions (mechanical, physical, biochemical) of intact living organisms and it emphasizes on the processes that regulate the important properties of living systems (Berne & Levy, 1998). Given that the boundaries between physiology and other scientific areas such as biochemistry, pharmacology, biophysics, and biomechanics (all derived from physiology) are not clearly distinguished, physiological data, here, are broadly defined as encompassing physiology, neuroscience, biology, genetics, and neurobiology.

The present paper will first provide a general definition of behavior analysis and neuroscience and their conceptual distinction. The latter scientific area is defined because it is considered by contemporary authors in the most recent issue of JEAB. These and other authors who study the relation between behavior analysis and physiological data refer to these data in a broad manner (as defined in the previous paragraph). Second, four arguments about the inclusion of physiological data in behavior analysis, previously addressed by Schaal (2003) will be further discussed as to whether they represent advantages or disadvantages to behavior analysis. Third, examples of compatibility between behavior analysis and neuroscience will be used to support the idea that these scientific fields are not mutually exclusive.

Behavior Analysis and Neuroscience: Definition and Conceptual Distinction

Behavior analysis is the science of behavior. It has a well-defined philosophical background, behaviorism, and many efforts have been invested in organizing this conceptual framework (e.g., Zuriff, 1985; Lattal & Chase, 2003). Some of the basic assumptions of behavior analysis are: (a) Behavior is the object of study in its own right, (b) behavior is determined and thus, it can be predicted and controlled, (c) behavior is a function of identifiable variables, which are environmental events, and (d) the goal of behavior analysis is to identify all those variables and functional relations between them (Michael, 1984; Skinner, 1966).

Neuroscience has been broadly defined as the science of the brain. The philosophical background that gave origin to neuroscience was Aristotelian thought later converted into Cartesian dualism (Bennett & Hacker, 2003). Neuroscience is still nowadays impregnated with Cartesian dualism, even though a more recent evaluation by Bennett and Hacker conveys that the identification of neuroscience with a defined conceptual framework is unclear.

There are two branches of neuroscience worth mentioning in the present paper: cognitive and behavioral neuroscience. The former evolved as a consequence of the strong influence of cognitive theory in neuroscience (Schaal, 2003). The latter emphasizes the study of brain functioning to understand behavior, and according to Schaal (2005), this area, regardless of its label, is predominantly influenced by cognitive theory.

The arguments presented by Schaal (2003) on the inclusion of physiological data in behavior analysis are referred to him as *positive effects of neuroscience on behavior analysis* (p.95). These arguments represent points of compatibility between behavior analysis and neuroscience that deserve a closer inspection to examine whether or not they truly represent advantages to behavior analysis.

A Closer Look at Schaal's (2003) Positive Effects of Neuroscience in Behavior Analysis

Identification of retention mechanisms of operant conditioning

Schaal (2003) emphasized the distinction between researchers in behavior analysis who are interested in filling the gap between past and current behavior by including physiological data, and those who consider that filling that gap is unnecessary and thus, do not include physiological data in their analysis of behavior. Some of these researchers interested in physiological data to *fill the gap* are Donahoe (2003) and Hull, Langman and Glenn (2001). These authors base the goal of discovering an analogous unit of retention of operant conditioning on the idea of the gene as a retention unit of natural selection. A retention mechanism, as defined by Donahoe, is one of three steps (among variation and selection) of a selection process and it "permits favored variations to endure long enough to add to the variation upon which future selection acts" (p.104).

Donahoe (2003), Hull et al. (2001), and Schaal (2003) consider that the site of such retention mechanisms is the brain of the behaving organism. If this is true, then more research in behavior analysis should be devoted to the changes in neural activity (Hull et al., 2001) and this is accomplished by including physiological data in behavior analysis. According to Schaal, the identification of these retention mechanisms "…may establish the reality of the operant for some theorists in a way that behavior analysis has not accomplished" (p. 95).

What Schaal means by "establishing the reality of the operant" may well be counterargued by those behavior analysts who find no advantage in filling the temporal gap between past and current behavior with physiological data (or not filling the gap at all). For these scientists, the reality of the operant is already established by the evidence accumulated until now in one domain of analysis, that of the realm of behavior. Thus, for these scientists, there is no need to include physiological data in the analysis of behavior (Reese, 1996).

Even though these scientists have convincingly argued their position on omitting, not ignoring, physiology in the study of behavior (e.g., Reese, 1996) they present several areas of research in behavior analysis in which physiology is a key component to the advancement of such areas, one example being behavioral pharmacology. Given this exception and the fact that Hull et al. (2001) pointed that operant selection (as a parallel of natural selection) occurs in two levels: behavioral and neural, pursuing the identification of retention mechanisms should be of long-term advantage for behavior analysis (Schaal, 2003).

Only if the analogy of the gene holds for the case of behavior analysis, then it makes sense to include physiological data to identify such unit of retention in behavior analysis. It might be the case that as genetics, with such identified unit of selection (the gene) is a strong and visible (to the scientific community in general) science, then the identification of a unit of selection in operant conditioning will have similar repercussion over behavior analysis. To prove this then, the search for that unit should be continued.

Baum (2001) in reply to Hull et al. (2001) argued that there is no need for genetics to be taken as a prototype for an analogy. Baum points that the advantage of doing so relies on the acceptance of genetics by the scientific community and by the knowledge accumulated until now in that field; however, one disadvantage is that genetics might then end up being considered necessary to understand behavior. Baum suggested taking operant evolution and not genetic evolution as a prototype. That is, to remain in the behavioral domain.

The heterogeneity of perspectives within researchers in behavior analysis is evident at this point of the discussion. Those researchers interested in filling the gap will most likely include physiological data in behavior analysis, some (e.g., Hull et al., 2001) with the goal of identifying what has been

labeled a retention unit, analogous to what the gene represents in genetics. Others (e.g., Baum, 2001) will argue that there is no need to include physiological data and that such unit can be identified within the domain of behavior. Either position, if behavior is not replaced by physiological data, represents an advantage to behavior analysis.

Physiology is helpful in providing explanations when descriptions are not sufficient

According to Schaal (2003), the inclusion of physiological data aids in answering critical questions of *why* when the mere descriptions of behavior are not sufficient. For example, behavior analysis provides convincing evidence and description of the effectiveness of immediate reinforcement, but according to Schaal, a critical part of the answer on this effectiveness lies in the physiology of the behaving organism.

This argument raises the issue of what is an explanation in behavior analysis. According to Reese (1996) an explanation in behavior analysis is a description of a functional analysis of a phenomenon. The view of behavior analysis as a descriptive science was inspired by Ernest Mach who in turn inspired B. F. Skinner's position on this issue (Marr, 2003). If this perspective is strictly assumed, then the question of *why*, as considered in the paragraph above, has no place. A description of behavior as defined by Reese, then, should be sufficient in behavior analysis; thus, the inclusion of physiological data should not be necessary.

Following Skinner's (1938) perspective on a descriptive science, a stipulation for a description of behavior is that the concepts involved in such description should remain within the domain of behavior. Such stipulation eliminates the possibility of including physiological data because it includes concepts from a domain different from that of behavior. Reese (1996), however, raises the point that such stipulation can be violated if the inclusion of concepts from a domain different from that of behavior improves prediction and control of behavior.

The inclusion of physiological data in behavior analysis improves prediction and control (Schaal, 2003). This is based on the fact that much behavioral regularity corresponds to physiological regularity (Schaal, 2003). Although such inclusion implies reductionism (Reese, 1996) in the sense that behavior is reduced to its physiological constituents, it does not imply the elimination of the study of behavior as a function of environmental contingencies. This means that physiological data can supplement the description of behavior, but do not replace the study of behavior.

If the ultimate causes of behavior are reduced to physiology, so that the environmental variables would cease to matter in finding the causes of behavior, it could be argued that behavior analysis could eventually disappear. Such reductionism has been considered impossible by Uttal (1998, as cited in Machado, 1999) because of the difficulties in predicting behavioral processes if conceived under the standpoint of chaos theory. This perspective assumes that the behavior of neural networks is random-like and hence unpredictable. Another reason why reductionism may be considered no threat to behavior analysis is that behavioral concepts such as the operant response "has an identity, a functional character that is not shared with any particular neurophysiological concept" (p. 84, Schaal, 2003). Schaal concludes that behavioral concepts cannot be derived from neuroscience, even though the operant can be considered a composition of neurophysiological variables. This shows that one of the basic assumptions of behavior analysis, that of behavior being the object of study in its own right, remains intact.

In sum, it is obvious that the behaving organism's physiology is part of the provenance of behavior. This though should not lead to think that behavior can ultimately be replaced by physiology. A line emphasizing the above boundaries must be drawn by behavior analysts.

Elucidation of the cellular and neural mechanisms of reinforcement

Schaal (2003) stated that the identification of such mechanisms might aid in solving some "persistent puzzles of behavior" (p. 96). Research on the identification of brain substrates modified by reinforcement can be considered of conceptual advantage to behavior analysis (Donahoe, 2003; Stein, Xue, & Belluzzi, 1993; 1994; Stein, 1997) because it has bearing on the distinction between classical and operant conditioning. Donahoe, Palmer and Burgos (1997) support a theory that integrates classical and operant conditioning, a unified reinforcement theory. These authors support that there might be two different procedures (classical and operant) that do not correspond to two different learning processes, but just to one process. A unified reinforcement theory is based on the idea that reinforcers select environment-behavior relations, regardless of the experimental arrangement. Such theory is congruent with some current findings on the underlying mechanisms of reinforcement (Schaal, 2003).

The neural networks created by Donahoe, Palmer and Burgos (1997) are based on the assumption that physiological mechanisms are equable with behavioral laws. A neural network consists of an input and an output unit. An input unit is activated by environmental events and an output unit arises from the effects of a reinforcer; reinforcers affect relations between input and output units. In a neural network there can be numerous connections between input and output units, in this sense, it is a model of the underlying processes of behavior. An organism is constantly immersed in an environment where there are always stimuli preceding behavior that is followed by a consequence. As with the behavior of organisms, a reinforcement history can also be traced in neural networks, that is, a history of connections of the network.

As Donahoe, Palmer, and Burgos (1997), Stein et al. (1993; 1994), and Stein (1997) have also examined underlying processes of behavior. Stein et al. (1993; 1994) investigated the neurophysiological underpinnings of reinforcement by examining how localized microinjections of dopamine and other substances administered in hippocampal slices resulted in bursting of individual cells and strengthening of synapses. Compared to Donahoe, Palmer, and Burgos (1997) Stein (1997) supports the distinction between classical and operant conditioning specifically by distinguishing two separate processes with distinct neurophysiological properties: (a) in vitro reinforcement as an analogue of operant conditioning and (b) long-term potentiation as an analogue of classical conditioning.

Research on underlying mechanisms of reinforcement could also raise discussion on conceptual issues on the distinction the molar versus molecular debate extensively examined in behavior analysis (Schaal, 2003). For example, Stein et al. (1993) asked the question of whether what is modified by reinforcement is a complex neuronal system or the activity of single neurons. In trying to elucidate which of the previous two physiological sites (or both) are modified by reinforcement, parallels can be drawn as to whether molar or molecular units of analysis account for changes in behavior.

In sum, it can be said that inclusion of physiological data in behavior analysis, specifically to elucidate cellular and neural mechanisms of reinforcement, is of conceptual advantage to behavior analysis. It adds heuristic value to the discussion of the conceptual topics mentioned in the two previous paragraphs.

There is a potential problem though, at a conceptual and practical level with the elucidation of cellular and neural mechanisms of reinforcement, and that is the risk of reification. Conceptually, this means that by focusing on elucidating cellular and neural mechanisms of reinforcement, the aim of the research can end up in trying to finding a physical substrate as the cause of behavior, as an essence, or something tangible inside the

organism. This is a threat to behavior analysis which holds that the causes of behavior are within the environment. It is also a threat because it the search for brain structures or specific neurons (Uttal, 2004) represents a structural rather than a functional approach to the study of behavior. This could have practical repercussions, for example, in the treatment of psychiatric/psychological disorders. More specifically, the modification of environmental contingencies responsible for maintaining certain patterns of behavior that are part of the disorder may be neglected because the focus of treatment is maintained on pharmacological therapies to modify internal neurochemical imbalances causing the disorder. The treatment then most likely will be incomplete and thus unsuccessful.

In conclusion, the risk of reification depends on the emphasis placed in physiological data relative to the study of behavior. The search for cellular and neural underpinnings of reinforcement represents and advantage to behavior analysis as long as the focus of research is maintained in the study of behavior. When the focus is switched to the search for a cause of behavior inside the organism, what was viewed as an advantage turns into a disadvantage to behavior analysis.

Characterization of degenerative alterations in the brain

Schaal (2003) pointed how behavioral neuroscience has contributed in the characterization of such degenerative alterations related to disorders such as mental retardation, autism, Alzheimer's Disease, Parkinson's Disease, among others. This aids to a better development of treatments of a diversity of these disorders consisting of pharmacological/surgical (based on the knowledge from physiological data) and the manipulation of environmental contingencies (based on behavior analytic knowledge).

From the above paragraph it is evident that a consequence of including physiological data in behavior analysis will be in accordance with a pragmatic goal of behavior analysis: that of improving the individual's condition. This is also a common goal of neuroscience and medicine. This seems to be not only an advantage to behavior analysis, but also to these other two fields of science. In the case of pragmatics, the advantage to behavior analysis depends on how much of these improvements are recognized in the scientific community and in society in general as accomplishments of behavior analysis.

The issue of visibility of behavior analysis in the scientific community and in society in general was addressed early in the introduction of the present paper. More specifically, relative to other fields of science, namely neuroscience, behavior analysis may be considered unpopular. It could be argued that by including physiological data in behavior analysis (and thus, the characterization of degenerative alterations of the brain being possible) there will be more chance for behavior analysis to survive, revitalize and diversify into areas of specialty (Green, 2006). Probably one of the most prominent examples (also mentioned earlier) of an area of specialty derived from behavior analysis is behavioral pharmacology. This area has been fortified by the inclusion of physiological data, still adhering to a behavior analytic conceptual framework (Barrett & Sanger, 1991).

This advantage of visibility can also be viewed as a disadvantage. In trying to capture such an extensive and heterogeneous audience, neuroscience has been said to fall into the production of an overflow of books and an uncritical use of language "(…) fostering a form of mystification and cultivating a neuromythology that are altogether deplorable" (p. 409, Bennett & Hacker, 2003). Thus, visibility of behavior analysis by relating to areas such as neuroscience may be taken with caution to try to avoid the pitfalls that neuroscience has been facing in aim of becoming a popular field. After all, popularity may be dangerous for the integrity of a science.

Conclusions

Behavior analysis and neuroscience are not mutually exclusive. Despite the strong influence of cognitive theory, conceptually incompatible with behavior analysis, over neuroscience, behavior analysis and neuroscience are compatible. Three examples of such compatibility are presented by Schaal (2003), Winger, Woods, Galuska, and Wade-Galuska (2005), and Mechner (2008).

Schaal (2003) recommends to maintain "(…) a healthy mistrust of explanations that go beyond functional relations that constitute the principles of behavior (p. 89)". Schaal supports that such skepticism is not rejection of neuroscience, but an asset in conducting research as a behavior analyst in the field of neuroscience. Schaal (2003) also suggests that physiological data can be included in behavior analysis by assuming interactive causation, that is, to view causes going from the brain to behavior and from behavior to the brain. Schaal supports that one goal of behavior analysts is to characterize "(…) processes that participate in and allow the establishment of environment-behavior relations" (p. 88, Schaal, 2003).

Winger et al. (2005) define drug addiction as a behavioral disorder (i.e., excessive behavior with increased probability of occurrence as a function of drugs viewed as more potent reinforcers than others not as readily available). These authors state that such behavioral approach to drug addiction is more advantageous than a purely neuroscientific one because it allows the possibility treatment of drug addiction through the manipulation of environmental contingencies. A treatment of drug abuse is commonly accompanied by a pharmacological component, so the neuroscience of drug addiction should also be incorporated, but in a more behavior analytic context. Such inclusion of neuroscience in a behavior analytic context may allow for the identification of neurological correlates of behavioral processes, and thus for a more complete and successful treatment of drug addiction.

Mechner (2008) reviewed a book entitled *In Search of Memory, the Emergence of a New Science of Mind* by Eric R. Kandel (2006), a contemporary leader in neuroscience. Mechner views the work of Kandel as an invitation for behavior analysts to collaborate with neuroscientists for the advancement of both sciences. Mechner emphasizes the commonalities between both sciences and expresses how the strict usage of language is not crucial for the advancement of science; the empirical evidence gathered is what determines the advancement of science. By focusing on commonalities instead of the differences, Mechner attempts to break barriers of communication and promote collaboration between neuroscience and behavior analysis.

From the examples reviewed above, it can be said that conceptually and practically, the inclusion of physiological data is not a threat to behavior analysis. More specifically, it can be concluded that the inclusion of physiological data in behavior analysis represents an advantage if: (a) Prediction and control of behavior are increased: (b) Improvement of treatments of disorders is achieved; (c) Productive conceptual advancements are derived; (d) The focus is maintained on behavior. All these conditions do not necessarily have to all be met at once for the inclusion of physiological data to be an advantage to behavior analysis.

When bringing behavior analysis and neuroscience together, the distinction between relation and integration should be considered. The idea of the integration of scientific knowledge remains a sequel of the main goal of the members of the Circle of Vienna (Bennett & Hacker, 2003) still reflected in more contemporary efforts of pursuing such goal (e.g., Wilson, 1998). On the one hand, such idea can be viewed as a conceptual advantage if the unity of knowledge is valuable for the advancement of science. On the other hand, it is not a purpose of this paper to support the idea that knowledge should be reduced to behavior, nor that behavior analysts

should become specialists in other scientific areas such as physiology. It is a purpose of this paper though, to support that behavior experts should continue devoting their efforts and focus to the study of behavior yet open to the study of other areas that will improve their own. The inclusion of other areas can be fruitfully accomplished by means of studying them and through scientific collaboration. Behavior analysts should draw lines between other sciences to maintain its conceptual integrity, and its practical accomplishments should be properly recognized by the scientific community. These ideas and practices will continue strengthening behavior analysis as the science of behavior.

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