

Original Paper

Invited Commentary on Animal Models in Psychiatry: Animal Models of Non-conventional Human Behavior

Linda J. Hayes¹  and Diana Delgado¹

(1) Psychology, University of Nevada, Reno, NV, USA

Linda J. Hayes

Email: lhayes@scs.unr.edu

Received: 31 August 2006 **Accepted:** 20 October 2006 **Published online:** 16 December 2006

Abstract Conventional behavior, of which linguistic behavior is the principal variety, is identified as responses having formal properties that are not determined by the natural properties of stimulus objects, but instead by properties attributed to those objects under the auspices of particular groups. Given the ubiquity of this type of behavior in the repertoires of human beings and its complete absence in those of non-humans, the argument is made that animal models of human disorders, in which disturbances of conventional behaviors constitute defining features, are not sufficiently analogous to these conditions in humans to be pursued with good result. Because conventional behavior of the linguistic type is ubiquitous in the repertoires of normally developed human adults, it is suggested that the behavior of pre-verbal infants and/or non-verbal persons is preferable to that of adults as the phenomenal source for the construction of animal models of human psychological events. The observation and measurement of psychological events is held to be complicated by a number of their characteristics, including their complexity by virtue of whole organism participation, their essential complementarity with stimulus events, and the corrigibility of both form and function over their repeated occurrences, among others. The implications of these features for modeling enterprises are discussed.

Keywords Verbal behavior - Linguistic behavior - Animal models - Human disorders - Psychological events - Murine models - Conventional behavior

Edited by Gene Fisch

Extrapolative research practices operate on the basis of significant commonalities between the events investigated and those for which an understanding is sought. This circumstance is reflected in the minimum requirements for serviceable animal models of human diseases, initially proposed by McKinney and Bunney (1969) for the study of depressive disorders and widely adopted since for the study of human psychopathologies in general. Of particular relevance to the present argument is the first of these requirements, namely that the model be “reasonably analogous” to the human disorder in its manifestations or symptomatology”

(Holmes and Cryan 2006). This criterion specifies that at least some of the *defining* features of the phenomenon of interest must be represented in the model of that phenomenon in order for extrapolative research practices with respect to it to be pursued with good result. Implied by this specification is that the phenomenon of interest must not embody highly significant factors that are absent the model, else the analogy is not reasonable (see Hayes and Delgado 2006, for further discussion).

It is our view that animal models of human psychiatric disorders are not sufficiently representative of significant factors of the human psychological sort to satisfy this requirement, whereby the utility of this enterprise is in doubt. To substantiate this claim, our plan is to evaluate the degree to which processes responsible for the expansion and elaboration of the human behavioral repertoire are participating factors in the behavior lives of non-humans. We turn now to the identification and impact of these processes.

Expansion and elaboration of behavioral repertoires

The processes involved in the expansion and elaboration of behavioral repertoires have to do with two conditions of stimulation, namely the properties serving as the sources of stimulation with which responding is coordinated, and the origins of those functions. With regard to the first of these, stimulus functions may have their sources in the natural properties of stimuli or in properties attributed to them under the auspices of particular groups. As for their origins, stimulus functions may operate from original object sources or from objects serving as substitutes for them. Human responding may be coordinated with stimulation in all configurations of these elements, while this is not the case for non-humans, with the result that human repertoires are possible of greater expansion and elaboration than those of non-humans. These configurations, and the elaboration of behavioral repertoires afforded by them, are described below.

Both human and non-human organisms act with respect to stimulation arising from immediately present enviroing things, wherein the formal characteristics of their responses are determined by the natural properties of those things. Both also engage in responding having formal properties determined by the natural properties of enviroing things when those things are not immediately present. While responding of this sort occurs in the absence of the object properties of particular things, it does not occur in the absence of their functional properties. When stimulus objects bear some sort of relationship to one another, the functional properties or stimulating actions of one object may come to inhere in another. As such, the physical presence of an object is not required for its stimulating action to prevail in a given circumstance provided that a substitute object of this sort is a participating factor in that circumstance (Kantor 1959).

Two sorts of relationships between stimuli are relevant to their acquisition of substitute stimulus functions, namely proximity and similarity. The outcome of classical conditioning illustrates the acquisition of substitute stimulus functions by contact with proximally related stimuli; while the substitutions observed in the phenomenon of stimulus generalization are afforded by relations of similarity.

The capacity of organisms to respond with respect to substitute stimulus functions is by no means a trivial matter. The psychological potential of an organism, in other words, the magnitude and complexity of the repertoire it is capable of acquiring, depends on its ability to learn from past experience; and it is only when its historical interactions with its environment are

afforded a place in the effective present that such learning possible (Hayes 1992). Substitute stimulation is the means by which this takes place. In the absence of a capacity to respond to substitute stimulation, an organism's responses are conditioned solely by the stable, natural properties of immediately present stimuli and, as such, do not evolve into more complex forms over repeated occurrences. Responses of this sort are not psychological, but rather biological, in type.

The potential for the development of an elaborate repertoire is also limited by the opportunity to respond to substitute stimulation. Inasmuch as substitute stimulation depends on relationships among stimulus objects, the more complex an organism's environment in terms of the number and variety of stimulus objects with which it is able to interact, the more prevalent are events of the substitutional sort likely to be in its behavior life. The more elaborate repertoires of humans as compared to non-humans are partially accounted for by this circumstance. To a very large extent, the human environment is a constructed environment, populated with an enormous quantity of an endless variety of things, deposited as the material products of human action. All of these things are potential sources of stimulation for individual organisms and, more importantly, their proximal relations with and partial similarities to one another are conditions favorable for the development and operation of substitutional functions among them (Parrott 1984). No other species modifies its natural environment in this manner and in none, thereby, is the opportunity greater for the operation of substitute stimulation.

Environing things, of both a natural as well as of a manufactured sort, do not exhaust the potential sources of stimulation in the human environment, though. In the environing conditions of any member of the human species are other members of its species, which is to say, humans live in groups. Hence, a major source of stimulation for the behavior of any individual member of a human group is the behavior of its other members, and responding with respect to stimulation arising from animate sources tends to be more varied than that arising from inanimate sources (Parrott 1984).

Animate objects are not merely sources of stimulation for responding on the parts of others though, they are also responding entities. As such, their stimulus functions arise not only from their object properties but also from their actions, and because these are constantly changing, so too are the responses of other persons coordinated with them. Hence functional relations involving animate objects evolve more rapidly than those involving inanimate objects, and this situation is further exacerbated when the interaction between two such objects is one of mutual stimulation and responding (Parrott 1986).

While this circumstance is not unique to the human species, a unique property of human behavior is manifested in these sorts of interactions. Specifically, humans engage in responses having formal properties that are *not* determined by the natural properties of stimulus objects, either when those objects are present in the immediate situation or when they are absent. Rather, their forms are arbitrary. For example, the formal characteristics of the vocal response "cup" have nothing whatsoever to do with the size, shape, weight, or any other natural property of the physical object cup.

Responses having formal properties that are not determined by the natural properties of either present or absent stimulus objects are still coordinated with stimuli. Any given object has multiple stimulus properties and only some of their properties inhere in their bare qualities and conditions as physical objects. Others have been attributed to them under the auspices of particular groups and are thereby characteristic of only those particular group circumstances (Kantor 1982). It is properties of this sort with which responses of arbitrary form are

coordinated. For example, in an encounter with the object cup, a response of the form “cup” will be characteristic of one group circumstance, namely one in which English is spoken; while a response of the form “la tasse” will be conventional within one in which French is spoken. 1

The effectiveness of responses coordinated with the attributed properties of stimuli is thereby critically dependent on the context in which particular stimulus objects are encountered. Moreover, the only standard by which their effectiveness can be measured is their formal correspondence with the responses of other members of the attributing group (Kantor 1982). As such, responses of this sort do not become refined over the course of repeated interactions with particular stimulus objects. 2 On the contrary, as conventional forms of responding, their acquisition requires explicit instruction from the group and, once acquired, their formal properties are fixed.

As previously discussed, the complexity of a behavioral repertoire increases with opportunities to respond with respect to substitute stimulation inhering in animate sources. These opportunities are greatly enhanced by the addition of stimulation inhering in the enormous quantity of arbitrary response forms characteristic of the human circumstance. Moreover, responses having formal properties that are not determined by the natural properties of stimulus objects, even in their physical presence, are particularly well suited for occurrence in the absence of those objects (Parrott 1984; Hayes 1991). In other words, engaging in the response of picking up a cup depends on the physical presence of a cup in a manner that engaging in the response of saying “cup” does not. 3 By virtue of their suitability in this regard, the environment of a human being includes not only that which is physically present as well as that which had been present in this person’s experience at a previous time, but also that which has never been present in this person’s experience because it happened prior to the onset of this person’s experience, or because it has yet to happen in anyone’s experience, or because it has always been present in a distant location, or because it has never been present in any location by virtue of its non-existence. 4 This is not the environment in which non-human organisms live and their psychological experiences have none of the properties that living in such an environment affords.

Further, conventional activities of arbitrary form, coordinated with attributed properties of stimuli are ubiquitous. They are insinuated in virtually every kind and variety of human interaction. Moreover, even when human responding is coordinated with stimulation arising from the bare qualities and conditions of particular objects, it is typically accompanied by conventional responses with respect to those objects.

Evidence of differential capacities

The above arguments, as to the absence of responding to attributed properties of stimuli by non-human organisms, are constructed on logical as well as observational grounds. Embedded within them are particular definitions and premises as to the nature and operations of conventional responding, particularly of the linguistic type. Other interpretations of these phenomena are thereby possible to construct and may prove more useful in accounting for the obvious differences between human and non-human organisms in this regard.

Nonetheless, evidence of significant differences in the capacities of humans and non-humans to respond to these and related conditions is available from a number of sources. For example, responses of arbitrary form are implicated in complex varieties of another type of behavior that has not yet to be observed in non-humans (Hayes 1989), namely derived relational responding (Hayes 1991, 1994, 1996). While it is beyond the scope of this article to examine the enormous

body of investigative and interpretive work pertaining to responding of this type (see Hayes et al. 2001, for a comprehensive review), a brief synopsis of some its features and their implications with regard to present concerns seems warranted.

Simply put, derived relational responding is conceptualized as the derivation of untrained relations among stimuli on the basis of previously trained relations among them. Investigations of this type of behavior are typically conducted in the context of symbolic match-to-sample preparations. In these procedures, organisms are exposed to a series of trials in which a sample stimulus is presented along with an array of comparison stimuli, among which is a pre-determined match for that sample, whereupon a response to the matching comparison produces reinforcement, while other responses fail to do so. Relationships among stimuli (i.e., sample-comparison matches) are directly trained by these procedures and both humans and non-humans (e.g., pigeons) develop relational responding by way of them.

The emergence of derived relational responding on the basis of trained relationships is observed under subsequent test conditions, wherein the original sample and comparison stimuli are reversed and differential reinforcement for correct matches is discontinued. Under these conditions, the performances of humans and non-humans diverge. Comparisons selections by human subjects on untrained relations are generally correct, while those of non-humans are not. These and related findings of a more complex sort, in which responses of arbitrary form are essential participants (Hayes 1994, 1996), have been interpreted by Hayes and Hayes (1992) as indicative of fundamental differences in the reportorial capacities of humans and non-humans. 5

There is some evidence of non-humans performing responses of arbitrary form, however, the best known and most significant of which are demonstrations of signing in apes (Gardener et al. 1989; Bonvillian and Patterson 1997). Responses of this sort are not acquired in the absence of human intervention, though. On the contrary, long term intensive training of a highly methodical and rigorous sort is required to establish even the most rudimentary of such repertoires in these animals. Hence, although it is the case that at least some non-human organisms are capable of performing responses of arbitrary form, it is also the case that the realization of their capacities to do so depends on contact with human organisms whose capacity in this regard is already realized. The fact that there is no credible evidence of language-trained apes independently transmitting these repertoires to their naïve cage mates lends credence to this argument. In short, while non-human organisms *can* engage in responses of arbitrary form under highly unusual circumstances, their usual circumstances are such that they don't.

Implications for the utility of animal models

In as much as the presence of conventional behavior in the repertoires of human beings is the basis upon which the psychological events of humans are differentiated from those of non-humans, the prevalence of such behavior in the human repertoire and its transformative impact on the human experience is not a trivial problem for the animal modeling research enterprise. Moreover, it is not a problem that can be solved by making improvements to these models: Animals do not engage in conventional behavior. More importantly, no quantity of facts pertaining to the non-conventional behavior of animals will ever be enough to constitute an understanding of the predominantly conventional behavior of human beings. Hence, to whatever extent an understanding of human psychopathology must take these sorts of interactions and their implications into account that is the extent to which an animal model of the same will fall short of its aim.

This does not mean that animal models of human psychological events are without utility altogether. On the contrary, human psychological events of the non-conventional type remain legitimate targets of investigation in such enterprises. Unfortunately, wholly non-conventional responding—which is to say, non-conventional responding without conventional accompaniments—makes up only a very small and ever-shrinking part of the human repertoire. In the case of normally developed human adults, for example, it is limited to unconditioned behaviors of the respondent type. While it is possible that disturbed or otherwise unusual repertoires of this sort are participating factors in particular human psychopathologies, the massive overlay of conventional behavior characteristic of such conditions in human adults makes it virtually impossible to isolate their effects.

Still, because conventional responding does not arise without explicit instruction, it is absent in the repertoires of human infants. It may also be absent in the repertoires of older children and adults with pervasive developmental disabilities. Animal models of the psychological activities of these groups may thereby be productive of very useful information. Very young children with autism constitute such a group and a great deal of modeling research has been focused on this group in recent years (e.g., Insel et al. 1999; Green et al. 2001; Lim et al. 2005).

Psychological events are unlike biological events in a number of important ways though, and the methods employed for the investigation of biological phenomena are not well suited to the accomplishment of similar outcomes in the psychological domain. Accordingly, the promise of achieving useful information about human psychological events by research of this type depends on the manner in which psychological events are investigated, which, in turn, depends on how such events are conceived. We turn now to these issues.

Distinguishing characteristics of psychological events

Psychological events have a number of features which complicate their observation and measurement. Among them is the fact that such events do not come in discrete units, but occur instead as continuous streams of activity. Hence, where one event ends and another begins must be determined on the basis of arbitrary criteria. This circumstance poses significant difficulties for the replication of findings in the absence of highly detailed operational definitions.

Added to this, given that the organismic participant in a psychological event is conceptualized as the action of the whole organism as opposed to its parts considered separately, such events are always of exceeding complexity. This is to say, a given response is conceptualized as a concatenation of multiple reaction systems of the sensory, muscular, and glandular sorts, among others (Kantor 1959). Its complete description thereby entails consideration of all of its organismic components, implying the need for their measurement in real time.

Other differences between psychological and biological phenomena are more important for present purposes, though. In the first place, a psychological phenomenon is not a thing. This is to say, it does not possess substantive properties, such as size, or shape, or weight, that instruments ordinarily employed for the measurement of things may be applied. On the contrary, a psychological phenomenon is an event. More specifically, it is a *function* obtaining between responding and stimulating (Kantor 1959; Skinner 1953). As such, it is not possible to identify or classify behavior in the absence of information about the stimulation with respect to which it is occurring. In other words, behaviors of the same form are not necessarily of the same sort. It follows that little of value is likely to be gleaned from investigations of animal models

engineered to mimic merely the forms of behaviors symptomatic of conditions such as autism. The promise of significant discovery in this arena depends on the mimicking of functional relationships not response forms. This is an aim that cannot be achieved by examining the biological correlates of particular behavioral topographies, but by rather by systematically manipulating its enviroing conditions. In our view, thereby, the adequacy of an animal model of a human psychopathology depends on the extent to which the behavior of the model is “reasonably analogous” to that of the phenomenon of interest—both topographically and functionally.

More than an adequate model is needed to fulfill this promise, though. Also needed are observational technologies, and particularly measurement systems, that are capable of capturing such relationships. Moreover, as previously discussed, behavior is corrigible, becoming more and more elaborate over the course of its development such that events initially selected for observation are likely to evolve over the course of their measurement. Accordingly, investigative techniques must also be capable of detecting gradual changes in both the formal properties of responses as well as in their functional relationships with stimuli, so as to avoid their inevitable changes being misconstrued as different types of events.

In summary, these characteristics of psychological events place extraordinary demands on systems of observation and measurement. In order to achieve an understanding of psychological events comparable to that achieved of biological occurrences in the context of modeling research, such systems must be capable of simultaneously detecting the participation of multiple responses systems in continuously evolving forms of responding related to changing stimulation in real time, as well as be capable of manipulating these events and their patterns of occurrence. This is a tall order.

Implications for model development

Although many psychopathological conditions are identified by the presence of anomalous behaviors, such as the positive symptoms in psychoses, many of these characteristics involve conventional responding which cannot be represented in animal models of these conditions. As a result, the psychological characteristics incorporated in animal models of these conditions are often responses that humans suffering from these conditions fail to emit. For example, models of schizophrenia typically have typically studies the failure to show inhibition of the startle response when a tone is preceded by a pulsating sound (Pre-Pulse Inhibition procedure). (Myers et al. 2005), failure to engage in problem solving behavior is often modeled to study depression or anxiety; and in autism research, failure to decrease olfactory investigations of con-specifics after repeated exposures has been interpreted as evidence of failure in social recognition and social memory (Ferguson et al. 2000).

Similarly, autism is characterized primarily by social and linguistic *deficiencies*, with stereotyped behavior constituting a secondary indicator. As a result, animal models of autism have been developed explicitly to mimic what is missing in the repertoires of children with autism, specifically (and by exclusion), effective social behavior (Bielsky et al. 2004; Dantzer et al. 1987; Ferguson et al. 2000; Insel and Winslow 1991; Insel 1992; Myers et al. 2005; Waterhouse et al. 1996; Winslow 2003). Science proceeds on the basis of contacts with events, though. By this logic, models of autism in which repertoire excesses (e.g., the presence of stereotypical behavior) are selected for representation may be more valuable than those in which deficiencies (e.g. the absence of social behavior) are represented.

Selecting stereotypy may be important for other reasons, as well. As discussed above, the expansion and elaboration of behavior repertoires is a function of organisms' capacity to respond to substitute stimulation as well as the opportunities afforded by their environments for these processes to operate. The latter depends on the complexity of their envioning circumstances, roughly measured in the quantity and pace of its variations. Repetitive behavior minimizes these indices of environmental complexity. It seems plausible that the prevalence of such behavior in the repertoires of persons with autism may have the effect of minimizing opportunities for the operation of substitute stimulation, thereby limiting the expansion and elaboration of their repertoires such as to make reference to these deficiencies defining criteria for the presence of this condition.

Our point in raising this issue is not to suggest that autism may be accounted for by this circumstance, and especially not by this circumstance alone. These suggestions are speculative to a fault. Our point is simply to suggest that the prospect of gleaning valuable information about some particular phenomenon may be greater if the focus of investigation is on what the phenomenon is as opposed to what it is not.

Implications for the understanding of psychological events

To reiterate, in so far as psychological events are conceptualized as functional relations between the responding of biological organisms and the stimulating of the physical environment, their investigation in the context of animal models necessitates as much scrutiny of their envioning as their organismic sources. Implied by this conceptualization of psychological events, about which there is general agreement among behavior scientists (e.g., Kantor 1959; Skinner 1953), is that psychological events are no more organismic in nature than they are environmental.

For the most part though, investigators of human psychological events by means of animal models are biologists, and this is decidedly not how most biologists conceptualize psychological events. Psychological events tend to be viewed as manifestations of conditions of a strictly biological sort, localized inside the behaving organism. This interpretation implies that psychological events, in being capable of reduction to events of the biological substratum, are also capable of explanation by reference to the same processes that are responsible for biological happenings.

Psychological events are not reducible to biological things, though. Neither are they localized in behaving organisms. They are functions of responding with respect to stimulating localized in the context in which organisms interact with envioning things, that context being the multifaceted field of interaction in which both organisms and envioning things are participating factors. In short, unless and until psychological events are properly construed by animal modeling researchers, this enterprise holds no promise for their understanding.

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Footnotes

- ¹ As exemplified, linguistic behavior is included in this category, and further constitutes the dominant variety within it. However, the category is somewhat broader than this, including responses of non-linguistic form that develop in concert with linguistic behavior. While responses of the latter sort would not arise in the absence of linguistic behavior, their forms are not linguistic per se. They are nonetheless acquired under the auspices of particular group circumstances and are conventional within them. For this reason, we prefer the term “conventional” rather than “linguistic” to nominate this category of human activity.
- ² An individual’s repertoire may contain multiple forms of responding coordinated with the same object encountered under different contextual conditions (i.e., a multi-lingual repertoire) however.
- ³ In our view this circumstance does not imply that such actions are occurring in the absence of stimulation, as suggested by Skinner (1957), but rather that they are coordinated with currently operating substitutional functions of physically absent stimuli.
- ⁴ While activities of various sorts may be coordinated with stimulus functions of these sorts, including perceptual activities, it is our position that nothing of this sort would be possible in the absence of conventional action which, we believe, is also the means by which the material environment of human beings is able to be so radically altered.
- ⁵ While it is possible that the failure to observe derived relational responding in non-humans is due to circumstances of a non-fundamental sort (Hayes 1992), the fact that behaviors of this sort have not been observed suggests they are at least not prominent features of the behavioral repertoires of non-humans.