COMMENTARY ON *CYBERRAT*

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ABSTRACT: This commentary on the development of *CyberRat* points out that 1) *CyberRat* is an excellent educational alternative to a live rat in cases where instruction of basic operant conditioning principles cannot be carried out with live animals due to a lack of laboratory facilities, 2) *CyberRat* simulates a live rat very nicely as long as one expects no more than demonstrations of basic operant behavior principles (i.e., *CyberRat* is not suited for *research* into operant behavior), 3) neither a Kantorian interbehavioral analysis nor a Skinnerian functional analysis is sufficient for *CyberRat* to work, yet a combination of both types of analysis is in fact necessary for *CyberRat* to emit an adequate and realistic flow of operant behavior interceded by other (non-reinforced) behavior, 4) *CyberRat* has developed to the point where it certainly provides a near perfect illusion of being a single animal that quite realistically demonstrates basic operant conditioning phenomena embedded in a flow of natural behaviors.
Key words: *CyberRat*, Kantor, Skinner, behavioral interdependence, computer simulation, operant behavior

Roger Ray (2011/2012) deserves considerable credit for developing *CyberRat*, which provides an excellent demonstration of basic principles of operant conditioning in a close-to-real video and data format. Operant behavior (lever pressing) can be shaped with *CyberRat* and maintained under different schedules of reinforcement and extinguished as well as put under discriminative control. *CyberRat* is highly interactive as the user can modify the rat's behavior via controls that can be clicked on the computer screen (e.g., reinforcer delivery and discriminative stimulus on/off). In addition, the operant behavior changes are documented visually in traditional formats such as cumulative records of bar pressing and tabulated averages of response rates. As such, *CyberRat* is an excellent educational alternative to a live rat in cases where instruction of basic operant conditioning principles cannot be carried out with live animals due to a lack of laboratory facilities. In addition to educating about traditional findings from operant conditioning experiments, *CyberRat* also illustrates that operant behavior occurs not in isolation but embedded within a stream of additional natural non-reinforced behaviors such as grooming, exploring the chamber, sniffing at the lever, visiting the food tray, etc. Indeed, *CyberRat* is a compilation of actual video of three live rats, and the viewing experience is, for the most part, akin to that of looking at video of a live rat. To put it simply, *CyberRat* simulates a live rat very nicely as long as one expects no more than demonstrations of basic operant

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behavior principles. *CyberRat* cannot be made to do something that the three live rats that form the video data base were not trained to do (i.e., you cannot shape a novel behavior other than lever pressing). Thus, *CyberRat* is not suited for *research* into operant behavior but serves well for demonstration purposes. The monograph provides an interesting and compelling narrative of the development of *CyberRat* along with descriptions of its theoretical underpinnings and validation methods for simulation authenticity or fidelity along the lines of various Turing-like tests.

CyberRat encompasses more than meets the eye as it is based on an approach that is a hybrid of Skinner's experimental analysis of behavior (Skinner, 1938) and Kantor's interbehavioral psychology (Kantor, 1959). Ray argues that the methods of experimental analysis of behavior by themselves do not provide a sufficient basis for development of *CyberRat*. The reason for this argument is that Skinner's analysis does not deal with other behaviors that intercede between the operant responses. Yet these behaviors are visible when one watches *CyberRat* in action, and given their electronic nature, they must be computer-selected based on some model. Ray suggests that there would be no way from a Skinnerian analysis alone to develop a model for how such other behaviors actually intercede between the operant responses, which behavior occurs when, how such behaviors follow each other, etc. For *CyberRat* to switch realistically among operant behavior and other behaviors, the computer algorithm that searches the video clips that form the basis of *CyberRat*'s behavior transitions must be based on some model of behavior flow and transition. Ray has based such a model on further extensions of his comprehensive research on structural hierarchies of interbehaviors (e.g., Ray & Brown, 1975, 1976). Carefully recorded behaviors (by visual observation) of live rats were analyzed in kinematic flow diagrams that capture conditional probabilities of behavior changes. These probabilities of changing from one form of behavior to another are used for the computer to select among the video clips. Apparently, some 1800 clips of varied length (i.e., 1–15 seconds) and behavior composition taken from three albino rats (presumably of the same size) and exposed to the same experimental conditions form the actual database that *CyberRat* operates on. For example, as the user gives a reinforcer to *CyberRat* after it sniffs the right side of the lever, in an attempt to shape lever pressing, the computer program will search for the next video clip based on what was the most likely behavior to occur next for the live rats as they received a reinforcer after sniffing the right side of the lever. So, an interbehavioral analysis was necessary to give *CyberRat* a realistic flow of behaviors. On the other hand, the interbehavioral analysis is not sufficient as the conditioning aspects of behavior obviously stem from a Skinnerian analysis. In essence, neither an interbehavioral analysis nor a Skinnerian analysis is sufficient for *CyberRat* to work. But both types of analysis are in fact necessary for *CyberRat* to emit an adequate and realistic flow of operant behavior interceded by other (non-reinforced) behavior.

Skinnerian and Kantorian analyses are sometimes set up against each other as being incompatible. Skinner's analysis is a functional analysis with a focus on independent and dependent variables in experimental arrangements with actual

manipulations of variables while Kantor's analysis is descriptive and focuses on determining conditional probabilities of behavior. For example, Ray writes:

> For Kantor, functional relations were a two-way process of reciprocated influence, or *mutual implications*, that logically rule out a distinction between independent and dependent variables. Instead, all contributing components in the psychological field were seen as being *interdependent*. (p. 213, emphasis in the original)

However, to say that two behaviors, A and B, are interdependent quite literally means that A influences B and that B influences A. For such influences to be determined empirically it may not be sufficient just to measure the behaviors and perform kinematic analyses. Interdependence can, in fact, be determined experimentally with separate manipulations of A and B as independent and dependent variables. For example, the length of post-reinforcement pauses in operant behavior maintained under fixed-ratio schedules of reinforcement can be manipulated in various ways and be shown to influence the extent of other non-reinforced behavior (e.g., water-drinking after food reinforcement in rats); on the other hand, the extent of such non-reinforced behavior (e.g., length of drinking bouts) can be manipulated in and of itself and be shown to influence the length post-reinforcement pauses (Henton & Iversen, 1978; Iversen, 1976). Thus, an experimental analysis can show that the same behavior (in this case drinking) can be both a dependent variable and an independent variable in different experimental settings, and its relation to the operant response can be characterized as interdependence. So, a Kantorian focus on interbehaviors can actually enrich and encourage an experimental approach to behavioral interdependence rather than deny or question it.

Progress in science and technology is often rooted in methods of validation based on experimental approaches. In contrast, Ray argues in favor of purely descriptive methods in psychological inquiry because they may more realistically represent interactions among many variables. It is true for some large-scale scientific domains (e.g., forecasting of weather patterns and ocean currents) that experimental manipulation is not possible except on a small scale in the laboratory. Ray includes modern brain- and neurosciences in the fold of areas where description is said to supersede experimental manipulation. An example is functional brain imaging (fMRI) with its complex measures of brain activity in conjunction with performance on various cognitive tasks. However, some recent advances in neuroscience have moved beyond description and now focus on manipulation of fMRI activity based on experimental approaches such as giving participants feedback on their ongoing fMRI patterns during sessions (e.g., Rota et al., 2009); definitions of dependent and independent variables are a necessity for such studies. Similarly, complex electroencephalogram (EEG) recordings, which traditionally served as descriptive or diagnostic measures of brain activity, can now be modulated based on feedback and can even be shown to submit to operant conditioning (e.g., Birbaumer, 2006 ; Iversen et al., 2008).

CyberRat is validated based on several separate Turing tests that seek to demonstrate how well CyberRat simulates a live rat under similar experimental conditions. Ray argues that the cumulative records and tabulated overall operant data generated by CyberRat show great fidelity to the operant behaviors generated by live rats under the same experimental conditions. That is indeed what would need to be the case for CyberRat to serve as a computerized demonstration of basic operant conditioning principles in lieu of live rats. The experience of watching CyberRat perform on the video display also has fidelity to the performance of a live rat. However, the interpretation of how well the experience of watching the video compilation of CyberRat matches the experience of watching a live rat under the same experimental conditions clearly depends on how much perfectionism the viewer seeks. Ray is clearly aware of the "jumps" that sometimes occur on the computer screen video as CyberRat suddenly moves from one corner of the box to the other. The smoothing of the video and diminishing of "jumps" progressed with additional behavioral analyses beyond those of Ray and Brown (1975, 1976) to improve and refine the conditional probabilities of switching among behaviors. It seems to be exactly at this juncture that Ray believes that the interbehavioral approach is superior to the Skinnerian approach because it is only by enhancing the interbehavioral analysis technique that the model for behavioral transitions can be improved so that video clip selections become smoother and less "jumpy" and therefore more realistic and lifelike. Ray deserves credit for basing the performance improvements of CyberRat on algorithms derived from performance of live rats as opposed to arbitrary video "smoothing" techniques, tempting as that may have been. However, to base the algorithms for CyberRat on statistical averages and standard deviations of empirical kinematic data across several live animals actually makes CyberRat fail another test of authenticity, namely that of depicting control of the behavior of a *single* animal. Skinner's experimental analysis of behavior became famous and influential, resulting in substantial clinical and educational applications precisely because it provided a system and a methodology for functional analysis at the level of the single organism (e.g., Iversen, 2013). Along the same lines, there is one hitherto unmentioned aspect of CyberRat that fails the Turing test, yet this failure is entirely invisible to the observer. Because the video basis for CyberRat is three live albino rats, one cannot distinguish the rats on the video. So a transition from one behavior (clip) to another may also be a shift from one rat to another. Had the three live rats been dyed red, green, and blue, then CyberRat would show random color changes that obviously would render CyberRat highly unnatural. The fact that CyberRat is based on the performance of identical, yet different, live rats is not a detriment but may be a necessity for a realistic educational experience for the viewer. In conclusion, CyberRat has developed to the point where it certainly provides a near-perfect illusion of being a single animal that quite realistically demonstrates basic operant conditioning phenomena embedded in a flow of natural behaviors.

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