

*IMPROVING THE HUMAN INSTRUMENT*  
**MEJORANDO EL INSTRUMENTO HUMANO**

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**Abstract**

In this review, *Homo sapiens* is considered as a scientific instrument functioning to arrange contingencies of reinforcement and punishment, and to measure the behavioral effects of such arrangements. The human's performance as an instrument can be understood, as can other behavior, as a function of both its behavioral history and the impingement of current circumstances. Knowing these variables allows the arrangement of environments that can improve the performance of the human instrument. Of particular importance is the human's development other types of instruments that complement or supplement their instrumental functions in behavior-analytic research and application. The proficiency with which human instruments use these technology-derived instruments is determined by the us-

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er-friendliness of the instrument, the human's training with such instruments, and the human's fluency with the principles from which the instrument was developed.

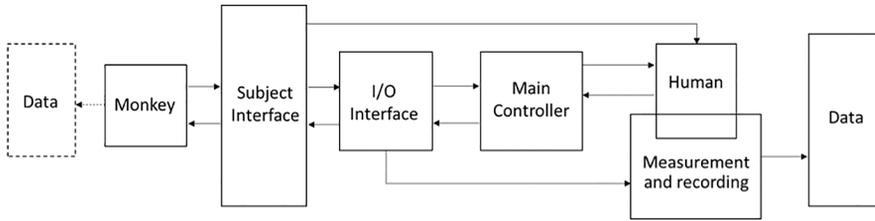
*Key words:* human-as-instrument, technology-driven instrument, observation, objectivity, measurement, intervention, instrumentation

## Resumen

En esta revisión, el *Homo sapiens* se considera como un instrumento científico que funciona arreglando contingencias de reforzamiento y castigo y midiendo los efectos de dichos arreglos en la conducta. La ejecución humana como un instrumento puede entenderse, como podría hacerse con otra conducta, como una función tanto de la historia conductual como de la incidencia de las circunstancias actuales. Conocer éstas variables permite el arreglo de ambientes que puedan mejorar la ejecución del instrumento humano. Es particularmente importante el desarrollo humano de otros tipos de instrumentos que complementen o añaden a sus funciones como instrumento en investigación y aplicaciones analítico-conductuales. La pericia con la que los instrumentos humanos usan los instrumentos derivados de la tecnología está determinada por la amabilidad del instrumento con el usuario, el entrenamiento humano con dicho instrumento y la fluidez con la que se usan los principios con los que fue desarrollado el aparato.

*Palabras clave:* el humano como instrumento, instrumentos impulsados por la tecnología, observación, objetividad, medición, intervención, instrumentación

In 1913, John B. Watson called for the establishment of a “purely objective experimental branch of natural science” concerned with “the prediction and control of behavior” (p. 158). The elements of Watson's call remain central to contemporary behavior analysis. Control can be translated broadly as the effects of the development and application of contingencies of reinforcement and punishment, and objectivity relates to both contingency application and the measurement of their behavioral effects. These activities in turn are accomplished by means of instrumentation. Such instrumentation facilitates the control of the subject matter by standardizing independent-variable parameters and their presentation through the arrangement of appropriate contingencies, and measurement of the effects of those variables on the behavior thus generated. In many settings where behavior analysts practice their profession, it is a human who performs both of these functions. Even



*Figure 1.* Diagram showing the interrelations among the organism and the various instruments and their functions that might enter an experiment with a primate subject. The data on the left side of the diagram in the box with dashed lines are those generated by the subject, to which it also responds. The data shown on the right side of the diagram in the box with solid lines are those generated by the subject, but mediated by the apparatus, to which both the apparatus and the human may respond, as noted in the text. The diagram illustrates the critical role of the human instrument in a system containing other devices derived from various technologies available to the human instrument. (adapted from Asano, 1970)

in laboratory situations, where these two activities typically are automated by digital computers and the like, still it is the human who designs and programs the contingencies to be emplaced, specifies the behavioral measurements to be made, and undertakes or at least oversees those measurements. For these reasons, the human can be considered as an instrument, one that occupies a critical link in the research chain. This chain is illustrated in Figure 1, which is a diagram developed by Asano (1970) showing the human's pivotal place in the chain of control systems and observation when studying primate behavior in the laboratory. In Asano's diagram both control and measurement flow through the human observer to other links in the research chain. To the chain, one only might add an arrow pointing to the human from the data rectangle shown on the right, emphasizing how the data change the operation of the human instrument, which in turn changes the other instrumentation and the subject's behavior in a continuous loop.

The diagram also suggests the themes of this review: that the human is the central instrument in the study of behavior and behavior change, that as an instrument the human can be refined and more finely honed, and that the instrument operates in the context of other types of instruments that have evolved in the hands of humans that in turn improve the human instrument's capacity to control/modify and measure behavior to the common good. In this review, we consider these three aspects of the development of humans as reliable, objective instruments in the study and change of their own and other species' behavior.

## Observation and Objectivity

Observation is the basis of every science and may be considered as consisting of the two related elements already discussed – controls over, or interventions in, the environment in the form of contingencies of reinforcement and punishment and the measurement of their effects on the behavior resulting from such contingencies. When referring to observation hereafter, it will denote either or both of these functions. Heeding Watson's (1913) call, all flavors of scientific psychology have striven for objectivity in their observations. But what does it mean for a human instrument to be objective? And what constraints are there on that instrument's objectivity?

Objectivity means observation without bias, or at least with minimal bias. The classic view of objectivity is more or less absolute, based on the correspondence between what is reported and what exists in the natural world. Observations deviating from this type of scientific-realist ideal are considered evidence of bias, or lack of objectivity. This classic view also distinguishes observation and interpretation, the former being the raw data on which the human instrument places its particular proclivities and biases. Moderating this classic view are variations on the Kuhnian (1970; see also Pepper, 1942; Reese & Overton, 1970) position that even objective observations may be influenced by the paradigm or framework or world view in which the observer operates. Although these positions do not deny scientific realism, they do suggest a more relativistic approach to observation and objectivity, somewhat at least blurring the distinction between observation and interpretation. Thus, in some sense at least, Freudians "see" the psychopathology of everyday life where behaviorists "see" the dynamic interactions of reinforcement contingencies as each observe the same scene. Even though objectivity may be on a continuum, within the constraints just discussed, a major goal of scientific psychologies remains that of assuring that both human and nonhuman instruments minimizing systematic bias, even if historical or conceptual bias cannot be avoided, in observing their subject matter.

There is an intricate dynamic between the scientific paradigm or world view, the instruments that are shaped in that context, and the observations that are made. As a science progresses, it develops and shapes instruments, including human ones, to operate in ways that advance the science's goals. These instruments in turn strongly influence how those observations are made, but also what is observed. Jenkins (1979), for example, noted that "[i]t is hard to overestimate the influence of experimental arrangements on the shape of a learning theory. The maze, runway, and

puzzle box do not suggest shaping, which is the operationalization of response-selection by reinforcement” (p. 200). The perfection of an instrument like the operant conditioning chamber simultaneously enhances observations by allowing such activity as greater precision and measurement of behavior, but at the same time it also can limit the generality of observations to those consistent with the use of that and related instrumentation. A pigeon’s keypeck, for example, can be reliably controlled under a host of conditions, but much of what else the pigeon is doing concurrent with its pecking the key goes unobserved (e.g., Herrnstein, 1970; see Manabe, 2017, this issue).

The above suggests that a broad, general influence on the human instrument is the context in which it is trained to arrange the contingencies of the science and measure their effects. The attraction to a particular paradigm, world view, or conceptual framework is itself determined by the human instrument’s individual behavioral history. Lines of research, problems of interest, and research tactics are affected by one’s experiences. Thus, individual histories affect not only the conceptual framework from which the human instrument operates, but, within that framework, how the human instrument approaches and solves specific problems related to intervention and measurement. Milgram’s (1963) compliant subjects and Asch’s (1951) misreporting observers of relative size brought with them to the experimental task individual histories that led them to observe and act in certain ways, as is the case for every human instrument. One can only speculate how the history of psychology might have been altered had individuals with different cultures and individual histories volunteered to operate the Milgram machine or judge the Asch sticks.

Individual histories like those discussed above interact with the current context to determine the actions of the human instrument. “Current context” describes a tapestry of circumstances and events that have been thoroughly, but far from exhaustively, investigated over the past eighty years by psychologists of many orientations, including a behavioristic one. Those analyzed by individuals holding the latter point of view include variables both antecedent to and following an observation or intervention.

Some antecedent events and conditions control behavior because of their immediate or contemporaneous proximity, both temporal and spatial, to the target behavior, while others have their effect because of their relatively near, but not necessarily immediate, proximity, as defined above, to that same target behavior. Given that observation is a class of behavior, both of these proximate types of antecedent events influence its quality and quantity. Both types include physiological and social vari-

ables, as well as the equally familiar (to a behavior analyst, at least) environmental variables that affect individual behavior (cf. Bijou & Baer, 1978). Other things being equal, a sleep-deprived human observer is more likely to produce unreliable data or err in implementing intervention programs than is one not so deprived. Following a heated argument, a human instrument may be less likely to detect and respond appropriately to the emotional distress of a client. An urgent need for a toilet by the human instrument may preclude precise recording of targeted classroom behavior that instrument is assigned to record. Human instruments with a neurological disorder that reduces attentiveness may be more likely to commit treatment-integrity errors than those without such disorder.

Antecedent events that are contemporary with the observation or intervention include the parameters of the discriminative stimulus that occasion such observation or intervention by the human instrument. Some stimuli, for example, by their nature are more likely to be detected or distinguished from one another. Part of this has to do with the organism's physiology – an older human instrument, for example, may be less likely to hear accurately a verbal response than a younger such instrument – and part to do with the qualities of the stimulus in interaction with the organism's history. Discriminations between certain spoken words in a non-native language may depend on one's experience with the language as well as the particular words being spoken (e.g., "dessert" and "desert," in English).

As with any response or class of responses, events following the observation or intervention also may affect its likelihood or quality. In investigations of human vigilance, for example, the likelihood of reporting detection of a stimulus against background noise depends not only on the parameters of the stimulus and the stimulus-to-background-noise ratio, but also on the contingencies of reinforcement in effect for positive and negative reports of stimulus detection (e.g., Green & Swets, 1966; Holland, 1958). Labeling a child with a particular psychiatric diagnosis, for example, depends not only the child's presenting symptoms, but also on the social and educational consequences for the child of assigning or not assigning the label. Choosing a treatment intervention for a behavior disorder involves evaluating many possible consequences, such as the costs and benefits of the different options for both the therapist and the child's family and the likelihood of successful implementation of the intervention by the client's support network.

All of the aforementioned variables affect the performance of the human as a scientific instrument. Depending on the variable and its parameters, the performance can be enhanced or impeded, with effects on both the advancement of the science

and the development and implementation of appropriate treatments for behavior in need of change. The conditions and circumstances described in this section constitute, without intervention to change them, a baseline of human instrument quality against which various interventions might be compared to examine their efficacy in improving that instrument. In the next sections, we examine parameters that might be manipulated to yield such improvement.

### **Improving the Human Instrument through Environmental (Re-)Design**

Potential ways of improving the human instrument involve changing both the conditions under which it operates and its history with respect to the observations required of it. Simple rearrangements of the physical environment in which the instrument's activities occur is a basic intervention that can improve its accuracy and reliability. Observations occurring in an environment lacking in appropriate lighting or noise abatement are destined to produce woes for all involved, including the instrument. The failure to have appropriate materials such as stimulus cards or reinforcers in place before a session begins is bound to diminish the instrument's effectiveness. Similarly, the human instrument must be appropriately fed and made otherwise physiologically comfortable before undertaking its assigned duties as observer or intervener. Eliminating, or at least minimizing, distracting activities, objects, and people is considered essential by all who investigate and treat human behavior. An observer engaging in the competing concurrent activities of texting on their smart phone and recording the number of times a child raises her hand during math class is bound to be less accurate than one who is phoneless.

A more skilled, that is, well-trained, human instrument is more likely to produce useful data and behavior control and change. Such instrument refinement is not achieved without systematic training. Among the first approximations to objectivity in scientific psychology was the attempt by early members of the structuralist school of psychological thought to train self-observation, or introspection (e.g., Titchener, 1914). Titchener objected in the strongest terms to what he described as "naïve introspection" as the basis for psychological measurement, arguing convincingly for its replacement by a type of introspection whereby observers were carefully trained to reflect on their experiences of the stimuli to which they were exposed. Even though Titchener's introspection as a research method was trashed by Watson, introspection has a sinusoidal history in psychology as a general discipline (see also,

e.g., Palmer, 2003). Introspection as a method aside, Titchener was a pioneer in fine tuning his human instruments as observers through systematic training.

There are many types of examples of training human instruments to potentiate their usefulness in research and practice. Operational definitions entered experimental psychology in the 1930s on the wave of what became methodological behaviorism. Although the dark side of operationism permitted mentalisms to ooze back into psychological theory, its obverse side contributed to increased precision of the human instrument. An operational definition of a psychological term reduces ambiguity in determining whether or not the phenomenon thus defined has been observed. Once an event is operationally defined, the human instrument need be trained only to match the operational definition to the observation in determining whether or not a targeted event has happened.

Closely related, if not always precisely identical, to both operational definitions, above, and interobserver agreement, below, are the use of checklists and other types of guidelines for observations and interventions. Written verbal descriptions of targeted behavior and procedures to be followed may be considered as a type of operational definition. They also provide a standard to which the human instrument can match its observing behavior. Checklists and guidelines for human instruments exist at many levels in both research and practice. They vary in the degree of variation allowed, and such allowable variation depends on the nature of the tasks that the guidelines are guiding. There is less room for variation in “hitting Johnny on the arm” than there is in “aggressive behavior toward other children.” Precision, however, sometimes is offset by the failure to catch otherwise significant exceptions to the more narrowly/precisely defined response class. Indeed, in many cases, different levels of guidelines are nested so that more specific ones either imply or are specifically tied to more general ones. The written definition of a specific problem, for example, “hitting Johnny on the arm” should be compatible with the more general definition of “aggressive behavior toward other children” such that a hit of the arm delivered in response to a humorous remark does not find its way into the latter category.

The old expression that “two heads are better than one” is applied most directly in honing the human instrument by employing interobserver agreement to bolster confidence in the integrity of observations and interventions. Interobserver agreement involves, first, the training of observers to consistently match their observations to the operational definition of whatever behavior has been defined and is being observed. Using any of a number of specific procedures for measuring the

percentage or likelihood of agreement as to the occurrence or nonoccurrence of the target behavior (e.g., Kazdin, 1982), two independent observers then are trained in observing until their interobserver agreement metric reaches a critical value (typically around 90 percent or higher agreement, depending on what is being observed). In this manner these human instruments become more finely tuned intervention and measurement devices. A question posed with respect to interobserver agreement is whether adding independent human observers beyond the usual two improves the instrument(s). Such a step most likely does, but the costs in terms of time, effort and training have to be weighed against the added benefit to accuracy, precision, and efficiency.

Another consideration in redesigning environments to optimize the human instrument is the consequences associated with the behavior of the human instrument as it engages in the tasks described in this section. These tasks involve the human instrument interacting with other human instruments with the functions of monitoring and consequating the actions of the former. The type of and manner in which these consequences are applied greatly affect the reliability and validity of these human instruments. Treat an observer badly and observations suffer. Apply aversive control to data not conforming to expectations and anything from miscalculation to distortion to scientific dishonesty in efforts by the human instrument to reduce aversive control may result. Conversely, observations consistent with best scientific practices should be reinforced. Humans, like any instrument, require monitoring, maintenance, and appropriate attention and feedback if they are work with efficiency and precision. Anything less can spell bad news for research and treatment programs.

All of the methods and examples in this section, are attempts to minimize bias and increase objectivity in human instruments. As noted previously, these methods also are developed and effected within a context that defines or implies a certain way of seeing the world, a set of scientific principles and values that guide what is examined, how it is defined and measured, and how interventions are designed and implemented in attempts to better understand, predict, control, or change what has been so defined and measured. These methods can improve the human instrument, but it still is less than perfect simply because it is human and subject to all the variables noted in the second section above. Humans themselves have observed these limitations and created observational systems that don't take them out of the instrumentation equation, where they remain both the most important link and the reason for the instrumentation in the first place, but do allow them assistance

in honing their efficiency and utility in harnessing the powers of observation to the benefit of the science and practice of psychology.

### **Improving the Human Instrument through Supplemental Technology**

Humans have engaged other technology that increases the speed, accuracy, durability, and capacity of intervention and measurement over what the unfettered human instrument can achieve in its absence. The instruments derived from such technology to a more or less extent remove the human instrument from direct, but not primary, roles in observation and intervention. These systems develop in response to selective pressure for “improvements” in control and measurement. Such pressure comes from within the discipline in which the instrument operates, but the technology that is harnessed to constitute these improvements can come from either within the discipline (e.g., an improved operant conditioning chamber, see Manabe, 2017, this issue) or be imported from other scientific disciplines or the general culture outside the system (e.g., a smart-phone app, see Lattal 2008; Stedman-Falls & Dallery, 2017, this issue). Because any such system is designed and implemented by a human, it still is not possible to remove the human instrument from the observation or intervention system. Thus it is a question of *supplementing* the human instrument with technology rather than *substituting* technology for the human. Although the human instrument may become at least once-removed by such steps, the technology can be no better than the human instrument that designed it.

This practice of supplementing the human instrument with technology is so embedded in the science and practice of behavior analysis that it is easily overlooked or ignored. Observations, for example, are recorded using at least a pencil and a piece of paper, two technological devices imported from the general culture that reduce the necessity of relying on memory and verbal reports of event occurrences. Much more elaborate technology-derived instruments have evolved that allow human instruments to study behavioral phenomena, such as subtle effects of schedules of reinforcement, that otherwise would be nearly impossible to examine. Beyond potentiating observation as both control and measurement, technology-derived instruments also facilitate the development by human instruments of new contingencies and new analyses that only could be imagined before the development of those technologies.

Technology-derived instruments improve precision by allowing operations to be repeated over extended periods of time. These same operations undertaken by human instruments would be subject to the vicissitudes of the kinds of variables

discussed previously, such things as human inattention and fatigue. The social dynamic that can develop between the human instrument and the participant also can be an impediment to precision. Technology-derived instruments can greatly reduce the need for verbal descriptions of both operations to be performed (i.e., instructions) and outcomes to be measured. Furthermore, in many circumstances where the human instrument is present to observe or intervene, the very presence of another human may affect the outcome, another variable that often can be minimized when humans are supplemented by other instruments.

Instruments derived from technology also allow the human instrument to achieve a wider range of observation – both control and measurement – than can be achieved without them. Dimensions of behavior, such as interresponse times, which are not otherwise easily accessible, become so with a relatively simple technology. Instruments also provide access to stimuli that otherwise could not be generated. Such things as visual and auditory stimuli outside the human sensory range, complex visual arrays, and tactile or olfactory stimuli all can be developed and presented with relative ease and precision by nonhuman instruments.

Technology-based systems are a bootstrap operation: human instruments build them to supplement themselves as observers. Once these devices are developed from within or imported from other disciplines, however, they must be interfaced with the human instrument. It is a person who conceives their uses, designs systems so those uses can be accomplished, monitors and maintains those systems, and then translates the data thus generated to a communicable form, which then is passed on to other human instruments whose behavior is in turn controlled by the data thus communicated. All of the above steps in the translation-to-communication chain are no better than human instrument with which the systems interface. It is on the human instrument that advances in science and practice depend, and that human instrument may be the weakest link in the chain shown in Figure 1, for all the reasons noted in the previous sections. With technology, however, many of these human limitations become manageable and often are either eliminated or at least minimized. Nonetheless, the chain ends with the human instrument, who retains the critical role of sorting out and communicating the observations mediated by technology.

### **Improving the Interface between Human and Technology-Derived Instruments**

The arrows in the diagram shown in Figure 1 indicate the reciprocal relation between instrumentation derived from technology and the human instrument. As

the latter monitors both apparatus and data (with the arrow noted above drawn from the “data” rectangle on the right side of the diagram back to the human), its behavior changes, sometimes changing another instrument sometimes creating a new one to accommodate or investigate the behavioral changes brought about by the current instrumentation.

Technology-derived instrumentation has to integrate appropriately with the human instrument for optimal utility of both. Certainly technology must be “user-friendly,” but this well-worn phrase masks a two-way street, for the human instrument also can be poorly designed for using the technological instrument. “Workable” technology requires not only product engineering, but also training of the human user. Poorly designed technology abounds (e.g., Norman, 1988), without doubt, but so do undertrained or mis-trained users. Misbehaving children are blamed for their own behavior just as “misbehaving technology” sometimes is blamed on its design. In both cases training of the human instruments associated with these entities may be a more useful solution than finger pointing. Training behavior where there previously was none is a solution well-known to behavior analysts.

Of what should such training consist if the interface is to be optimized? The most advantageous use of technology to supplement the human instrument occurs in the framework of the human instrument’s mastery of the research or application to be undertaken and the conceptual framework to which it relates. Beyond this, the human instrument requires the requisite technical skills for optimally applying the technology to the problem of interest. In short, the human instrument has to sufficiently understand the research or application problem it is asking the technology to assist in analyzing.

Technological instruments often are the human instrument’s direct connection with the data generated by subjects and participants. To not understand those instruments’ workings would be like closing one’s eyes when making direct measurements of behavior or putting away the reinforcers in one’s pocket rather than delivering them contingent on the appropriate response of the subject. The degree of “understanding” of the instrumentation being used, and the science or more general technology behind the instrument, is discussed below. Before turning to that topic, however, it seems worth noting that, in a general sense, improving the interface between the human and technology-derived instrument requires contact or interaction between the two. This often starts with formal instruction, in which initial skills are developed through the sharing of rules, but what is essential at some

point is contact between the human instrument's behavior and the consequences of interacting with the technology-derived instrument. Instructing a human instrument on the problems of recording a pigeon's key peck responses using a normally-open circuit cannot substitute for that human instrument coming into direct contact with the consequences of the loss of hundreds of responses from using this circuit instead of a normally-closed one.

With respect to the more general science or technology behind the instrument, it is one thing to learn specific technology, such as the circuitry necessary for recording operant responses, but what of more general technological skills, such as developing a working knowledge of electricity and electronics and of computer programming? There is no hard and fast answer to the level or depth of technological knowledge – “understanding” - that is useful in interfacing technological and human instruments. With technology, as with anything else, there always is more to learn, and there are pluses and minuses to “mastering” a particular technology. “Mastering” is on a continuum. At one end, it can mean simply demonstrating the requisite skill in using the technology-derived instrument for the present application. At the other end, it implies more general skills in applying and adapting the instrument across multiple specific applications. In the latter sense, such mastery can make the human instrument more versatile and in so doing perhaps sensitive to the contingencies in use or under study. Lack of skills in using the technology inevitably leads to bad science and disastrous, often unethical interventions. On the negative side, mastering the technology at the more generalized level takes time away from other research activities. It also sometimes is the case that one becomes so enamored by a technology that the technology becomes the end rather than the means to the research end.

Finally, technology-derived instruments change at what often seems to be an ever more rapid rate. As they increase in utility to the human instrument through these changes, there has been an increasing dependence on them to supplement the human instrument. By contrast, during all of the rapid technological change that has occurred and is occurring, human instruments have not changed and are unlikely to change in the foreseeable future in the sense that they will retain the same physiological makeup, sensory capabilities, and behavioral functions. As instruments, however, humans must not only adapt to but also master the rapid changes in these other instruments if such technology-driven instruments are to be harnessed to useful purposes in the science and practice of behavior analysis.

## Conclusion

To turn slightly Alexander Pope's observation that "the proper study of mankind is man," it does not seem unreasonable to observe that the study of humankind rests on the human instrument. This instrument might be labeled a "soft" instrument, as compared to such "hard" instruments as those derived from digital technology. The latter operate with greater precision and minimal variation over time as compared to the soft human instrument performing the same functions. What the human instrument lacks in precision, however, is compensated for by its flexibility and adaptability to the myriad circumstances that define research and intervention. Furthermore, as has been discussed above, the human instrument not only creates these other instruments, but also is the instrument that monitors and interprets the data collected by its nonhuman counterpart. This review has suggested that many things can be done to improve the human instrument, both as a primary research instrument and as a developer and monitor of other instruments. A human is not a piece of hardware, it is a human. Humans nonetheless often function as the ultimate instrument, participating actively with subjects, other technology, and the broader scientific community to develop the data base that underpins the development and practice of behavior analysis.

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