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Abstract

Every year technologies become more sophisticated and more accessible. Some have become a seamless extension of mind, so much so that they are better understood no longer as tools, but as integral parts of how our mind works. Biofeedback devices are examples of such technologies that are increasingly used in institutional contexts and for personal use. They offer a presumed scientific and objective basis for life decisions and behavioral health interventions, as well as a promise of new forms of self-knowledge. Yet in the very design of biofeedback technologies are cultural and institutional values that are rarely critically appraised. This paper focuses on four such processes. (1) Simplifying and interpreting bio information; (2) Advancing ideals of health determined by the few; (3) Conceiving health as the systematic pursuit of these ideals, and (4) Perceiving bio data as authoritative and trustworthy. As biofeedback technologies are integrated more fully and function as cognitive extension of mind, we should be critically aware of the paradox of seemingly objective data reflecting values inherent in the design of biofeedback technologies and the recommended health interventions that result.

Keywords

biofeedback, bio data, self quantification, self knowledge, extended mind

Disciplines

Biomedical Devices and Instrumentation | Biomedical Engineering and Bioengineering | Philosophy of Science

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Biofeedback Technologies as Extended Cognition:

A Philosophical Analysis

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Abstract

Every year technologies become more sophisticated and more accessible. Some have become a seamless extension of mind, so much so that they are better understood no longer as tools, but as integral parts of how our mind works. Biofeedback devices are examples of such technologies that are increasingly used in institutional contexts and for personal use. They offer a presumed scientific and objective basis for life decisions and behavioral health interventions, as well as a promise of new forms of self-knowledge. Yet in the very design of biofeedback technologies are cultural and institutional values that are rarely critically appraised. This paper focuses on four such processes. (1) Simplifying and interpreting bio information; (2) Advancing ideals of health determined by the few; (3) Conceiving health as the systematic pursuit of these ideals, and (4) Perceiving bio data as authoritative and trustworthy. As biofeedback technologies are integrated more fully and function as cognitive extension of mind, we should be critically aware of the paradox of seemingly objective data reflecting values inherent in the design of biofeedback technologies and the recommended health interventions that result.

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Biofeedback Technologies as Extended Cognition: A Philosophical Analysis

We humans are distinctive for our use of technologies for applying scientific knowledge and objective reasoning for practical purposes. As our collective scientific knowledge has expanded exponentially in the past century, so have the capabilities of technologies that extend the limits of cognition. As they've become more consequential and inseparable from our lives, a particular understanding of what they are has emerged and gained traction. It is the idea that technologies shape not only our world but also who we are by becoming integral extensions of cognition. In this paper, I will examine one such technology in emergence, biofeedback technology. It is an especially interesting example of a relationship between technology and the mind, as it is one which increasingly extends cognitive awareness to bodily processes that have been inaccessible and allows manipulation of such processes.

Biofeedback is commonly understood to be a process of gaining awareness of one's own biological processes and using that information to improve physical or mental health (Frank et al., 2010). By gaining insight into our bodily processes which we are normally unconscious of, and observing changes in real time, advocates claim that we can gain greater control over these processes. Biofeedback training has begun in clinical settings, but its use has spread beyond these settings. Technology companies have produced biofeedback devices for commercial use that reveal significant technological improvement in the past decade. Their promise is to monitor our health and produce health behavior change (Richardson, 2022). Biofeedback technology can be seen as the most technologically advanced form of, and a new driving force behind the self-quantification movement, which has become an emerging paradigm of health care self-management (Almalki, 2015). Each year the range of

biological processes that we can track is expanding and biofeedback devices are becoming more compact and widely available.

Millions are already tracking their heart rates and walking paces with their smart watches or their sleep quality with their phone apps. We will soon be able to track our neural activities and levels of hormones or gut activities. Such tracking is already being performed in labs and clinical settings today, and the promises of integrating these technologies into our daily lives seem too attractive for us to ignore. Just as we seek the help of GPS navigation in finding the quickest path to a location, or the calculator app to do divisions, we increasingly rely on biofeedback technologies as new forms of self-knowledge that enable us to make health decisions.

While the benefits of these technologies are likely to be undeniable, several pitfalls exist that must be considered before embracing the widespread use of biofeedback technology. This paper will examine four such pitfalls. (1) Simplifying and interpreting bio information; (2) advancing ideals of health determined by the few; (3) conceiving of health as the pursuit of these ideals, and; (4) perceiving bio data as authoritative and trustworthy.

The problems and the consequences of biofeedback technologies are not novel in the discussions of the philosophy of technology and information. Similar problems arise from cognitive technologies such as artificial intelligence and from digital technologies and social media use. But we expect the consequences of biofeedback to be more far-reaching. Biofeedback technology is distinctive for the type of information it produces. Such data is intimate and reveals who we are at our most basic level and opens up new forms of behavioral health interventions and guidelines for decision-making.

Background

Biofeedback Training

The biofeedback process comprises four steps. It begins with data acquisition, in which technology is used to measure a bodily process from which raw data is gained. Then there is the vital step of data analysis in which only aspects of data relevant to the user's goal are extracted and are turned into something meaningful. This information is then relayed to researchers or users. As a last step, the user is given the opportunity to modify his behavior based on the information communicated to him, as the clinician (or the technology) advises. An example of such a process is measuring the conductivity of a person's skin (sweating) to measure their level of relaxation and providing that information to the person as a sound tone. Research indicates that users who could hear their level of relaxation rise or fall from a device were more able to control their physiological state than those who were simply told to try to relax (MacInnes et al., 2016).

Biofeedback works based on what is known as operant conditioning in psychology (Frank et al., 2010). It is the process through which we learn to behave in a particular way to either reap reward or avoid punishment. During a typical session with a biofeedback technology, a reward would be an indication that one has reached or is approaching a desired biological state. Punishment would be a sign that they have failed to do so. Biofeedback technologies send these signals in real time, typically on a screen but also as sound or vibration. Thus, biofeedback training is not a magic pill that one can take and ignore. It requires a higher level of active and conscious involvement of the user, who must be internally motivated and willing to engage. The promise of biofeedback training is that the user will eventually internalize those skills that the technology encourages to the extent that he will be able to perform them independently of the devices. A study has found neuroplastic

changes in those who underwent biofeedback training, as circuits of actions learned from its operant conditioning process have been hard-wired in their system (Ros et al., 2010).

There are as many types of biofeedback processes as there are ways to measure aspects of our body. They all serve different purposes in treating or training us, with varying levels of research proven efficiency (Frank et al., 2010). Though these technologies have existed in clinical settings for a very long time- some, over a century- many are only now being incorporated in consumer devices to meet consumer needs. For this paper, we will look into one of these biofeedback technologies integrated into self-tracking wearables and which has been on the rise, EEG measuring devices.

EEG Neurofeedback: A Case Study

Electroencephalography, or EEG, is a process of measuring electrical activities in the brain (Farnsworth, 2020). Of the many ways for measuring brain activity that include fMRI, MEG, and PET scans, EEG is the cheapest and easiest to perform. Non-invasive EEGs require electrodes to be placed only along the scalp without the need for a bulky machine. This means that EEG, compared to other methods, can be done in a wider range of environments and on participants performing varying activities. It also has excellent time resolution, meaning it records our brains as things happen. Today, we can find commercial EEG measuring devices that are as small as a headband, and cost as little as a few hundred dollars. And through neurofeedback (a type of biofeedback that measures our neural activities), EEGs can inform users of their cognitive and affective states.

Frequency-Based Analysis is the type of analysis commonly used for EEG commercial devices, which analyzes the frequency of electrical waves in our brains. For research purposes, the scientific community has categorized the rate of these neural

oscillations. Oscillations in the 1 to 4 hertz range are known by the name, Delta wave, and are the slowest and the highest amplitude brain waves found in humans. Delta waves are mostly present during deep sleep, and are used to research sleep and sleep disorders. Oscillations within the 4 to 8 Hz range are Theta waves that are generated during light sleep and deep meditative states. Alpha band oscillations, occurring between 8 and 12 Hz, indicate a resting state that is common during meditation, and when our eyes are closed. It is the most common type of wave involved in neurofeedback training that aims to improve relaxation, mental coordination, and mind/body integration and learning. Oscillations occurring in 12 to 24 Hz occur during our normal waking state when we are mentally or physically active. Electrical waves occurring at 24 Hz or above are known as Gamma waves, and are currently least understood by the scientific community. Frequency based analysis is used to study our cognitive affective states during various activities. For example, motivation and engagement are associated with higher frequencies in the frontal cortical regions (Davidson, 2004). And higher activity in the left frontal cortex than in the right suggests positive emotion during engagement and vice versa. Other than revealing the general mental, affective and cognitive states, frequency-based analysis can also reveal abnormal brain activities such as those that occur during seizures or from sleep disorders.

EEG technology has been part of science research labs for almost a century. But over time, the technology has improved to make these devices more available to the public. And since the early 2010s, they have finally appeared in the consumer market. Wet electrodes are the lab standards, but dry electrodes have become more common as they are even easier to apply. While research grade machines cost over ten thousand dollars, these new devices are much more affordable. While high grade machines often have 128 electrode channels or more in their setup, these budget devices have sixteen or as few as four electrodes. Neurosky, a

manufacturer of bio sensors for consumer product applications, has a device that comes with just one electrode placed on the forehead. The biggest advantage of these devices is that they are quick and easy to use which is why in a study, researchers could afford to measure the EEG activities of over 6000 participants (Hashemi et al., 2016). In another study researchers were able to examine the level of focus of students in a real lecture setting (Kosmyna & Maes, 2019).

These devices usually come with mobile phone apps through which they, with the data extracted, interact with the users. For example, a meditation tool, MUSE headband and its app, play distinct sounds (bird singing, light rain, and storm) to indicate different states the mind is in and navigate the user to his desired mental state (bird singing). With sleep, the device tracks different sleep stages during the user's sleep and informs the user of its interpretations of the data. Over time, users can track their sleep under different circumstances to determine their best sleep patterns. Today the power of consumer EEG devices is limited. But we can expect that the quality of these devices and the algorithms will improve and so will the breadth and the depth of cognitive and affective states that they can measure. And if they become part of our daily lives, they will change the way we make our decisions and, ultimately, how our minds work. The extended mind theory discussed in the next section proposes an interesting way of conceiving of the relationship between cognition and technology, emphasizing its continuity and seamlessness.

The Extended Mind Argument

Philosophers of mind have long argued over many aspects of cognition and emotion, one salient example being where the boundary of mind and world should be drawn. The typical and intuitive answer to the question is that the mind resides and ends within the brain.

But current theories such as embodied cognition and the extended mind argument challenge this assumption.

In 1998 Philosophers Andy Clark and David Chalmers co-authored a paper that introduced the Extended Mind thesis. They argue that mind extends beyond our bodies and that external objects play a significant and often irreplaceable role in our cognitive processes. Thus neglecting the environment in theorizing mind and cognition, instead of seeing the two as a coupled system, is a mistake. Objects should be considered an extended part of mind if certain criteria are met. Clark and Chalmers describe a thought experiment in which two individuals must navigate through New York streets. One of them has Alzheimer's disease, and thus uses a notebook that has all the needed directions and serves as the individual's memory. The other person navigates the streets by recalling directions within her internal memory. Clark and Chalmers claim that the only difference between these two people is the source from which their memories are derived. The notebook for the first person acts as an extension of mind. In order for an object to qualify as such an extension of a person, the two philosophers suggest the criteria that must be met. These criteria are that the object is constantly available, easily accessible, automatically endorsed, and consciously endorsed in the past. (Clark & Chalmers, 1998)

This concept is familiar to anyone living in the twenty-first century. It is rare to find a person without a phone in their hands or in their pockets. We rely on this device to perform many cognitive activities and to function as expected to do so. We search for information on Google, find locations with an online map, know of the week's weather ahead of time and communicate with others in the other parts of the world. It's no wonder why people report feelings of being lost or being restless without their phones (Raypole, 2019). And as phones affect our performance and behavior in our day-to-day lives, they also cause more lasting

effects to our minds. Studies have shown that the internet has affected our attentional capacities, memory processes and social cognition (Firth et al., 2019). Studies show, for example, that people remember less about an event if they take photos of it (Lurie & Westerman, 2021). Our brain recognizes that taking photos can outsource the burden of remembering. Thus, even though we recall less of an event without the photos, with them, we recall with more certainty than those who took no photos to begin with. If one studies how the minds of humans in the twenty-first century work, but leaves out iphones and how we interact with them daily, they would miss a piece to the puzzle they're trying to solve. This is because, as an Extended Mind theorist would argue, our phones are now extensions of our minds.

Whether Extended Mind Theory, among all other theories on the mind, most accurately reflects reality, is debatable. However, the power of a theory often comes from how useful it is to us as a tool for understanding the world. The extended mind argument, as extreme as it may seem, provides an insightful approach to understanding the relationship of mind and cognition in relation to biofeedback technologies. In this way we can appreciate the potential of such technologies to shape cognition through increasingly sophisticated, often wearable devices that provide streams of biodata as a basis for health interventions.

Discussion

If EEG measuring devices and other biofeedback technologies become widespread, they will probably be integrated into our phone usage habits and introduce an additional dimension of interaction between us and the world. Currently, these technologies have found application in supplementing medicine and in improving performance and productivity, focusing on informing users of the bio data that has been produced. But if they become more

widespread, they may become new ways by which we communicate with the rest of the world. In the past, we could only share our feelings and preferences through our own interpretations, and our expression of those interpretations. Today, algorithms predict them with the use of our data derived from our choices on the internet. But with EEG neurofeedback and other self quantifying technologies on the rise, we will have new ways of communicating them through biological data. Hence, biofeedback technology and data have the potential to be extremely valuable to industries and businesses for research and development. This may be the case even if consumers resist the idea of sharing their bio information. It has been found that many data generating practices that began as private eventually became involved with larger networks of businesses without users knowing about it (Boyd & Crawford, 2012). As social media became part of our lives not only for serving many purposes for the public but also because industries had much incentive to develop them, biofeedback technologies too are likely to quickly become part of our lives. The following section will discuss the processes by which biofeedback technologies are created and the ethical and social issues they give rise to.

Interpretation and Simplification of Data

Every time we pass on knowledge, we make a choice of how to package that information. And to do that, we must not only consider what kind of information we want to convey, but also to whom we're conveying it and why. A YouTube channel WIRED shows its importance. Experts are brought in to explain a single concept at five different levels of complexity to five different people- a child, a teen, a college student, a graduate student in a related field, and another expert. These experts must overcome the demanding task of providing value to each of these people in a way that is not too complex for the audience to

feel frustrated by while not too easy to become bored. For each reduction in the level of complexity, the experts sacrifice depth and accuracy for engagement and learning. Fortunately for these experts, they have a clear sense of their audience, and are able to deal with just one person at a time. Biofeedback technologies today used in clinical settings by certified practitioners are in a similar position. They can afford to tailor the feedback to the patient. When biofeedback technologies become widespread and are used by the masses through algorithms, similar hurdle must be overcome.

On one end of the spectrum of bio information, we have something resembling raw data, such as rates and levels of hormones and neural activities. But information in such a form is meaningful only to the experts. At the other end of the spectrum are interpretations of what those raw measures reveal of the state of our body and our mind. But at this end of the spectrum, knowledge is subjected to errors, bias, and omission of details that can distort the more complex nature of the raw data by representing it in terms a layperson can understand. Biofeedback technology is unlikely to be conveyed in its original more complex form, one that most closely reflects reality. The purpose of technology is to make information accessible, and accessibility implies comprehension. If an untrained mind cannot make sense of the biological data provided, it is of no use.

Even if the bio information is turned into words that everyone can understand, it may need more to convince the public. Further simplification will be needed. First, people generally prefer reductive explanations (Hopkins et al., 2016) and second, studies on human information processing show that decision making deteriorates with information overload (Eppler & Mengis, 2004). Biofeedback technologies promise increased depth and breadth of knowledge about our body. But as they are introduced to our lives, this promise may get in

their way of meeting our needs. Thus, in order for them to be used widely by the public that consists mostly of non-experts, the public must accept some interpretation and simplification.

The interpretation and simplification, however, may be taken even further. Our goal as users is not to only understand our physical and mental states, but to change them as we desire. And like with any other goals, we want to achieve them with the least amount of effort and strive for them with a sense of certainty that technical and medical experts can provide. With this in mind, businesses competing to integrate their technologies more deeply into people's lives will not stop at just providing knowledge. As they remove as many layers of information processing as they can from their customer, they will end up also recommending solutions. Consumer biofeedback technologies in the future, as biofeedback clinical treatments do today, will tell us not just about our body, but also how we should behave.

Unfortunately, in the current state of biofeedback technologies, we would be mistaken to blindly endorse these interpretations. Biological data and its interpretations differ from GPS data or many other types of information we trust in our daily lives. A latitude and a longitude always translate into the same location, but how do we define or measure good sleep? Or learning? Countless disagreements exist within the scientific community about these issues. Counting calories and carbohydrates is not all there is to losing weight (Dunn, 2013) yet many diet apps today are reliant solely on those factors. Actionless sleep is not necessarily good sleep (Paquet et al., 2007) and there are debates on whether sleep tracking devices today can even distinguish between sleep and wakeful states (Peake et al., 2018). Plus, with the current technologies, we rarely have access to the “full picture” of our body, which would include data on all relevant bio measures. However, the biofeedback devices on the consumer market today rely on limited types of bio measure which is often inadequate for authoritative judgments.

Such shortcomings in technology and science research, however, can be addressed. But even if we become equipped with highly confirmed scientific research and sufficient technology, other problems arise when we uncritically accept interpretations of our bio data.

Standards and Ideals Set by the Few

It seems inevitable that biofeedback data must undergo layers of interpretation if it is to be adopted by the mass. But who will make these interpretations? It would be done by the few people trusted for their expertise on the matter. As with other industries today, advances in the biofeedback tech industry will cause the choices of the few people to be consequential to the lives of the rest. In the worst-case scenario, these people might be motivated by interests that don't align with the interest of consumers. They might be told to push the company's product, or convince people to develop habits that make them depend on their services. They may package information in such a way that makes their technology addictive, giving them competitive advantage over other services.

Even in a perfect world in which the profit of the company is not their dominant interest, it remains that norms and the standards set by the few always need appraisal and critique. Consumer biofeedback technologies will invariably set ideals of health and wellness that push users to think about their behaviors according to these standards. But these ideals may be the result of the cultural background, education and upbringing of the few designing the system. And they might disrupt the lives of many who have lived, or wished to live, different lives. Such bias in information is not novel in biofeedback technology, but is a common problem for all technologies that aim to provide better and easier access to information. Social media platforms convey social norms and trends that are often curated by a few. And artificial intelligence has been found to make decisions that discriminate by

gender or race (Köchling & Wehner, 2020; Crawford & Calo, 2016). Similarly, biofeedback technologies may push us to make decisions about our body and our mind based on insufficiently examined beliefs.

The designers of these technologies, of course, should strive to base those beliefs on scientific findings and clearly articulated value assumptions. Scientific research never itself dictates value-based design intent. But it is important that technology designers make clear their notions of health and how they believe a biofeedback technology can assist a user to realize that ideal. But if they rush the process, the scientific grounds too may be those that reflect a certain group of people. WEIRDness in psychology is a notion that current psychology research is based mostly on western, educated, industrialized, rich and democratic groups of people (Brookshire, 2013). Those who build the system may believe that their algorithms are created fairly for everyone to use because they're grounded in empirical research. But it may still have been affected by biases that will disrupt people's lives. Living in an industrialized world of technology, we risk much by relying on a few people to design systems which, even if they have a minor mishap, cause rippling consequences as they scale up.

Personal differences in people's values must also be considered. For example, where do we draw the line for "good enough"? We all have different standards on how far we're willing to work and where the cost of our efforts overshadows the reward. It is also hard to determine where the technology will begin to impede the user's health and wellbeing. One might argue that users should easily be able to control and limit their tech usage. But if we reflect on the current affairs of our society, that may not be true for everyone. Excessive and irresponsible use of technologies degrades the quality of people's lives. But more unfortunate is that we have a hard time controlling our relationship with technological devices, even if we

are aware of their negative effects. Biofeedback technologies have the power to improve health and wellbeing. Thus a top priority should be avoiding problematic design and misuse of these technologies.

Never Ending Chase for the Standards

If we gain greater access to cognitive and other processes, we are likely to face significant challenges that come with such knowledge. If and when the biofeedback technology companies determine the standards and we compare them to our own bodies, we may find that no aspect of our body is up to those standards. And it would be profitable for the companies, and engaging (in the beginning) for the users to have an ideal to chase. In order for technology industries to sustain and grow, they must be careful not to convey to users that they are good enough. Ultimately, they must convince the public that their body should not just be monitored, but controlled.

"Medicalization" is labeling conditions and behaviors as medical issues that must be treated. Industries and businesses, such as the biofeedback technology industry, that sells solutions to problems have a high incentive to broaden the boundaries of those problems because that increases the need for their solutions. Once we rely on biofeedback technologies, physical and mental states that our judgments used to overlook may turn into conditions that are considered subpar to an ideal. What may follow is a constant need to adjust our lives to strive for that ideal. While people envision biofeedback technologies as tools to empower themselves, "the current trajectory of design and regulation [for these technologies] pose significant threat to that end" (Baker, 2020, p. 1488).

If we are not on guard to protect our autonomy, we risk handing over control of decisions to purposes that are not our own, including when to stop and rest. Today, even

when people feel social media is negatively affecting their life, they find it difficult to quit because of social obligations, as well as how addictive they are. Similar strategies by designers may make it difficult for individuals to quit using their biofeedback devices. For example, we might be invited to share our data with our peers or be compared with others for further scrutiny and social pressure. Wellness programs in corporations track their employees' physical activities and offer lower health insurance fees based on their level of activities (McGregor, 2014). They claim the programs improve the health of their employees and their productivity and morale by adding friendly competition. But critics find them a means to monitor them in various environments and impose control over them (Lupton, 2014).

Today, we separate the use of biofeedback technologies according to two purposes, one for treating medical conditions and the other for reaching peak performance. But once these technologies are integrated into our lives, the two will merge. Taking care of our physical and mental health will be no different from constantly chasing after the peak state. Fixing our physical and mental problems is good, and so is preventing them beforehand. But we must question how far we will go to prevent them and if doing so is costing more than it will save. And if we set our mind on improving our performance, we should contemplate whether the result will be worth the anxiety and stress of striving for that perfection. Unfortunately, for the reasons discussed, doing so will be our responsibility. More likely than not, the businesses behind these technologies will want us to chase after and invest more than would be actually good for us.

The Allure of Bio Data

The issues with emerging biofeedback technologies are not novel to biofeedback technology. They are recurring problems explored in the philosophy of technology and information ethics. But there also are issues that are specific to biofeedback technologies because of the type of information such technologies provide and their effect on users.

Part of the promise of biofeedback technologies is the highly individualized information offered to users. Such information is directly determined by the real time biological information of the individuals. This may boost the accuracy and effectiveness of their message. A person seeking physical or mental health advice will receive much more tailored and therefore helpful information with a biofeedback technology than with contents about health available on the internet today. However, their effect is not limited to this. Studies found that individualized messages are much more effective than group targeted messages in persuading the target (Hawkins et al., 2008). It changes the attitude of individuals and increases their level of attention and depth of processing. Even when the same information is conveyed, if a person believes the message is tailored for him, it is much more likely to be endorsed and inspire action. And biodata is one of the most intimate forms of information closely tied to a person's identity. This implies that biofeedback technology, compared to other technologies available today, has the potential to have tremendous influence over our decision making.

Another characteristic of biofeedback makes it even more persuasive. The message that biofeedback technologies convey have been filtered through layers of interpretations and subjectivity. However, we will probably fail to notice such interpretation and rather focus only on the resulting data. The language and the culture surrounding biofeedback technologies imply that they generate knowledge of objective reality. Words such as ‘sensors’, ‘track’ and ‘measure’ are being used to educate the public on their potential. They

appeal to our intuition that our biological sensors, such as our eyes, make credible and objective observations, and tell us they can replicate such processes for aspects of our bodies previously unknown to us, with their 'sensors'. They are also armed with scientific rhetoric and sophisticated technology that conveys authority and diminishes critical questioning in users. Studies have found that people put more trust in information obtained from scientific mechanisms than from a subjective source because the former is believed to be objective (Dumit, 1999). Furthermore, biological explanations were found to be more persuasive than psychological explanations (Baker et al., 2016).

To summarize, humans have a cognitive bias toward believing bio information to be objective and more reflective of reality than other types of information about ourselves. Coupled with the fact that bio information will be tailored to the user, and thus seem personal, biofeedback technologies are likely to be highly persuasive and therefore consequential. All this may be so for the good of the public. But it is also a higher risk for all the potential pitfalls discussed so far.

Conclusion

Biofeedback technology has the potential to advance knowledge and influence human behavior in new ways. It provides a new depth of self-knowledge that, if applied cautiously, can change our lives and the world for the better. With the unprecedented accuracy and accessibility of acquiring such knowledge, it enables us to foresee our future and act with enhanced cognition. And more so, it can help us reach a new level of self actualization and guide us towards a healthier and more productive life. All of this is thanks to the scientific knowledge that has accumulated in the effort to create more and more accurate models of

body and mind. It is this approach to knowledge, of empirical observation and critical questioning, that best characterizes biofeedback technology.

This, however, is not to say that biofeedback technology and its influence on our lives will be wholly free of subjective interpretation. Even though science is driven by critical questioning and empirical observation, technologies rooted in science are inevitably shaped by cultural and subjective values and yet perceived as authoritative. Biofeedback technology has cultural and personal values present at every stage of its design and use. This paper is a reminder to not relinquish our autonomy and to think critically about biofeedback technologies and their consequences. It is also a reminder to consider the values of other forms of self knowledge that come from experience, introspection, emotions and critical reasoning, and not to lose touch with our own sources of judgment.

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