CHAPTER 12

Monitoring the Status of the Human Brain

FORTUNATELY, just when it is most needed, a critical human-centered technology is emerging to help address the problems of human frailty in our nonstop world. Human alertness technology offers the opportunity to control the state of activation of the human brain so that the goal of "Alertness When Required, Sleep When Desired" becomes a feasible target.

An intelligent, fully interactive human alertness technology first requires continuous quantitative information about the state of the human brain. Is the person, the user of the equipment, alert and firing on all circuits, or has the fog set in? Is the person paying attention to the task at hand, or is he attentive to some other distraction? Is his functioning impaired, by sleep deprivation, drugs, or alcohol, so that he is not fit to interact with the equipment?

Some of these characteristics vary from minute to minute, for the human brain is a very dynamic device. For utmost responsiveness, a human alertness monitor must be constantly scanning, to keep track of the fluctuations in human brain state as they occur. In contrast, to detect drug and alcohol impairment, the updating can be less often.

The optimal approach to tracking the alertness and attentiveness of the brain varies depending on whether the need is for fast responsive action or only occasional checks on state. Some methods are already developed and are entering the marketplace; others we know how to do but need investment of time and money to achieve.

FITNESS FOR DUTY

THE GROWING awareness of the enormous and potentially catastrophic consequences of human error in industry, particularly with the amplification effect of capital-intensive operations (see Chapter 1), has lent some urgency to the problem of checking whether employees are fit for duty when they arrive at work. Increasing awareness and concerns about drug and alcohol abuse, and recognition of the debilitating effects of sleep deprivation, have led employers to seek ways to determine whether an employee is likely to be dangerous to self and others—not to mention whether the employee is capable that day of efficiently performing the job.

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Computer performance tests designed to test employee fitness for duty are now being developed and marketed. They are intended particularly for the so-called "safety-sensitive positions" (jobs where the consequences of human error are large). They are clearly preferable to urine testing. Employee acceptance is higher, and because the results can be obtained immediately, they are relevant to making decisions about that day's work.

This is the simplest form of human alertness/attentiveness monitoring. The decision is yes or no—the employee works or doesn't work. There is no attempt to modify or manipulate the level of performance capability that day, other than telling the employee to take a nap, or to go home and sleep off the hangover. Disciplinary action may often be triggered, with termination if the problem is repeated.

Such tests carry several limitations:

1. They determine the state only at the moment the measurement is made. A person may arrive for the night shift at 11:00 P.M. and pass the test but then be downright fatigued four hours later and not functioning well. Alertness states in particular may change fast, so a single snapshot of performance taken at the beginning of the shift does not protect the employer very well.

2. The employee can muster special effort to pass the test but then be impaired in the normal monotony of work. If one's job is at stake, paying attention for a few minutes will really pay off for the employee, at the employer's expense.

3. Employee acceptance may be a problem because the employer is playing a Big Brother role that employees may resent. If not well handled by management, the computer performance test could become a visible reminder that the employer does not think the employees are to be trusted.

4. There is always the danger that the computer test does not measure a type of performance that is relevant to the person's job.

Fitness-for-duty tests nevertheless can be a good first step in addressing a difficult problem. Certainly they are better than the alternative of letting a person do a safety-sensitive job in an already impaired state.

THE MEASUREMENT OF ATTENTIVENESS

WITHOUT attentiveness, the human brain is deprived of essential input and severely limited in the tasks it can perform. As with fitness for duty, it is of little value to check attentiveness only at the beginning of a work shift. The dynamic and changing state of attentiveness can be meaningfully measured only by continuous monitoring, or at least, monitoring at times when attentiveness really matters.

During the process of landing an airplane or changing the positioning of the rods in a nuclear reactor, a person's state of attentiveness five minutes ago is yesterday's history if the individual is not attentive at the vital phase of a critical maneuver.

This makes measurement of attentiveness a significant challenge. Constantly alert and rapidly responsive must be the hallmarks of such a system. It must know when paying attention matters, and provide feedback that helps the sustenance of attentiveness without itself being a distracting element that could reduce attentiveness to the task at hand.

We are in the process of developing such a device that is rapidly responsive, nondistracting, and information rich. Using special remote sensor technologies, we can obtain a continuous update on the attentiveness of the operator, without that person being aware.

For successful introduction into the around-the-clock workplace, the feedback method must be sensitive to the needs, perceptions, and attitudes of the monitored person. Constant watching by Big Brother is not a mental image that we want to foster. Rather, the system needs to be considered a helpful and unobtrusive aid that backstops the human operator. It cannot take away a person's job responsibility—instead it must be a supportive reminder and facilitator.

ALERTNESS MONITORING

ATTENTIVENESS without adequate alertness is not sufficient. The state of activation of the human brain—that is, alertness—should also be monitored in critical safety-sensitive jobs. Attentiveness by a foggy brain may result in impaired processing of essential information, dumb errors made, wrong buttons pushed.

But alertness monitoring cannot replace attentiveness monitoring, for a fully alert person who is distracted by some extraneous event or thought will not be effective on the job. The truck driver distracted by the sight of a pretty woman at a busy traffic intersection, your daughter doing her homework in front of the TV, and the sailor watching the dolphins play rather than the rocks ahead, are alert but not appropriately attentive.

Perhaps the most dramatic example of failure of attentiveness was the Eastern Airlines crash in the Florida Everglades. Crewmembers were so distracted by a faulty landing-gear position indicator that they ignored their altitude, and the plane crashed needlessly into the ground.

Their alertness was stimulated by the potential danger posed by the perceived landing-the driver jerks the drifting car back into its lane. Patterns of steering-wheel movements vary significantly between individuals, but by learning the characteristic behavior of each driver, the device can detect deteriorating deviations from each person's norm.

Better still, advance warning can be given by measurements of the state of activation of the brain. We expect to see great strides made in this area in the next few years.

CONSTRUCTING THE FEEDBACK LOOP

DETECTING danger is of little use if you do not take advantage of the information. Thus essential to the design and implementation of alertness and attentiveness monitoring systems are feedback systems that ensure good use is made of the information.

This is not as easy as it sounds. You might think that warning the human operator that she is dangerously sleepy might be enough, but merely telling a person she is sleepy may be an irritation, something she feels she already knows. The lighted coffee cup on the dashboard that the Nissan device uses as its warning signal may not be noticed or may be treated as a statement of the obvious.

Furthermore, if the sensitivity is set too high, so that the device keeps sending off warning klaxons at the first signs of reduced attentiveness, the device is likely to get "fixed." People are amazingly creative in finding ways to deactivate or circumvent devices that bug them.

The best approaches are more subtle. Unless the person has already fallen fast asleep, corrective actions that stimulate attentiveness and alertness are best. Increasing the work load, requesting the individual to perform extra but necessary tasks, is a way both to stimulate alertness and at the same time to diagnose performance impairment. It cannot be a meaningless exercise that the operator "sees through," but rather a set of tasks that must be done periodically anyway. The alertness/attentiveness monitors just select the times the operator has to do the task based on when operator stimulation and performance testing would be most useful.

Another approach is to use what we know about the factors that influence alertness. Bright lights and cool temperatures help switch on alert behavior. One can envisage systems being developed that automatically modulate lighting levels and ambient temperatures so that their fluctuations sustain the operator's alertness level. The changes might be so subtly triggered that the human will not be conscious of them.

Just like old Professor Cannon's recognition, that the autonomic systems of the body "removed the control of the essential functions of the body from the caprice of an ignorant will," so might these human alertness technologies take over the sustenance of alertness in the middle of the night because our conscious decision-making capabilities are not up to it.

Sleepy people often do not have the mental or physical energy to take actions that would make them less sleepy. The recognition of an oncoming wave of sleep may just be a passing thought on the way to becoming fully submerged.

RETHINKING THE JOB DEFINITION

THE MORE power the engineer has to monitor and correct human attentiveness and alertness, the more realistic the engineer must be about human capabilities. I once was shocked by a conversation with an oil-refinery process engineer who defined the key requirement for the control room operator as the continuous monitoring, minute by minute throughout a twelve-hour shift, of the process control monitors. When was the last time you constantly monitored anything for longer than a few minutes?

We must be realistic about alertness and attentiveness on jobs, such as that of the oil-refinery operator, especially on the night shift. Any job, however responsible or critical, that involves monitoring a computer screen can require only brief, intermittent bouts of attentiveness, and a reasonably sustained, although fluctuating, alertness level.

Attentiveness/alertness feedback systems must be designed accordingly, calling for fully attentive behavior only when necessary. Alertness has to be maintained at a state of readiness without expecting the full physiological flight-or-fight response at all times. This is essential to the effectiveness and acceptance of these systems by the employee at the man-machine interface.

USING MULTIPLE SENSES IS COMMON SENSE

ATTENTIVENESS should ideally focus on all relevant senses. The fully attentive operator will use sight, sound, smell, temperature, and vibration in tracking machine performance. We do it every day in operating our automobile while driving to work or to the store. The dashboard displays emphasize visual cues, but an abnormal vibration of the chassis, an unfamiliar smell, strange noises, and steam escaping from the hood are also well-recognized signs of trouble.

Less well appreciated is how much an oil-refinery operator, a machinist, or a paper mill technician also relies on a wide variety of senses in tracking equipment performance. Indeed, in this computerized age we have focused on visual cues because that's what computers do best—a classic case of machine-centered thinking.

We may be depriving operators of essential information by moving them away from their machine and placing them in a quiet room with a computer terminal. Certainly, the necessary information can appear on a computer screen, but a number or bar chart is far less compelling than a change in the vibration frequency in the floor beneath one's feet. An operator may be tuned out, engaged in a conversation, or not watching the computer screen but still instantly alerted by the vibration change.

It is hard for computer engineers to output information as vibrations, so they don't do it. But such information can make the difference between life and death. As the pilot reported in the story that opened Chapter 6, it was the change in vibration as the plane started to stall that aroused him and saved lives when the whole cockpit crew inadvertently fell asleep.

Computer engineers are only now attempting to make better use of sounds as cues. Moving away from the simpleminded precomputer gong and buzzer approach, sound synthesizers provide rich opportunities for auditory information, but they are as yet barely plumbed by man-machine interface designers.

Certainly unrecognized by engineers is the alertness-stimulating effect of having multiple, information-rich sensory cues. Remove a machine's vibrations, replace its reverberant whistles and gasps and rumblings with a computer console's constant white noise or a sixty-cycle hum, and eliminate the distinctive smells of the process, leaving the smell of the carpet—and you take away the factors that used to keep operators alert and responsive. Some key switches that stimulate the level of alertness have been flicked off.