IX

Temperature, Humidity and Work

The energies of men wax and wane with temperature, both inner and outer. Most ordinary work is performed best when the temperature is about 68° F., the air 50% humid, with a circulation of about 45 cubic feet of fresh air per minute maintained around the worker's body. Let the work be somewhat more arduous than average, and the worker's efficiency declines sharply with each increase of temperature and humidity. Peak performance at 85° F. is found to be about 37% poorer than at 75°.

The best temperature and humidity conditions for factory workers have been studied by Carey P. McCord. Here are the findings:

Temperature in F.	*Relative Humidity (%)*	*Capacity for work*
70°	40	Greatest comfort
	85	Comfort when inactive
	91	Depressing fatigue
80°	20	No discomfort
	65	Discomfort
	80	Rest necessary
	100	Hard work impossible

Temperature in F	*Relative Humidity (%)*	*Capacity for Work*
90°	25	No discomfort
	50	No work should be done
	65	Hard work impossible
	81	Body temperature rises
	90	Dangerous to health

In mental work so little energy is converted that the need of radiating heat through the skin is slight; hence we perform almost as well in stagnant air at 85° as in fresh air at 60°. Some people, indeed, of whom I am one, seem to work at intellectual tasks more successfully when the thermometer registers in the eighties. A considerable rise in humidity is also generally tolerated with little drop in efficiency, provided the thinker does not walk about or otherwise use his large muscles much. Be guided here by the foregoing table, though don't take it too literally in applying it to mental work.

May not our energies change with that primary source of all heat, light and power, the sun? A few students have lately pointed out curious correlations between changes in solar heat and changes in world business. L. V. Burton, for instance, has exhibited before the New York Electrical Society charts showing the ups and downs in sun and in industry. During the last twelve years, each drop in the sun's heat output coincided with a period of prosperity, while each rise coincided with a period of depression. Solar

radiation, as shown by the records of the Smithsonian Institution, was well above normal throughout the depression of 1920–21 as well as in 1924 and 1927, both bad years for business! Likewise during 1932 and 1933! This may be a mere chance harmony, but it is worth watching. One theory advanced to explain it as a true cause is that an abundance of ultra-violet rays makes men optimistic, while a shortage depresses us all.

Be this as it may, we can assert with confidence that the average man thrives better under bright sunlight than in shadow and gloom. If each single person so thrives, why not suppose that the cumulative effect of sunlight on two billion people is powerful as a social and economic force?

THE WELL-WARMED BRAIN

My own experiences persuade me that we need a thorough inquiry into the effects of general body temperature upon the tapping of the higher mental energies. There is, so far as I can discover, no research in this field. Yet all that has been proved about the familiar correlation between temperature and chemical velocities should encourage such studies.

All my life I have been much more alert in moderately hot weather than in either cool or cold. At the same time I have reduced my gross muscular activity, as nearly all people tend to do in midsummer. Many years ago I also dis-

covered, largely by chance, that cold showers in the morning bath seriously lowered my mental activity for several hours of the forenoon. I gave them up and was immediately rewarded. My next experiment was with end-of-the-day baths. I used to finish off with a cold shower; but I tried dispensing with it and was more than pleased to find myself fresher through the evening and more fully relaxed for later sleeping.

In the course of these simple investigations, I checked up on the best seasons of study, writing, and serious reading. It turned out that exceedingly hot weather was a poor time for such activities, but fairly hot weather was the best of all; that is to say, days ranging between 80 and 90 degrees Fahrenheit. If, however, I had to exert myself physically on such days, the spell was broken; my head work deteriorated greatly then. The ideal formula seems to run about as follows: keep as quiet as possible; eat more salty foods than the dieticians authorize; get very thirsty as a result; then drink vast quantities of plain water, coffee, and milk; under no conditions lie down, even for ten seconds, during the work day; stand on my feet or else walk about the room gently, whenever the first sign of a tension or boredom or mental stalemate develops; and, above all, shift often from topic to topic, or else from one aspect of a subject to some other.

Would I recommend this procedure to all the world? Rather not! It happens to fit my own particular temperature-velocity pattern. It

may not fit ten other people in North America. But this need not turn us from the immediate issue: the unmistakable connection here between temperature, internal and external, and alertness suggests that most people have some optimum heat condition favoring the freest release of mental energies.

A warm body results from fast burning, of course. So do fast nerve currents. These run along, in ordinary temperatures, at about 406 feet per second; but if you chill them away down to the point at which they almost cease to function, and then measure their velocity as you warm them up again slowly, you find that the currents *double their speed with each rise of 10 degrees Centigrade.*

So, you see, that a rise of only one degree speeds the currents up about 10%, while a rise of only one-tenth of a degree speeds them up about 1%. Does this seem trifling to you? Well, it is not. Bear in mind several facts. First of all, healthy people may run as much as 15% above or 10% below the average body heat; so here, you see, is a possible variation of 25% from average, which is by no means inconsiderable. It indicates a parallel difference in the velocities of nerve currents, though of course the absolute speed of the latter remains to be calculated. Probably other factors influence the speed variously in different people; but we have no reason to believe that the general relation between temperature and speed is greatly modified by any such. So we are not far

from the truth if we conjecture that an extreme difference of 100 feet per second in nerve current speeds may occur between the coldest, most sluggish healthy person and the warmest, swiftest one.

Now, in the simplest muscular reflexes, this would not make any measurable practical difference in behavior, would it? So far as you could detect anything with the naked eye, the slowest man would sneeze about as fast as the swiftest. But the picture changes when you turn to the most complex acts of reflecting over some problem. And it changes for the simple reason that here the thinker must, so to speak, traverse thousands of feet of nerve tracts before he finds, at the heart of the labyrinth, the solution of the problem. Take this literally. His central nervous system contains billions of cells, each with ramifying fibres many feet long; and other billions of cells with much shorter fibres. To work out a simple task in arithmetic, such as dividing 5,677 by 13, he may have to send currents scooting up and down several thousand feet of nerve fibre. To make up his mind whether he ought to pay his rent or pack up and move before the landlord sees his furniture coming down stairs, our hero may have to excite a mile of nerve. The greater his indecision, the more likely that he excites a longer tract before reaching the right adjustment. So, in easy problems, the fast man may reach his solution only a fraction of a second ahead of the slow; but in very hard tasks he may

beat the slow one by five, ten, or twenty seconds *for each distinct mental operation.*

Now consider a prolonged task in which there are an even thousand such operations, all hard. A fair illustration here would be learning the elements of some foreign language or a branch of mathematics or the history of a strange country or the principles of a business or trade. At every moment throughout the entire learning process the hot, fast person gains on the slow, cold one. He finishes 100 steps in the mastery of his subject while the slow one is covering 75. But even this difference does not reveal the larger superiority of the fast one. For the field of associations widens with each step in learning. We always learn more that the item we strive to master. We tie it up with sundry other facts and principles as we advance. Though we may aim in one dimension, we achieve in many. A wave of mental stimuli runs out in all the space-time dimensions as we move onward in any given dimension. This, as I see it, is the exact equivalent of electromagnetic and radio processes; a current moving in one direction sets up a field all around it transverse to the line of motion. The faster the nerve current moves, the wider its transverse spread; hence the richer its associative field and hence the net final "experience mass." Mass is always a function of velocity.

Stimulation of brain centers by radio currents taken from high-frequency vacuum tubes speeds up mental processes. Recent experi-

ments in Germany, reported by O. H. Caldwell before the American Electrochemical Society at the May 1933 meeting, show striking improvements in both the speed and accuracy of thinking under such influences. Caldwell stated that the practical bearings of this phenomenon are not yet clear, but he made the interesting conjecture that "perhaps in the future the electric heating of men's brains may make us like gods."

I think we need not launch off into any such dizzy speculation. It is quite enough to know that, just as the body as a whole is accurately brought to any desired degree of fever by radioactivity today, under the amazing new techniques perfected in the past two or three years, so the central nervous system must likewise respond. Faster metabolism means faster neural reactions, of course; and faster reactions, under proper controls, can scarcely fail to improve mental behavior.