57. Lilly, John C. 1958. "Some Considerations Regarding Basic Mechanisms of Positive and Negative Types of Motivations." Am. J. Psychiat. 115 498-504

SOME CONSIDERATIONS REGARDING BASIC MECHANISMS OF POSITIVE AND NEGATIVE TYPES OF MOTIVATIONS [1]

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SOME CONSIDERATIONS REGARDING BASIC MECHANISMS OF POSITIVE AND NEGATIVE TYPES OF MOTIVATIONS [1]

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Over many years, some portions of the brain have been found which are intensely involved in the primitive, basic, motivating, moving, emotional states. Pioneer work by Sherrington, Cannon, Bard, Hess, Masserman, Ranson, Magoun and others demonstrates that there are zones of the brain which when stimulated evoke dramatically violent responses and others where more subtle, less understood, milder, less dramatic, more pleasure-like responses are evoked. However, a sharp and clear operational separation between these two classes of responses was not made until recently; the regions giving such responses are now separated as two distinct sets by using electrical stimuli placed in the brain; in such regions such electrical stimulation is found to function as a motive in behavioral learning situations. Through the work of Olds and Milner(1); Delgado, Rosvold, and Looney(2); Delgado, Roberts, and Miller (3); Cohen, Brown, and Brown(4); Brady, Sidman *et al.*(5); and that in our laboratory(16) the picture of two kinds of powerful "motivational" brain systems has developed rapidly: The first kind functions as if a reward and the second as if a punishment to the learning and learned animal, *i.e.*, motivationally positive and negative systems.

Each kind of system exists side by side with the other within very small regions in the midline deep subcortical structures including the hypothalamus and the midbrain. Our results from mapping such regions of the brain demonstrate that most if not all of the systems previously described which powerfully change an animal's total behavior fall into one or the other of these systems.

To find such systems one may follow the lead of two groups of investigators: Olds and Milner(1) showed that a rat could be trained to switch on short trains of electric stimuli in certain parts of its own brain; Delgado, Roberts, and Miller(2) showed that a cat could be trained to climb a wheel to switch off electrical stimulation started by the observer in other small zones in its brain and in the "painful" zones of the periphery. Using such techniques, Brady *et al.* demonstrated that the first, the rewarding effect, could be found in a monkey. We demonstrated that both rewarding and punishing could be found and mapped in the monkey in great detail(16); and, recently, we have found both effects in another larger mammal, the dolphin of our southern coastal waters.

For a time we were surprised to find in the monkey that the positive, pleasure-like, motivating-to-start-stimuli systems were so large, and the fear, pain-like, motivating-to-stop systems were so small. But when one sees the very powerful effects of stimulating the relatively small negative systems, one can understand that this kind of system may be quite large enough to fulfill its extremely high priority stop, escape, or avoidance functions. When one sees the fearful, down-hill, sickening, destructive effects of continued stimulation of the negative systems in an animal one is reluctant to say that they need be any larger.

The positive, start, approach systems in the monkey are relatively very large, occurring in certain zones as a proximate twin with the negative ones, and also occurring in other regions possibly without its twin such as in the corpora striata. Reciprocal relations and balanced activity of positive and negative motives seem to be assured structurally in the deep powerful midline systems, and something of the positive aspect may be in excess for other regions. Such other regions include functions like sexual ones, which we find to be both motivationally positive and negative. We find alternation over short time inter-

[1] Read at the 17th annual dinner of the Devereux Foundation held during the 114th annual meeting of The American Psychiatric Association, San Francisco, Cal., May 12-16, 1958.

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vals between the two opposite effects in the monkey, *i.e.*, he will first start such romantic activities then stop them within a period of minutes again and again for a disgraceful number of hours(48). This system seems to be at that very demanding primitive level that requires mutual reciprocity between a starting motive and a stopping one to preserve the individual's integrity.

The other positive functions for the larger amounts of tissue seem to be connected with relatively uncharged innocuous prosaic everyday non-romantic activities; in a monkey this may be searching for food, grooming, chattering, *etc.* In the human animal it may be writing and talking—including giving speeches. In other words, any and all activities of the animal all of the time seem to require an oversupply of the positive, pleasure-like, start-like function at a low-level in the brain for continued normal functioning of the whole animal toward better survival and more fun.

Of course, we like to think that in the total action of the brain, the positive tends to overbalance the negative, and that the intellectual functions might be neutral ones, neither positive nor negative, found in excess over both the positive and the negative. Therefore, in the relatively huge cerebral neocortex and in the cerebellum, one might expect to find neutrality or a small excess of positive, rewarding sort of function. This expectation was recently found to be somewhat erroneous even in the small-brained monkey. With proper electrical stimuli and proper time courses, we have found rewarding effects elicitable from cerebellum and punishing and rewarding ones elicitable from cerebral neocortex.

Well, one might say, so what? Rats, cats, and monkeys are small and stupid creatures—may not a larger brain be more impervious to such tampering within its innards? May not the trained, sublimating and sometimes sublime human mind resist and even conquer such artificially evoked crassly primitive impulses? This question of how powerful such stimuli can be in large brains seems only properly answerable by experimenting each on one's own brain so that we have the really individual *inside* answer—even someone else experiencing such stimuli who knows one's language will never be able to thoroughly convince one. And, there are sceptics, who when oneself is experiencing it will not be convinced. Empathy and sympathy do help, but not in the fashion that personal experience can.

However, certain technical dangers make me pause before I put bits of wire in my own head, and, at this time, I am reluctant to ask anyone else to undergo what I won't do or have done on myself. It looks as if normal controls may be slightly delayed in the field. All we have are a few data from sick humans: Some psychotic, epileptic, and Parkinson cases have been stimulated by Bickford, by Sem-Jacobsen, and by Rémond(6); the results show that these two kinds of systems can be found in the human brain but are small and difficult to explore safely.

However, we think it is important to find out more about big-brained animals in far greater detail than we can with the human. For example, do they resemble the small-brained ones in the urgency of motivation aroused in these systems? So far we have found only one animal that has a brain the size of ours who will cooperate and not frighten me to the point where I can't work with him—this animal is the dolphin, a small whale with teeth, an air-breathing mammal (not the fish of the same name). The species used is that caught by the Marineland Research Laboratory for us—the shoal-water porpoise, *Tursiops truncatus*. As adults, these animals reach eight feet and 400 pounds, with a brain up to about 1750 grams. Compared to our 230-250 grams of brain per foot of body length theirs is about 220—he is a fairly close second to us if we remember that the gorilla as our nearest anthropoid cousin has only about one-third of that value. The dolphin also has an edge on his giant cousin, the sperm whale, who, according to Kojima, at about 60 feet scores about 130 grams of brain per foot of body on this scale; a more distant cousin the (balleen) fin whale at 60 feet also, says Jansen, rates about 110(7).

Several investigators have essayed a neurophysiological attack on the dolphin's

large brain, with disappointing failures. An expedition from Johns Hopkins to the Carolina coast in the 1930s brought back neuroanatomical specimens but no data on the living brain; Langworthy(8) reported that failure occurred "because of technical difficulties." Eight of us from five research laboratories[3] in 1955, went on a similar expedition to Florida, with similar results: Our neuroanatomical specimens were magnificent and our neurophysiological findings were zero. We found out what Langworthy may have meant by "technical difficulties": dolphins cannot be anesthetized without danger of dying. These animals, in contrast to dry land ones, fail to breath with relatively light doses of anesthetic, one-fourth that required for surgical levels of anesthesia. In other words, they lack our unconscious, automatic, self-sustaining breathing system. In retrospect this seems reasonable: an unconscious dolphin, under water, will drown if respiratory inspiration occurs. They, as it were, must relate their breathing to surfacing and to the coming opportunities to surface—so this function is almost if not fully voluntary. Therefore, a drunken dolphin dies when he passes out. It seems a sure bet that there are no alcoholic porpoises!

We seemed farther than ever from our intended goal of investigating a brain the size of the human one. However, the Marineland people meanwhile thoroughly imbued me with their enthusiasm for dolphins: Dr. F. G. Wood, Mr. William Rolleston and others were extremely helpful but also quite insistent in their arguments and demonstrations that these beasts, with man, are extremely kind, cooperative, intelligent, trainable, fun-loving, romantic, never hostile or vicious but at times, like some persons, exasperating to deal with; yet they can destroy sharks and whales and battle ferociously with one another during mating season. As a consequence of further indoctrination—at times we felt almost as if the dolphins were playing the same game as the persons at Marineland—some time was spent developing a method which would by-pass the need for and dangers of general anesthesia.

During the last year, it was found to be feasible to hammer percutaneously guides for electrodes into the skull of monkeys (9). The method was tried on dolphins in November 1957; the guides were inserted under local anesthesia into the skull of a dolphin in a small shallow tank so easily and so quickly that the dolphin and we hardly realized what had happened.

To return from this history to the motivational systems, we found such positive and negative systems within the dolphin's brain. The systems are farther apart in this large brain than in that of the monkey; yet they seem as large in absolute size as they are in the monkey; more brain with other, yet-to-be-found functions lies between and around these systems. As in the human brain, evocable motor movements also were found only in relatively isolated regions. The urgency of motives elicited by stimulation of those zones which we have found to date is high and there is evidence that we have yet to stimulate the most powerful ones. Stimulating a punishment area (a negative, destructive, stopping motivational spot) caused a dolphin to shut off the electrical current very accurately at a certain level of intensity. The difference between this naive, wild animal's performance and that of monkeys was the incredibly short time in which she learned to use the switch: compared to the naive monkey's several hundreds to thousands of random trials to learn, she took about 20 to shape up the proper motions of her beak and each of those "trials" had a purposeful look that was a little disturbing to watch.

How did we know first when we were in a negative zone? Every time we first stimulated here, she emitted the characteristic dolphin "distress whistle" (another story!). From that time on she shut off the current at a level well below that at which we previously could elicit the distress call. This whistle, a crescendo-decrescendo in frequency and loudness, was a clue for finding negative, punishing, destructive, stopping systems; we had no

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criteria for positive, rewarding, pleasure-like, starting systems. Empathic methods did not help with this handless, streamlined, hairless animal who lacks our mobility of facial expression. We may have missed such systems because of the lack of such human criteria but finally found one such zone.

With a bit of luck with our next animal we found a positive, rewarding, starting zone. The luck was in obtaining an animal who vocalized vociferously: as soon as we stimulated the positive zone, he told us about it by covering a large repertory of assorted complex whistles, bronx cheers, and impolite noises. Giving him a switch at this point was quite an experience—he sized up what I was doing so rapidly that by the time I had set up his switch he took only 5 "trials" to figure out the proper way to push it with his beak. From that point on, as long as he could obtain his stimulation for every push he made with his beak, he quietly worked for the stimuli. But if we cut off his current, he immediately stopped working and vocalized—apparently scolding at times, and mimicking us at others. One time he mimicked my speaking voice so well that my wife laughed out loud, and he copied her laughter. Eventually, he pushed too rapidly, caused a seizure, became unconscious, respiration failed, and he died. Apparently unconsciousness because of any factor, anesthesia, or brain stimulation, or others, causes death in these animals.

In this abbreviated account, I cannot convey to you all of the evidence for my feeling that if we are to ever communicate with a non-human species of this planet, the dolphin is probably our best present gamble. In a sense, it is a joke when I fantasy that it may be best to hurry and finish our work on their brains before one of them learns to speak our language—else he will demand equal rights with men for their brains and lives under our ethical and legal codes!

Before our man in space program becomes too successful, it may be wise to spend some time, talent, and money on research with the dolphins; not only are they a large-brained species living their lives in a situation with attenuated effects of gravity but they may be a group with whom we can learn basic techniques of communicating with really alien intelligent life forms. I personally hope we do not encounter any such extraterrestrals before we are better prepared than we are now. Too automatically, too soon, too many of us attribute too much negative systems activity to foreign language aliens of strange and unfamiliar appearance and use this as an excuse for increasing our own negative, punishing, attacking activities on them.

What does all this mean in terms of us, our species, aside from communication and empathy with and between us and other species? Turning inward, examining our minds, their deep and primitive workings, can we see evidence of the actions and inner workings of the positive, pleasure-like, start and the negative, pain-fear-like, stop systems? I believe most of us can say, "unequivocally yes". In order, however, to see such activities in the mind in pure culture, as it were, special conditions are needed: First, one must be alone—without a lover to exchange the positive, and without a human sacrificial goat to load with the negative. We are mostly not alone and are exposed to an organized human society which uses both kinds of our activities for its own growth and survival. These surroundings obscure the internal origins of our motivations in a medley of organized background noises, sights, clothing, housing, transport, schedules, and deluges of information demanding replies and action. So one must first be freed of persons and people: Solitude is the first requirement.

Secondly, one should be freed of sources of information from one's then residual surroundings, animate and inanimate. Thirdly, maximum attenuation of physiological and physical stimuli of reactions and exchanges with the surroundings, including all of gravity's and temperature's powerful demands is needed. And, fourthly, a sufficient period of time, a sufficient amount of training, and sufficient number of repeated exposures must be given to develop one's tolerance to one's inner mind.

Once all this is done, (we and other research workers are only beginners at this

isolation work) we find depths dimly seen without these conditions, and we find the positive and the negative, rewarding and punishing, activities deeply imbedded within ourselves. Many men and women before and in our time knew and know these experiences. Our only advantages today are : 1. Our knowledge of these systems in some animals ; 2. Our particularly modern abilities to concentrate our interests on a given region of experience, to withhold easy explanations and thus to avoid killing our curiosity ; and 3. A powerful motivation resulting from the imminent prospects of either total annihilation of our species, or of moving off this planet to other planets and of encountering other species with attainments equal to or greater than ours.

In regard to the basic human motives of reward and punishment, of rewarding and of being rewarded and of punishing and of being punished, we have found some data which may be of interest. For several years we have been studying autobiographical accounts of pairs of persons and of solitaires isolated in the long night of the polar winter and isolated in protracted sea voyages in minimal size vessels(10, 11). Our detailed findings are too lengthy to recount here and are being presented in a book currently in preparation. In essence we find that persons in such circumstances tend to divide themselves into two extreme groups : those who are convinced continuously (or become so) that they will survive (the self-confident or "egophilic" ones) and those who will not survive if alone long enough (the self-fearing or "egophobic" ones). Some of those in the self-confident group have come through experiences which are as extreme as can be imagined and still allow one to survive at all. Those in the self-fearing group about whom we hear at all are usually one of a pair or are in larger groups and are reported second hand. Usually it is found that such persons move toward their own destruction in circumstances not necessarily too extreme for real survival. Walter Gibson gives us both extremes in his book, *The Boat*(12). "Who Ate Who (sic) in the Arctic" is a grim old joke with a parallel one of "Who Killed Who's Self at Sea". The more important group are those who survived and why they could do so.

Some of the mechanisms involved in these extreme groups of persons possibly may be analyzed in more microscopic detail in shorter term experiments in isolation of small groups and of solitaires. If one frees up a person from other persons and attenuates his physical exchanges with his surroundings, one can detect some phenomena which apparently are related to the above considered basic internal structure of his mind. If alone long enough in surroundings which are the *same* and *even* enough long enough, one's internal mental workings reveal their basic character rather quickly, *i.e.*, in a relatively few hours. *Sameness* and *evenness* are absolutely necessary. I am referring now to the results of our "tepid dark silent bath in the tank" at NIH(10, 11) experiments rather than the "monotonous rest on the bed in the box experiments" at McGill(13) ; even though, apparently, similarities exist, I know our own results in far greater detail, especially in my own case. (Such work has become so popular recently that it seems very difficult to isolate experiments and subjects on isolation to the point where they are isolated enough to have significance). In such extreme surroundings one can find out if one is self-confident or self-phobic. By careful and slowly applied graded dosage of many short exposures to such conditions, one can develop an increasing immunity rather than an overwhelming love or aversion for the tank. During such training it becomes obvious which of the basic drives, positive or negative, rewarding or punishing, surviving or dying, predominate at a given time. By carefully watching and recording all those phenomena which one watches and records in psychotherapy and psychoanalysis one can see the algebraic sign of the dominant themes. Analysis of the material may show the powerful hidden desires, even such extreme ones as incorporation, incest, cannabalism, and murder. There is one advantage in the isolation situation over the other kinds of situations. There are no real present excuses to blame for the emotional storms of love or hate, the fantastic beliefs, or the mental projec-

tions which can and do occur. Alone with one's God there are no alibis(14, 15).

Contrary to the case of the acting out of the usual analytic patient, there is no reality to serve as a sacrificial goat on the twin altars of either love or of hate. In this way a mind in pure culture can see its own true nature, and have an opportunity to see if it can solve its own basic internal self-contained conflicts in order to have a try at changing the unsatisfying parts. Contrary to those who say such experiences in the tank or on the isolation bed are identical with mental illness or even psychosis, those healthy intact subjects who have been through such experiences know and feel this point of view to be wrong. For such subjects, the experience can be quite interesting.

Along this exploratory path of research a seemingly more trivial but possibly eventually important finding was made : when weightlessness is approximated in the tank by the floatation, and isothermicity of one's skin is achieved at 94.1°F., one can rest better and *faster,* as it were, than on a bed. The mental problems in the tank ensue *after* one becomes *too rested* and hence too restless and too eager. In my case, two hours rest without sleep in the tank can equal about 8 hours sleep on a bed within a 24-hour cycle unrepeated. Thus we may write a note to the "man in space" program : the major problem with weightlessness at the beginning of the exposure may be a superabundance of energy and *no need for sleep* (unless the man fights himself internally and wears himself out). Of course real pain and/or fear will use up energy rapidly and counterbalance the above effect. Those who, mentally, can afford to relax and enjoy the above effects, who are not exposed to outside dangers too continuously, and who can effectively meet the other real demands of the control of their container, will be able not only to survive but to have one of the most moving adventures (inside and outside !) ever to be experienced by man. In our ventures into the frontiers of outer space we will carry the frontiers of our inner minds with us. It seems that to best empathize with a dolphin man may have to move into outer space ; or conversely the dolphin may teach us how to live in outer space without gravity.

The cogency and urgency of finding and understanding the internal origins and substrates of rewarding and punishing systems are obvious to many persons. But one must avoid taking too seriously that which one has within oneself and finds so clearly in persons in isolation : Projections of negative and of positive motivations, powerful projections acting as if coming from other persons and external reality but actually originating inside one's own self. In isolation the evidence of the truth of the existence of one's own projections is so obvious as to be unescapable and humbling. In our experience, to try to escape these truths, subjects use ingenious and subtle techniques similar to those well-known to psychoanalysts and to psychotherapists. To recognize in one's self at least some of these techniques may allow one, one may think, to see them in others. But, a caution is in order : The human mind is the only province in science in which that which is assumed to be true either is true or becomes true. (That law I do believe to be true !) This is a sublime and dangerous faculty. To have and to hold a useful and successful set of basic beliefs and truths about the rewards and punishments in one's self is also sublime, sometimes satisfying, and sometimes punishing, but never dull or monotonous. To find one's self to be more egophilic than egophobic is, of itself, an egophilic advantage increasing one's own fun and that of those persons closest and most important to one. By careful and continuous nurture one may achieve the classic command to "love thy neighbor as thyself," but only after learning how to lessen thy fear of thyself and how to increase thy love for thyself.

Summary

In recent years the exploration of the brain has shown some of those systems which are involved in the production and maintenance of certain motivational states. In rats, Olds and Milner demonstrated rewarding effects of stimulating certain systems ; in cats, Delgado, Roberts, and Miller, and Delgado, Rosvold, and Looney showed punishing effects

from stimulating other zones. Brady *et al.* confirmed Olds and Milner in the cat and monkey. We have confirmed both effects in the monkey, and have investigated in some detail the reward and the punishment effects in various loci. We have found also the same effects from a few loci in the porpoise's (dolphin) brain; this animal's brain is as large as the human one and hence is of interest. A number of workers have been doing exploratory studies on healthy intact human individuals in isolation from other persons and from their usual levels of exchange with the physical environment; by such means one may investigate positive and negative motivations in more or less pure culture in the subjective psychological sphere. Such research is full of technical problems and pitfalls; it shows that in these special conditions some minds tend to disguise the presently acting true motives and to project them in multitudinuous forms into the minimally stimulating and non-reactive reality. Some useful data are also derived from autobiographical accounts written by those who have been exposed to isolation at sea or in the polar regions; the dominance of the positive or of the negative motivations can be seen operating especially clearly in such accounts. Such exploratory studies are slowly adding to an understanding of positive and negative motivations and offer powerful tools for further studies.

BIBLIOGRAPHY

1. Olds, J. and Milner, P. : J. Comp. Physiol. Psychol., **47** : 419, 1954.

2. Delgado, J. M. R., Rosvold, H. E., and Looney, Edmund : J. Comp. Physiol. Psychol., **49** : 373, 1956.

3. Delgado, J. M. R., Roberts, W. W., and Miller, N. E. : Am. J. Physiol., **179** : 587, 1954.

4. Cohen, B. D., Brown, G. W., and Brown, M. L. : J. Exp. Psychol., **53** : 228, 1957.

5. Sidman, M., Brady, J. V., Boren, J. J., Conrad, D. G., and Schulman, A. : Science, **122** : 830, 1955.

6. Forster, F. : First Conference on Electrical Studies on the Unanesthetized Brain, Georgetown Univ., Washington, D. C., June 10-13, 1957. In press.

7. Jansen, J. : Norwegian Whaling Gazette, 480, 1952.

8. Langworthy, O. R. : Brain, **54** :225, 1931.

9. Lilly, J. C. : Science, **127** : 1181, 1958.

10. Lilly, J. C. : Group for the Advancement of Psychiatry, 1790 Broadway, New York : Symposium No. **2** : 13, 44, 1956.

11. Lilly, J. C. : Psychiatric Research Reports 5, American Psychiatric Assoc., 1-28, June 1956.

12. Gibson, Walter : The Boat, Boston : Houghton Mifflin Co., 1953.

13. Heron, Woodburn : Scient. Amer., **196** : 52, 1957.

14. Freud, Sigmund : The Future of an Illusion. New York : Horace Liveright and the Institute of Psycho-analysis, 1928.

15. Huxley, Aldous : Heaven and Hell. London : Chatto and Windus, 1956.

16 Lilly, J. C. : *In* : Reticular Formation of the Brain, Boston : Little, Brown and Co., June 1958.