73. Lilly, John C. 1962. Cerebral Dominance in Interhemispheric Relations and Cerebal Dominance. Vernon Mountcastle, M.D., Ed. Johns Hopkins Press, Inc. Baltimore, Md. P. 112-114

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The problem of cerebral dominance in the human is best exemplified by the tendency for a lateralization of the speech areas and of handedness as is presented in other papers in this symposium. In the case of another species, the bottlenose dolphin (Tursiops truncatus Montagu), some unexpected additional evidence of another type of cerebral dominance is beginning to appear in our current research program (Lilly, 1961a), alternation of dominance. Here I will present a short summary of our findings. Since the dolphin properly has no hands, one might look for a question of lateral dominance of one flipper or the other. None such has been found. The animals can use each flipper independently or co-ordinated with the other.

Some swimming patterns show a preference for one side. In the case of Elvar, a swimming pattern has appeared in which he swims in very tight circles, touching his flukes to his rostrum as he swims: his preference is to swim to the left. He does this so frequently that wrinkles have appeared in his skin on the left side; no similar wrinkles have appeared on the right. The animal most closely associated with Elvar, Chee Chee, also tends to swim in tight circles to the left, similar wrinkles are appearing on her skin on the left side.

In regard to lateralization of the sleep pattern, these animals sleep with one eye closed at a time. The eye closures are 180 degrees out of phase; it is rare to have both eyes closed at once. The accumulated sleep for each eye runs from 120 to 140 minutes per day. The sleep occurs in brief periods between each respiration running from 20 to 40 seconds per eye closure. A dolphin wakes up in order to take each breath. Alternate sides are rested alternately.

Their phonation mechanisms are bilateral though unsymmetrical. We have demonstrated (Lilly & Miller, 1961b; 1961c) that a dolphin can whistle and click or whistle and buzz simultaneously under water. Recently we have had opportunities to observe animals in air with open blowholes, using the right and left phonation mechanisms separately and/or simultaneously for different kinds of emissions (Lilly & Miller, 1962a). A small female, Sissy, recently has been clicking with her left side and whistling with her right side simultaneously in air. Elvar has been producing humanoid sounds simultaneously with his left side and with his right side, or with his left side alone, or with his right side alone. In several emissions we have detected very large frequency differences, and quite different patternings between what he says with his left side versus what he says with his right side simultaneously. He can produce humanoid sounds at a low frequency on one side and at a very much higher frequency on the other.

Eye movements can be quite independent of one another. An animal can scan a whole 180 degrees of solid visual angle on each side of its body quite independently of the eye movements of the other side. The dolphins have a stereoscopic binocular visual field, forward and downward, which they apparently use at the last instant before grabbing their prey. In mapping the motor cortex of these animals in the unanesthetized state, we found that the monocular eye movements are represented contralaterally and that binocular eye movements are represented homolaterally and contralaterally.

There are no obvious gross neuroanatomical findings which can adequately account for the above behavioral and physiological findings (Lilly & Miller, 1962b; Langworthy, 1932). To gross inspection the two halves of the brain look equal; the corpus collosum in the adult is well developed, as are all the subcortical cross-connections.

The phonation sacs just below the blowhole are paired, and usually the right side is larger than the left. This may be merely a matter of the lowest pitch which the animal can produce by each of the right and the left sides. Questions as to whether all animals prefer the right side for whistling and the left side for clicking are yet to be answered. Other kinds of preferences establishing laterality of action are yet to be explored. The one generalization that we can make about this species is that they are able to control quite independently, and yet simultaneously, with different patternings the two sides of their body in regard to vision and in regard to phonation and swimming. They are able to control quite independently the motions of the right and the left flippers and have control of symmetrical movements of the tongue.

Motions such as those of swallowing, of high speed swimming straight ahead, and of slow speed swimming backwards are done with great exactness and presumably require symmetrical use of the nervous system on both sides equally.

Problems such as the dominance of one hemisphere over the other hemisphere during these extremely complex vocalizations are yet to be explored. Central representation of the phonation mechanism (afferent and efferent) is yet to be determined. It may turn out that like the eye movements, the phonation mechanisms have a contralateral and a homolateral representation. It would be expected that the phonation mechanism, for example, during respiration would be a bilateral representation. During respiratory movements the two sides of the phonation mechanism each open very widely, allowing the passage of air quite symmetrically on the two sides.

Problems such as the localization of their whistling language on one side and their click language on the other, or each of them bilaterally, in the cerebral cortex are yet to be answered. From our results with the humanoid sounds, it looks as though each cortex will turn out to be functionally able to carry on quite independently of the other side. However, during emotional states, i.e., when the dolphin is irritated or sexually aroused, the phonation mechanism on each side says the same thing and is operated simultaneously with great vigor and intensity. The dolphin's bark or angry buzz is a highly symmetrical and single minded operation. The independence of the two sides is seen best with a relaxed dolphin who can concentrate on the problems in hand without emotional involvement.