# THE FUNCTIONAL RESULTS OF MUSCLE TRANSPOSITION IN THE HIND LIMB OF THE RAT

Muscle transposition is ~~commonly~~ occasionally undertaken in orthopedic surgery for the correction of motor paralyses, and has been used in the laboratory to study the adaptability of the central nervous system.

Functional adjustments of two types have been reported to follow the transposition of muscles: According to the general clinical view, the action of transposed muscles is adjusted <u>gradually</u> by means of a <u>learning process</u>. Several laboratory studies, on the other hand, report an <u>immediate</u>, <u>automatic</u>, <u>reflex</u> adjustment without any learning period--indicating an extreme plasticity of the nerve centers.

In order to analyse further the adjustment process following muscle transposition, flexor and extensor muscles of the hind foot of the rat were transplanted so as to produce a reversal of foot movement.

(1st slide.) The slide shows the essential part of the operation. The lateral gastrocnemius muscle inserting normally on the achilles tendon of the heel was brought forward and inserted on the dorsal surface of the foot so as to produce dorsi-flexion instead of plantar flexion. And the two main dorsi-flexors of the foot were crossed underneath the gastrocnemius and sutured to the achilles tendon so their contraction caused plantar flexion instead of the normal dorsiflexion.

All the other shank muscles acting on the foot were extirpated. This removal of associated muscles, according to orthopedic principles, presents the best possible condition for readjustment. It also clarifies for study the action of the transposed muscles.

On recovery of function, nine rats so operated, ranging in age from 50 days to 1 year, displayed complete ~~clear-cut~~ reversal of all the active foot movements.

( slide 2 ) The diagrams indicate the type of reversal of foot movement which occurred when the leg as a whole was extended.

( slide 3 ) The same thing is shown in the photographs. The plantar flexion which normally accompanies knee extension is reversed to dorsi-flexion.

( slide 4 ) These diagrams indicate the reversal when the leg was flexed. The normal dorsi-flexion of the foot accompanying flexion of the knee was reversed to plantar flexion.

( slide 5 ) And the photographs show the same (This reversal of movement shows up quite clearly in motion pictures.)

When the rat tried to lift the foot in walking, instead of raising it, the knee, the foot pulled downward and scraped along the floor, & when they tried to rise upright on their toes, they fell back on their heels and the toes swung up in the air.

No automatic reflex adjustment as reported in other studies occurred in these rats.

Nor, contrary to expectations, did ~~any~~ even a gradual adjustment appear, although the rats were kept longer than a year after the operation.

This reversal of movement was not only useless & awkward, but in many activities was a decided hindrance to the rats

When no adaptation had occurred after $2\frac{1}{2}$ months, special measures were taken to help induce reëducation:

(1) The contralateral hind leg was amputated on two of the rats. (2) On three others, both front legs were amputated at the shoulder. (3) Four others were trained for $3\frac{1}{2}$ months to rise upright on their hind legs for food ~~almost out~~ just barely w'in reach. (4) Then two of the four were compelled for more than four months longer to climb a vertical ladder for their food.

But the reversal of foot movement persisted in all cases unchanged.

1. Control animals similarly operated, save that the muscles used for transposition were left uncrossed, were run along with the experimental group on all of the training procedures.

2. The reversed movement was not a passive mechanical action. It disappeared on cutting the nerves of the transposed muscles, and it did not occur when the knee was passively flexed and extended by manipulation under light anesthesia.

3. Nor was it produced directly by stretch reflexes because it persisted after deafferentation of the limb.

4. Control rats with the nerves crossed instead of the muscles (operation similar otherwise) exhibited the typical reversal of movement that followed muscle transposition.

5. Controls with both the nerves and the muscles crossed in the same leg (operations otherwise identical) displayed as

a result of the double reversal, foot movement in the <u>normal</u> phase. This was important in that it showed conclusively that the transposed muscles were quite capable of producing normal coordination when the motor nerve discharges were properly timed. There seemed to be no reason as far as the anatomical and mechanical conditions of the operation were concerned why readjustment should not have occurred.

The [illegible] fact.

The unmodifiability of the hind limb contraction patterns in these rats and their persistence after deafferentation indicate that the motor processes for limb coordination have a [illegible] <u>central</u> nervous organization. Locomotion is certainly not the simple automatic effect of stretch reflexes, as has on occasion been suggested.

The inability of the rat to change these fundamental motor patterns by reëducation, as is sometimes possible in the case of human beings, is due probably to the lesser degree of specialization of the central nervous system.

In view of the adeptness shown by this same strain of rats in modifying their behavior in mazes, inclined-plane problems, ladder climbing, and such performances: these results support the contention that the process of habit formation is heirarchical in nature and involves the association of elementary units of behavior which are already organized.