

of these phenomena are explained by assigning the rôle of hydrogen transportation to the SH-insulin complex. These experiments, however, are inconclusive because insulin cannot be prepared chemically pure.

Conclusion. Cysteine diminishes the hypoglycemic action of insulin.

9831

Further Studies on Tongue Innervation.*

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This study constitutes an attempt to elicit proprioceptive impulses from the tongue musculature and to determine their pathway into the central nervous system. Since the cathode ray oscillograph has recently proven extremely valuable in the determination of the sensory innervation of the accessory musculature,¹ it was used in this study.

The observations of Langworthy^{2,3} (cat), Van der Sprenkel⁴ (hedgehog), and Corbin, Lhamon and Petit⁵ (monkey), suggest an afferent contribution to the hypoglossal nerve from the upper cervical dorsal root ganglia, proprioceptive in function. However, Hinsey and Corbin⁶ obtained no evidence of myelinated fiber degeneration in the peripheral portion of the hypoglossal nerve of the cat after removing the upper 4 cervical dorsal root ganglia. Barron⁷ obtained no evidence of proprioceptive activity in the hypoglossal nerve from traction on the tongue but did record action potentials, which he believed to be proprioceptive in origin, from the lingual nerve. Although Langworthy^{1,2} (cat) and Tarkhan⁸ (rabbit) re-

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¹ Corbin, K. B., and Harrison, F., *J. Comp. Neurol.*, in press.

² Langworthy, O. R., *J. Comp. Neurol.*, 1924, **36**, 273.

³ Langworthy, O. R., *Johns Hopkins Hosp. Bull.*, 1924, **35**, 239.

⁴ Sprenkel, H. V. Van der, *J. Comp. Neurol.*, 1934, **36**, 219.

⁵ Corbin, K. B., Lhamon, W. T., and Petit, D. W., *J. Comp. Neurol.*, 1937, **66**, 405.

⁶ Hinsey, J. C., and Corbin, K. B., *J. Comp. Neurol.*, 1934, **60**, 37.

⁷ Barron, D. H., *Anat. Rec.*, 1936, **66**, 11.

⁸ Tarkhan, A. A., *Z. Anat. u. Entwickl.*, 1936, **105**, 349.

port the presence of muscle spindles in the tongue, Boeke⁹ was unable to find muscle spindles in the tongue of the hedgehog, and we¹⁰ failed to find muscle spindles in the intrinsic tongue muscles of the cat.

Sixteen cats under pentobarbital sodium anesthesia were used in these experiments. Recording leads, consisting of two 26 gauge silver electrodes chlorided electrically and separated by 1 to 3 mm. were connected to a 3-stage resistance coupled amplifier which led to a cathode ray tube and loud speaker. Amplification was such that an input of 10 uV gave a deflection on the screen of 1 cm. at the highest amplification used. The tongue was stretched by means of a thread through its tip. Twisting and distortion of the tongue were achieved by an insulated clamp applied to the tip.

In that portion of the hypoglossal distal to the ramus descendens hypoglossi there is little or no background activity of the type commonly seen in nerves mediating proprioceptive impulses from skeletal muscle.^{1, 11} Stretching or twisting the tongue elicits no activity in this portion of the hypoglossal. When C1, C2 or C3 ventral rami are placed on the recording electrodes, there is background activity characteristic of proprioceptive fibers, but no increase in this activity is obtained by traction or torsion of the tongue. However, if the tongue is forcibly pulled so that the hyoid muscles are stretched or if these muscles are individually stretched, an increase in activity is obtained from C1 ventral ramus. The descending branch of the hypoglossal has been similarly studied but has never yielded a response to stretching of the tongue.

The lingual nerve, peripheral to its anastomosis with the chorda tympani, exhibits very little background activity. There is a burst of spikes when the upper surface of the tongue is lightly stroked. Similarly, an increase in the activity in this nerve is produced by pulling the tongue if such a maneuver causes the tongue to touch adjoining structures. However, if the tongue is stretched so that it does not rub against the teeth or oral mucous membrane, no increase in activity is obtained. Furthermore, brief application of 8% cocaine to the tongue's surface so as to just eliminate tactile impulses, abolishes background activity if it is present and no impulses arise when the tongue is stretched or twisted. These observations were made immediately upon disappearance of tactile responses, before

⁹ Boeke, J., *Z. f. Mikr.-Anat. Forsch.*, 1927, **8**, 561.

¹⁰ Lhamon, W., Yee, J., and Corbin, K. B., work in progress.

¹¹ Mathews, B. H. C., *J. Physiol.*, 1933, **78**, 1.

there was time for the penetration of cocaine into the muscles, as indicated by the fact that simultaneous faradic stimulation of the hypoglossal nerve evoked contraction of the intrinsic tongue muscles at the same threshold as before cocaine was applied.

The conclusion that proprioceptive impulses are set up in the lingual nerve by stretching or distortion of the tongue is not convincing unless tactile impulses are excluded. Barron's⁷ statement that, "These discharges, when recorded in single fibre preparations, did not have as high an initial frequency as that described by Mathews ('33) for muscle spindles and the end organs producing them adapted more rapidly," suggests to us that these discharges may well have been tactile.

In 3 cats, C1 ventral ramus was sectioned on one side and C2 on the opposite side. After 9 days had elapsed, the distal portion of the hypoglossal was studied for degenerating fibers by the direct osmic acid technique,¹ which we prefer to the Marchi technique for peripheral nerves. No degenerating fibers were seen in these preparations after careful teasing and study.

From the data presented it is reasonable to conclude that if there are proprioceptive endings in the intrinsic muscles of the cat tongue (which seems very likely), the impulses set up by these endings are (1) so few in number as to escape detection by our methods; (2) mediated by fine myelinated or unmyelinated fibers which may not produce recordable potentials at the amplification employed; or (3), mediated by nerves other than those we have studied. If the proprioceptive impulses from the tongue musculature are mediated by unmyelinated fibers, unlike fibers generally accepted as proprioceptive in function, they would not have been detected by the degeneration technique employed.

Summary. The above data offer no evidence that the hypoglossal, lingual or upper cervical nerves mediate proprioceptive impulses from the intrinsic tongue musculature of the cat.