

ausgerichteten Strichgruppen verblaßten in der Wahrnehmung abwechselnd mehr oder weniger stark. Dies geschah nicht, wenn die senkrechten und waagerechten Striche der Fig. 1 d so gegeneinander verschoben waren, daß sie sich kreuzten. Auch bei monokular gesehenen gekreuzten Liniengittern trat im Gegensatz zu gekreuzten Sinusgittern [4] kein Wechsel auf. Linienkreuzungen ergeben nur dann eine stabile Wahrnehmung, wenn sie schon vor der Fusion vorhanden sind, nicht aber, wenn die senkrechten und die waagerechten Linien erst binokular überlagert werden (Fig. 1 b). Man kann dies so deuten, daß es schon im monokularen Bereich des visuellen Systems neurale Korrelate für Linienkreuzungen gibt, die notwendig sind, wenn im binokularen Bereich Kreuzungen abgebildet werden sollen.

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Lateral-line Efferents to Mechanical and Visual Stimuli

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The sensory cells of lateral line organs in fish and amphibia are endowed with both afferent and efferent innervation exactly like those of the close-related stato and acoustico system [1]. Shearing displacement of the cupula, which produces excitation of the sensory cells in the vestibularis and lateral line system, may be caused by mechanical stimulation or active body movement as well [2]. Klinke [3] and Hashimoto *et al.* [4] found in teleosts a mechanism in the vestibularis and lateral line system that compensates excitation during body movements by centrally controlled activity changes of efferent nerve fibers. Klinke [3] noticed changes of afferent activities after visual stimulation. Roberts and Russell [5], on the other hand, did not observe efferent lateral line activity in exposing dogfish to water jets and visual stimuli.

In order to clarify whether this is true for teleosts (*Tilapia leucosticta*, Cichlidae), we examined the influence of these stimuli on the efferent lateral line activity.

The experiments were carried out on curarized animals which were fixed in swimming position [6]. The recordings were obtained from the proximal part of the R. lat. lat. superior by means of Ag-AgCl hook electrodes. Water jets of different pressure (column of water 25–175 cm) were applied to the intact lateral line organs on head and body, and visual stimuli (light pulses: duration 0.2/0.5 sec; intensity 800 lux) were applied to either eye. The stimulation sites were located ipsi- and contralateral with respect to the recording site.

In the recordings an evident efferent spontaneous activity was observed as in *Rutilus rutilus* [7]. The experiments showed that efferent activities are increased by ipsi- and contralateral water jets. Contralateral stimulation shows a stronger response than does ipsilateral stimulation. The frequency increase comes up

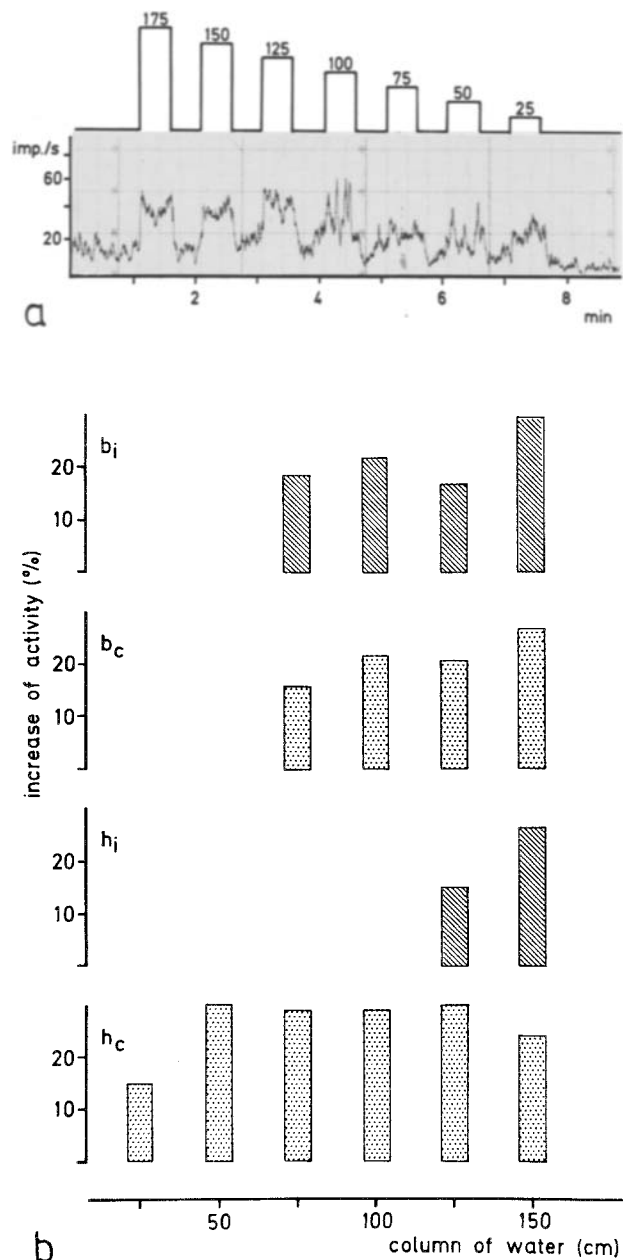


Fig. 1. (a) Continuous analog writing of efferent lateral line activity during periods of water jets. The columns show the different intensities of stimuli (height of column of water in cm). (b) Increase of efferent activity in different stimulation sites (averaged from 3 single responses); b_i body, ipsilateral; b_c body, contralateral; h_i head, ipsilateral; h_c head, contralateral; duration of water jets 10 sec

to 100% (Fig. 1 a) with high stimuli (column of water 100–175 cm, duration of stimulus 30 sec). The increase can be observed by stimulating the lateralis regions in head and body. A comparison of percent increases of activity in a single animal is demonstrated in Fig. 1 b.

Visual stimuli showed a lesser increase (about 20%) of efferent activity in all cases. In addition, there often was a burst discharge after the end of stimulation. In 39 ipsilaterally applied stimulation series, only 7 showed changes in efferent activity. In 13 contralaterally given stimulation series, changes of activity were observed in 6.

The results clearly show that there is, in fact, a compensation of natural stimuli (water jets) in the lateral line system. Visual

stimuli also lead to the transfer of efferent impulses to the lateral line organ; this allows the conclusion that these impulses are given synchronously to motoric efferent impulses. Thus the lateral line organ remains admissible to relevant stimuli at active movements.

Further experiments should explain why the applied stimuli induce an increase of efferent activity in all cases.

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Active Trigeminal Regions in Fish Medulla

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Knowledge about transferring and processing of mechanical and thermal information in bony fish is very incomplete [1]. Only a few detailed studies exist concerning the course of the sensory nerves and their connections in the brain [2, 3]. The morphology of the brain, especially of the medulla oblongata, varies over a wide range according to the fish's way of living [4]. Therefore locating and delimiting the fiber tracts and corresponding nuclei is difficult.

In a recent anatomical investigation on cyprinoids [5], degeneration experiments on trigeminal, facial, and anterior lateral line nerves are described, which show their nuclei regions and courses in the medulla oblongata. Our own degenerating experiments on the trigeminus in the medulla of *Rutilus rutilus* L. (total length 14–15 cm) did not give clear results as to distinct regions. The observed fiber degenerations are to be found up to a depth of about 900 μm in the rostral part of the medulla. The nerve bundles seem to split and overlap in widely branched terminals.

In order to gain further insight, marking experiments were carried out after recording from active neurons which responded to peripheral mechanical stimulation. Here central parts were studied which belonged to the maxillary branch of the trigeminus in the medulla. The position of the steel electrode was marked after successful recording [6]. The electrodes were insulated except for a free tip of 10–20 μm . The best results were obtained with DC impulses with a magnitude of 3–4 μA and a duration of 5–7 sec. The diameters of the marks ranged from 20–30 μm ; their length was 20–100 μm . The marks were histologically stained by the Prussian blue reaction.

Fig. 1a shows the transverse distribution of the identified marks with regard to the descending trigeminal tract within the medulla. The lateral depth of the marked spots ranges from 450–1,100 μm , the distance from the ventral side of the medulla from 300–1,300 μm .

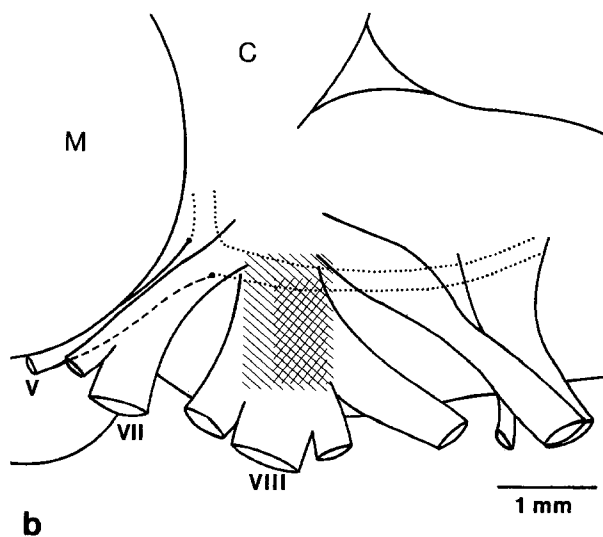
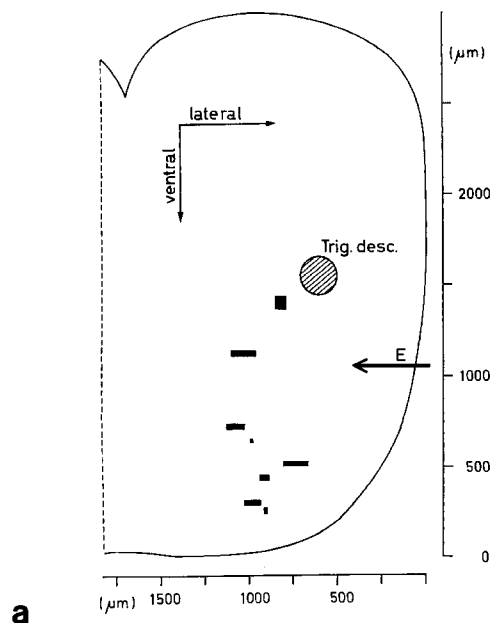


Fig. 1. (a) Transverse section through medulla oblongata with marks of active neurons (maxillary branch); *E*: direction of entrance of marking electrode. (b) Lateral view of medulla with zone of active neurons; *double-hatched*: marking zone; *single-hatched*: recording zone without marking; *C*: cerebellum; *M*: mesencephalon. The dotted lines represent the trigeminal tract

These results prove that in fish the distribution of the 2nd-order neurons, corresponding to the maxillary branch, spread over a large region of the medial and ventral part of the medulla.

Another finding is the distinct small zone for the region of the 2nd-order neurons in the longitudinal axis of the medulla. The nerve fibers of the R. maxillaris terminate below the caudal part of the acoustic root. The marks are confined in length to a zone of about 500 μm . Recordings without following marking confirm this finding. The whole region of the 2nd-order neurons found for this trigeminal branch is restricted to an area of about 800 μm . Fig. 1b demonstrates the zones of the marks (double-hatched) and the successful recordings without marking (single-hatched) in the longitudinal axis of the medulla.