When GABA was added to the normal medium in a concentration of $2.8 \times 10^{-4} M$, the postsynaptic potential was markedly depressed (Figure A-b). Though in this record the presynaptic tract potential was slightly increased in height, this was not the consistent observation in the present series of experiments. The concentration of GABA to cause minimum detectable suppression was about $5 \times 10^{-5} M$. Washing the slice with the normal medium resulted in the recovery of the control potential (A-c). The slice was then imersed in the Cl-free medium. In this medium, the postsynaptic potential was substantially augmented (B-a) but application of GABA ($2.8 \times 10^{-4} M$) no longer caused any noticeable suppression in the potential (B-b). Subsequently, in Figure C, the slice was immersed in the normal medium containing strychnine in a concentration of $3 \times 10^{-5} M$. Just as in Figure B, the control response was augmented in this solution and GABA was without effect (C-b). Picrotoxin (up to $1 \times 10^{-3} M$) was found in another experiment to be entirely without effect either on the control response or on the depressing action of GABA.

In the present experiments, it was found that GABA strongly suppressed the potential evoked in the superior colliculus in a substantially low concentration. As reported previously[3], in the slices prepared from the cortex, GABA could not cause such strong suppression even in much higher concentration (about 100 times). The fact that GABA was effective in a low concentration in the superior colliculus suggests that GABA exerts a specific inhibitory action on the neurons in this part of the brain.

The natural inhibitory transmitter in the mammalian brain has been shown to exert its depressing effects mainly by increasing membrane permeability to Cl ion[4]. Therefore, it is expected that effects of the inhibitory transmitter are blocked in the Cl-free medium[5,6]. Strychnine is also a well-known blocker of the action of the inhibitory transmitter in the spinal cord[4]. The observation made in the present experiments that the depressant action of GABA was blocked by strychnine or in Cl-free medium indicates that in the superior colliculus GABA closely simulates the action of the inhibitory transmitter.

The control response was larger in the Cl-free medium or in the presence of strychnine than in the normal medium. In order to explain this observation, we assume that, in the slice, the inhibitory transmitter was released spontaneously from the nerve terminals. The released inhibitory transmitter might be without effect in the Cl-free medium or in the presence of strychnine but might exert some depressant effects in the normal medium. This could result in the decrease of the control response in the normal medium[7].

Résumé. L'acide butyrique gamma-amino (GABA) en basse concentration a réduit le potentiel suscité in vitro dans une tranche de *Colliculus superior* chez le cobaye. Cette action suppressive de GABA ne s'est pas produite dans un medium sans chlore ou avec de la strychnine. On en a conclu que GABA simule le transmetteur inhibitoire dans le *C. superior*.

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Responses of the Oculomotor Units to the Labyrinth Stimulation Under Hypothermia

In previous experiments, the influence of the labyrinth on the unitary discharge of the oculomotor nuclei was investigated in curarized guinea-pigs[1-4]. Object of the present research is to analyse the behaviour of the oculomotor unit responses to the stimulation of the labyrinth in curarized guinea-pigs during progressive body cooling and rewarming. It is well known that the body temperature modifies the ocular responses to stimulation of the labyrinth[5-7].

Experimental. The experiments were carried out in 36 curarized guinea-pigs (1–2 mg of Intocostrin). All the technical procedures (anaesthesia, surgery, recording, microelectrode preparation) were the same as those employed in our previous papers[1-4]. In several experiments the lower beam of the oscilloscope recorded the action potentials of a few fibres of the ipsilateral oculomotor nerve, picked up by means of a microelectrode. Progressive cooling of the guinea-pigs was accomplished by covering the body of the animals with pieces of ice. The body temperature was recorded from the colon during the entire course of the experiments by a Hg thermometer (sensitivity 0.1 °C). The colonic temperature of 18 °C was usually attained in 30 min after which the guinea-pigs were brought back to the initial colonic temperature of 37 °C within 30 min by dipping the animal's body in warm water (40 °C). The records of the mesencephalic unitary discharge were made both during decrease and increase of the body temperature. In many experiments the temperature of the mesencephalon was also recorded by means of a copper-constantan thermocouple connected to a 4 stage DC amplifier. The mesencephalic temperature variations consistently followed the colonic temperature modifications.

Stimulation of the labyrinth was usually performed by warming a limited point of the osseous ampulla of the superior or lateral semicircular canals exposed by opening an epitympanic recess; the tip of a steel needle heated to a temperature of 60–70 °C was applied to the bone of the

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superior or lateral ampulla for 1–2 sec. It was established in our previous investigation[2] that warming a point of an osseous ampulla induced a temperature variation from 0.3–1.5 °C in the respective semicircular canal.

The sites of recording within the mesencephalon were marked by electrolysis and ascertained by histological control.

Results. In all the experiments the effect of the labyrinth stimulation was tested at a body temperature of 37–36 °C, before cooling the animals. A single semicircular canal was stimulated and preference was given to the semicircular canal whose stimulation induced rhythmic responses. In this investigation the same 3 types of response were recorded as those observed in previous studies[1,2]. That is rhythmic (quick and slow) and tonic responses (continuous activation).

This report is based on 18 correct locations of the recording microelectrode tip within the oculomotor nuclei of guinea-pigs. The spontaneous discharge of the oculomotor units decreased during progressive cooling. The frequency of the rhythmic quick bursts elicited by stimulation of the labyrinth showed an increase at the beginning of the cooling. Subsequently a slow and progressive decrease of the rhythmical quick responses occurred until they totally disappeared and only a continuous activation could be elicited by stimulation of the labyrinth. No rhythmic responses could be provoked by labyrinthine stimulation in the great majority of the animals (89%) at a colonic temperature below 24–26 °C (Figure). In the remaining 11% of the experiments, the rhythmic responses disappeared at a body temperature of 30–32 °C.

The continuous activation which replaced the rhythmic responses to stimulation of the labyrinth could be obtained at body temperatures down to 18 °C. During rewarming of the animals, labyrinth stimulation again elicited rhythmic oculomotor responses in 71% of the cases. In the remaining 29% of the guinea-pigs, no rhythmic responses were observed after stimulation of the labyrinth, although the body temperature was once again at 37 °C. In such instances labyrinth stimulation only elicited continuous activation of the oculomotor units. Reappearence of the rhythmic responses of oculomotor units took place in the great majority of the experiments (80%) at 1–2 °C above the temperature at which they disappeared.

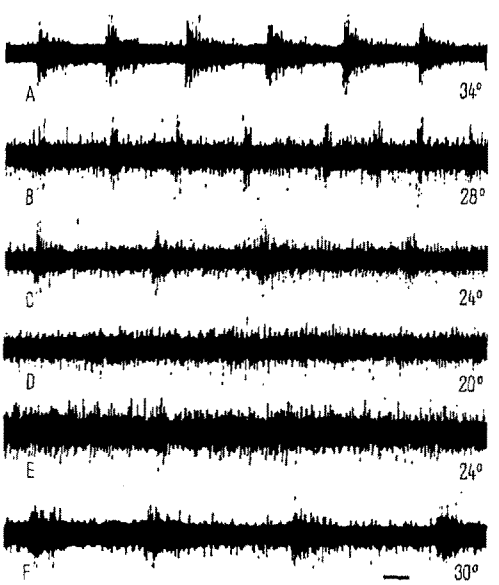
In only 20% of the cases did the rhythmic responses disappear and reappear at the same temperature. The discharge of units in the oculomotor nuclei was accompanied by synchronous action potentials in the ipsilateral oculomotor nerve during both cooling and rewarming. In 18 other experiments, the microelectrode tip was located within other structures adjacent to the oculomotor nuclei; 9 of the 18 locations were in the grey substance ventral to the aqueduct, 8 in the mesencephalic reticular formation and 1 in the medial longitudinal bundle.

The mesencephalic units, which exhibited rhythmic responses to the labyrinth stimulation, showed the following behaviour during cooling. In the great majority of them (65%), the rhythmic responses were abolished at a colonic temperature of around 30 °C; below 30 °C only continuous activation was induced by labyrinth stimulation. The remaining 35% of the units exhibited the same behaviour as the oculomotor neurons, that is the rhythmic responses disappeared on cooling the animal below a temperature of 26–24 °C.

Discussion. The findings of the present experiments showed for the first time that the rhythmic responses of the oculomotor units to the stimulation of one semicircular canal were abolished by cooling the guinea-pigs below a colonic temperature of 24–26 °C. Below this critical temperature, tonic activation of the oculomotor units took the place of the rhythmic responses. Such continuous activation was recorded down to a body temperature of 18 °C.

The oculomotor cells represent the final efferent motoneurons of the nystagmogenig pathway[8,9]; an important role in eye nystagmus mechanism is played also by the vestibular nuclei and by the reticular formation cells.

One may suppose that hypothermia acts on such brain stem structures abolishing the rhythmical responses. It is difficult to state whether the hypothermia directly influences the oculomotor cells or the other brain stem formations involved in the eye nystagmus mechanism. However, it is noticeable that the rhythmic responses disappeared in the reticular formation at a body temperature higher than in the oculomotor cells.



Guinea-pig 314. Rhythmic responses recorded from the left oculomotor nucleus after warm stimulation of the left lateral semicircular canal at different body temperatures during progressive cooling and rewarming. The quick responses increased in frequency at a body temperature of 28 °C, and were replaced by a tonic activation below 24 °C. During rewarming, no quick responses were recorded at a body temperature of 24 °C, but they reappeared at higher temperatures. Time, 0.1 sec.

Riassunto. E'stata studiata l'influenza del labirinto vestibolare sulla scarica unitaria del nucleo oculomotore comune durante l'ipotermia progressiva nella cavia curarizzata. Le risposte ritmiche del nucleo del III paio di nervi cranici alla stimolazione di un singolo canale semicircolare scompaiono alla temperatura corporea di 24–26 °C. Sotto questa temperatura e fino a 18 °C sono evocabili soltanto risposte di tipo tonico.

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