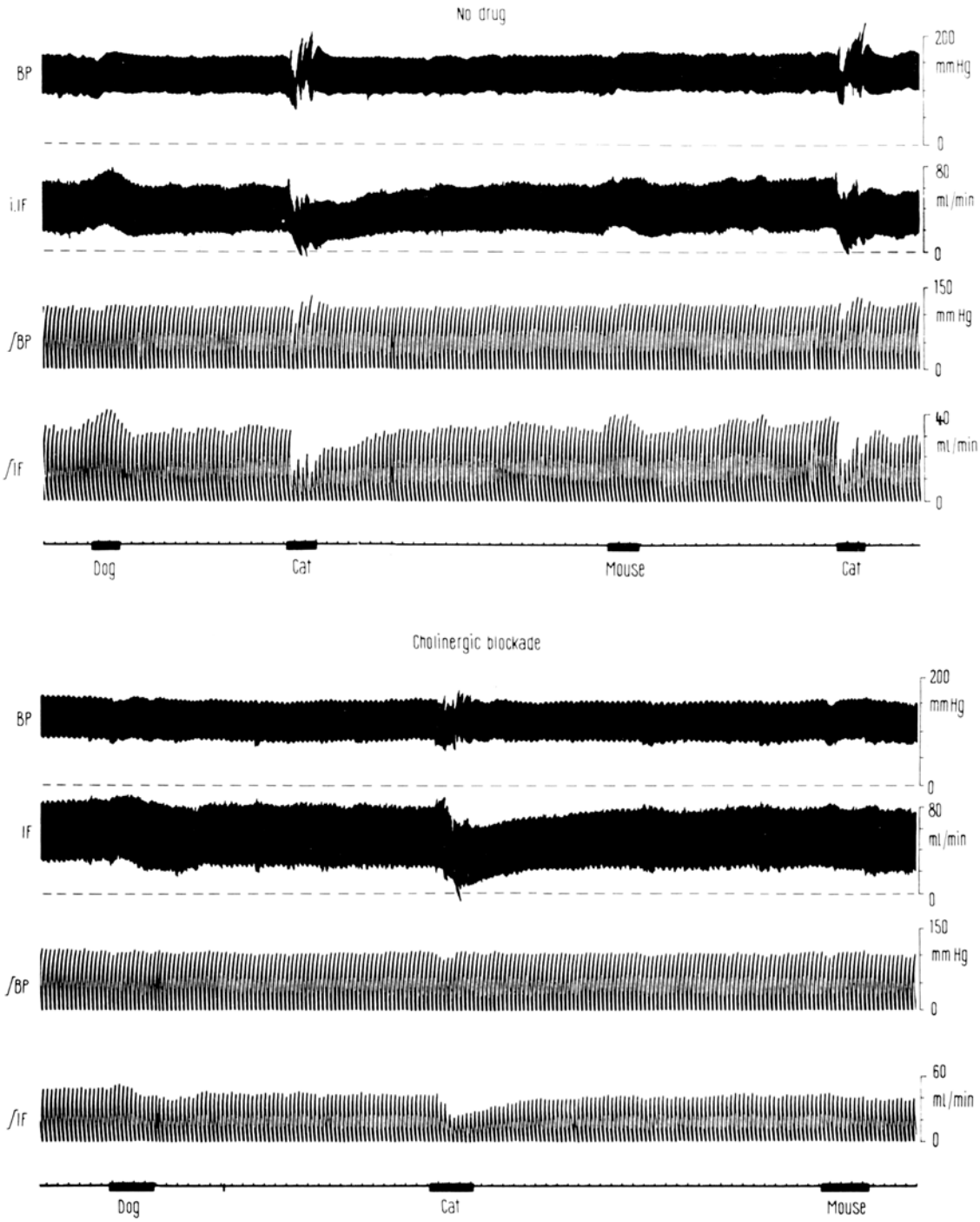
Opposite Responses of Muscle Circulation to Different Emotional Stimuli

Electrical stimulation of certain hypothalamic and mesencephalic areas in the anaesthetized cat or dog produces dilatation of muscle blood vessels through cholinergic sympathetic fibres[1,2], and, in the unanaesthetized animal, elicits the so-called defence reaction[3]. These observations have led to the assumption that cholinergic dilatation of muscle vessels represents a characteristic feature of the cardiovascular response to emotional stimuli[4]. It has also been suggested that cholinergic vasodilatation might usefully occur as a preparatory



Cardiovascular reactions of cat L to presentation of a dog, of another cat, or of a mouse (indicated by stimulus signals in the bottom tracing of each panel) before (upper panel: no drug) and after i.v. administration of 1 mg/kg of methylatropine (lower panel: cholinergic blockade). Tracings are from above downwards: BP, right femoral arterial pressure; iIF, instantaneous blood flow through the left external iliac artery; $\int$ BP, mean (integrated) arterial pressure; $\int$ IF, integrated left external iliac blood flow; time in 5 sec.

reaction when the animal is warned of an impending emotional task[4,5].

These assumptions have not been confirmed in a naturally occurring emotional behaviour studied by our group. Indeed, when a cat was attacked by another cat and fought back in response, instead of the expected cholinergic dilatation of muscle blood vessels, there was a vasoconstriction in the iliac district, provided that the hind limbs did not participate in the fighting movements[6]. Iliac vasoconstriction was also observed in a somewhat different experimental condition, namely when a cat could foresee that a battle was imminent and prepared for fighting, but the attack was then prevented. In this case, fighting did not take place, and the emotional components of fighting were dissociated from the exertional ones.[7,8].

The experiments summarized below represent a further attempt to compare changes during natural behaviour with those obtained with electrical stimulation of the hypothalamus. Muscle blood flow was recorded from unanaesthetized cats while they were exposed to several different stimuli having emotional significance for them: confrontation with a potentially aggressive cat, confrontation with a dog, presentation of a mouse or of food. During the behavioural studies the cat was placed in one compartment of a cage subdivided by an opaque movable screen from another compartment housing the attacking cat. A trial started whenever the screen was raised, or the dog was brought into the room, or a mouse or food were placed into the cat's cage. On all trials to be reported, the cat stared at the stimulus intently but remained immobile, merely showing isolated movements such as flinching, retraction of ears (and sniffing when food was the stimulus). Trials during which fighting movements occurred or the cat jumped to grasp the mouse were not analyzed for the present report. Muscle blood flow was recorded in 6 cats by implantation of a Statham electromagnetic flow probe and a collapsible snare (used to produce zero flow for calibration) around the left external iliac artery, 7–10 days before testing. A blood pressure cannula was placed in the contralateral femoral artery. 4 additional cats had electromagnetic flow probes implanted around both external iliac arteries and a cannula placed in a side branch of a femoral artery. The instantaneous blood flow to 1 or the 2 hind limbs and their integrals were displayed on a Grass P7 polygraph together with instantaneous and mean (integrated) arterial pressure. The hind limb EMG was recorded to check the possible occurrence of movement.

The Figure illustrates the striking observation that in the same cat muscle circulation can be oppositely influenced by different emotional stimuli. In the upper half of the figure one can see that presentation of a threatening cat repeatedly induced a marked decrease in iliac blood flow associated with little or no change in mean blood pressure: this indicates the occurrence of a conspicuous muscle vasoconstriction, and confirms our previous observations[7,8]. However, when the cat was presented with a dog or a mouse there was a definite increase in iliac blood flow, once again with no change in mean blood pressure: this indicates dilatation of muscle vessels. That this muscle vasodilatation was mediated through the cholinergic sympathetic system is illustrated by the lower section of the Figure: after cholinergic blockade induced by intravenous injection of methylatropine (1 mg/kg) iliac vasodilatation to presentation of dog or of mouse was almost completely abolished, while iliac vasoconstriction upon confrontation with the other cat remained unaffected. The cats implanted with flow probes around both iliac arteries showed a bilateral vasodilatation when approached by a dog, and the iliac vasodilatation could be unilaterally abolished or markedly reduced upon close intra-arterial injection of minute amounts of methylatropine (0.125 mg), the dilatation remaining unmodified on the non-injected side.

It is interesting to mention that, while muscle vasoconstriction upon confrontation with a cat was a very consistent response in all the cats tested and all the trials, vasodilatation to a dog, a mouse or food was much more variable from animal to animal, and indeed three of our cats regularly showed vasoconstriction to the stimuli inducing vasodilatation in the other cats. In the majority of cats, however, vasodilatation to the dog (as well as to a mouse or food) was a consistent response, statistically significant throughout the trials ($p < 0.01$) provided that the trials were not repeated too closely. Too frequent testing greatly reduced the vasodilator response.

Our experiments suggest that differences in somatic expression, so well described in emotional behavioural patterns since DARWIN's[9] times, can be paralleled by marked differences in visceral responses as well. Even conditions, like confrontation with an attacking cat or with a dog, that are apparently similar in terms of somatic reaction (flinching, retraction of the ears, animal otherwise immobile), can differ as far as the neural control of muscle circulation is concerned. Cholinergic dilatation of muscle blood vessels is indeed a part of an emotional cardiovascular pattern, as previously suggested[4], but not an invariable component of any emotional pattern. Indeed, in other emotional conditions muscle vasoconstriction occurs.

Résumé. La circulation musculaire du chat est influencée par les situations émotives: la vue d'un autre chat, agresseur, cause une vasoconstriction de nature adrénergique, tandis que la vue d'un chien cause une vasodilatation de nature cholinergique.

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