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THE EFFECT OF DIRECT HEATING AND COOLING OF HEAT REGULATION CENTERS ON BODY TEMPERATURE

Henry Gray Barbour

Translation of "Die Wirkung unmittelbarer Erwärmung und Abkühlung der Wärmezentra auf die Körpertemperatur," Naunya-Schmiedebergs Archiv fuer Experimentalle Pathologie un Pharmakologie, Vol. 70, 1912, pp. 1-26

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16. Abstract

Experiments were done on 28 rabbits in which puncture instruments were left in the brain for 1-2 days until the calori-puncutre hyperthermia had passed and the body temperature was again normal. The instrument remaining in the brain was then used as a galvanic electrode and a second fever was produced, this time due to the electrical stimulus. It was concluded that heat is a centrally acting antipyretic and that cold is a centrally acting stimulus which produces hyperpyrexia "cold-induced fever".

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THE EFFECT OF DIRECT HEATING AND COOLING OF HEAT REGULATION CENTERS ON BODY TEMPERATURE

Henry Gray Barbour
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Aronson and Sachs [1] have localized a region in the corpus striatum which is connected with the regulation of body temperature. /1*

By puncturing the brain in this region the authors not only caused fever, but they also showed that this is the effect of an active, mechanical stimulus and not the passive result of tissue decomposition. This was demonstrated by leaving the puncture instrument in the brain for 1-2 days until the calori-puncture hyperthermia had passed and the body temperature was again normal. The instrument remaining in the brain was then used as a galvanic electrode and a second fever was produced, this time undoubtedly due to the electrical stimulus.

The stimulation of heat centers by toxic substances in connection with infectious illnesses is undoubtedly the decisive factor in the production of clinical fevers. In the majority of cases, however, this stimulation of the centers is prevented from raising the temperature to dangerous levels because of the existence of a counteracting influence. The overheated blood itself, which flows through the brain, must be regarded as an alleviating influence on the activity of the centers--hence no automatic regulation exists. The temperature is set at an abnormally high level which depends on the individual and the stimulant [2]. This soothing property of the overheated blood has been clearly

*Numbers in the margin indicate pagination in the foreign text.

explained by the work of R.H. Kahn [3]. This investigator surrounded the functioning carotid artery with a small tube, /2 through which water flowed, and in this way arbitrarily changed the temperature of the blood. If the overheated blood enters the brain, all of the signs of successful counterregulation are evoked. That the origin of this was central and not peripheral is shown by the fact that the normal body temperature remained unaffected. The blood flowing back from the brain had given off its heat and could not be the direct local cause of the observed vasodilation, dyspnea and perspiration.

This sign of regulation with respect to overheating, however, was all that could be achieved with this method. An actual decrease in body temperature was not achieved, because the bloodstream, which rapidly gave off its heat was repeatedly forced to flow through the carotid heating apparatus.

Gottlieb [4] has shown that the usual antipyretic drugs, such as morphine, antipyrine and chinine have a central temperature-reducing effect. In calorific punctured animals, the stimulating effect of the puncture was completely eliminated by these drugs.

Prof. H. Meyer advised me to investigate the possiblity of influencing the body temperature by heating or cooling the brain centers, independently of the bloodstream. Can heat, as a contra-stimulant, actually decrease the body temperature, and can cold, as a pyrogen, be ranked with mechanical, electrical and toxic (chemical) stimulants?

Experimental Procedure

Adult rabbits on a normal diet were used for the experiments. During each individual experiment they were kept under as uniform

as possible external temperature conditions. The body temperature was determined by inserting an animal thermometer 8 cm into the rectum of the animal as it sat quietly or was held by the experimenter.

To influence the temperature of the heat centers, water was allowed to flow through a thin metal tube--double tube--which was inserted into the brain in the normal calorific puncture procedure (see Fig. 1).

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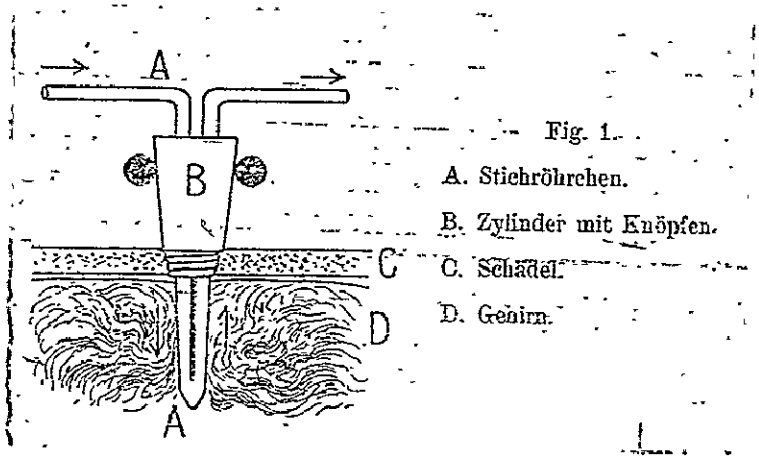

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Fig. 1. Key: A. Puncture tube
B. Cylinder with small knobs
C. Skull
D. Brain

The animals were operated on under light ether anesthesia and extremely asepsis. An opening was made in the skull with a 7 mm wide trephine closely anterior to the coronal suture and lateral to the midline. The dura mater was then carefully incised in 3 or 4 directions, if possible without damaging the veins. Then a narrow metal cylinder (Fig. 1, B), the width of

the trephine, was firmly screwed into the opening in the skull. The puncture tube (Fig. 1, A) was now inserted through the cylinder into the gray matter for a distance of 15 mm. It was attached with strong silk to the two small knobs on both sides of the cylinder. After the wound was sutured the entire unit was fixed and held in place by a layer of cotton and collodion. With one or two exceptions, the operation was performed without any loss of blood.

The rest of the apparatus used to conduct the experiments consisted of two rubber hoses, each about one meter long, used for the inflow and outflow, a large vessel containing water, a tripod with burner and a smaller and larger thermometer. The vessel with water was placed somewhat higher than the head of the animal and the temperature of the water was regulated by the flame. With some care the temperature could be kept constant. In most cases, it was measured with the large thermometer. If, however, we wanted to check the temperature very precisely, as in the experiments in which it was intended to determine the effective temperature limits (see below), the smaller thermometer was used. The bulb was stuck into one of the three openings of the T piece, while the other two openings were connected /4 with the rubber hoses close to the head of the animal.

Water was allowed to flow through the entire system at a rate of 35-40 cc per minute. During the entire experiment set unconstrained in a small open box covered with fine wood shavings.

Results

1. Normal temperature of the rabbits. In a series of 28 rabbits on a normal diet the usual temperature for 20 animals varied between 39.0° and 39.45°C. The maximum temperature for this series of animals was 39.8°, and the minimum 38.6°.

2. Temperature curve for the simple caloripuncture. In view of the necessity that the operation has to been done "blind", the observers never obtained absolutely identical results. After the operation we normally see a temporary drop, the duration and amount of which depends on numerous factors, among others the length of the anesthesia, the temperature of the room and the operation punctrue as well as the degree of the so-called shock. Then the curve usually rises fairly sharply, reaching its maximum after several hours. Six caloripuncture curves, which were made in April and May (other influences excluded), reached an average height of 2.65° above the starting temperature. Nine experiments in June and July yielded a maximum increase of only 1.1°C. During the warmer weather the animals undoubtedly store up a smaller amount of oxidizable material. It has been shown by Rolly [5] that glycogen-free animals do not react to caloripuncture. These animals probably also suffer from a relaxation of the peripheral blood vessels, and for this reason, in the summertime, the two regulating processes--the chemical and physical processes--are less suited to pyretogenesis.

Curves 1 and 2 show the path of the fever for caloripunctured animals observed over a two-day period without any other experimenting.

3. Heating the temperature centers cools the body. After a satisfactory caloripuncture fever had been produced, we tried to sooth the stimulated centers with heat. The results are very striking. As a rule, the water in the vessel was heated to 48°-51°C. On its way to the puncture tube in the brain it lost about 2°C. The temperature of the rabbit fell by about 1.5° within one hour from the start of the hot water flow. If the inflowing hot water is replaced by cold water, the body temperature responds with a rapid rise. These two opposite experiments can be repeated as often as desired with constant success. These

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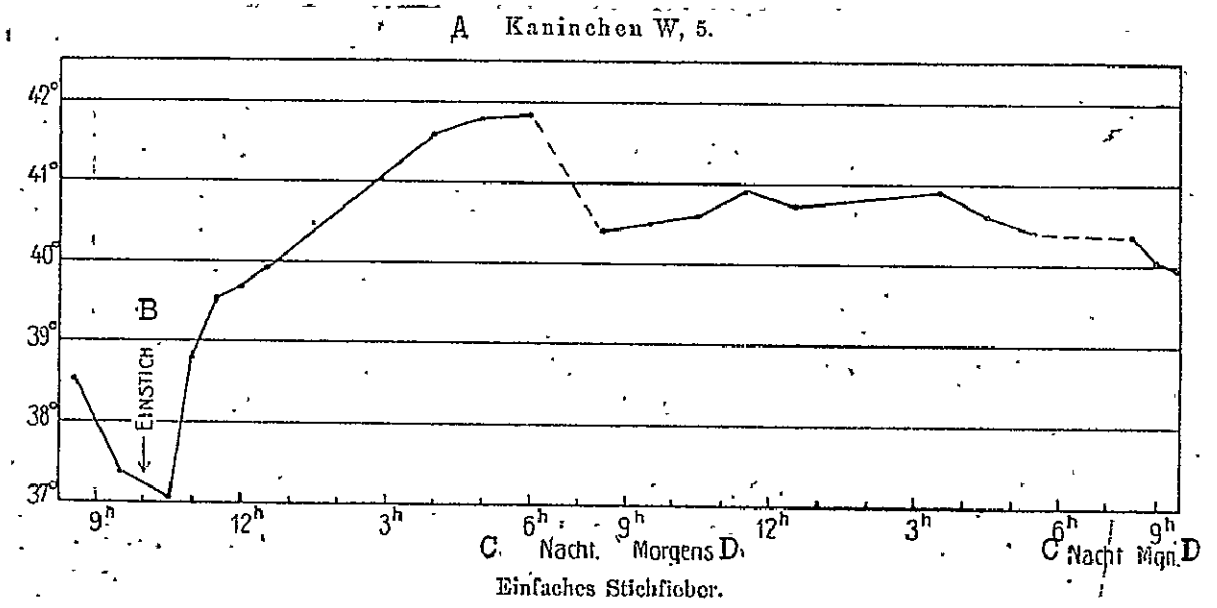
Curve 1

Simple puncture fever.



Einfaches Stichfieber.

Key: A. Rabbit
B. Puncture
C. Night
D. Morning

can be repeated as often as desired with constant success. These 16 facts are illustrated by Curves 3, 4, and 5.

It is obvious from the above experiments that heat soothes the brain centers even in the presence of the stimulating puncture. It has not yet been tested whether the cold itself is an active temperature-increasing stimulant. Just stopping the soothing

Curve 2

Simple puncture fever.

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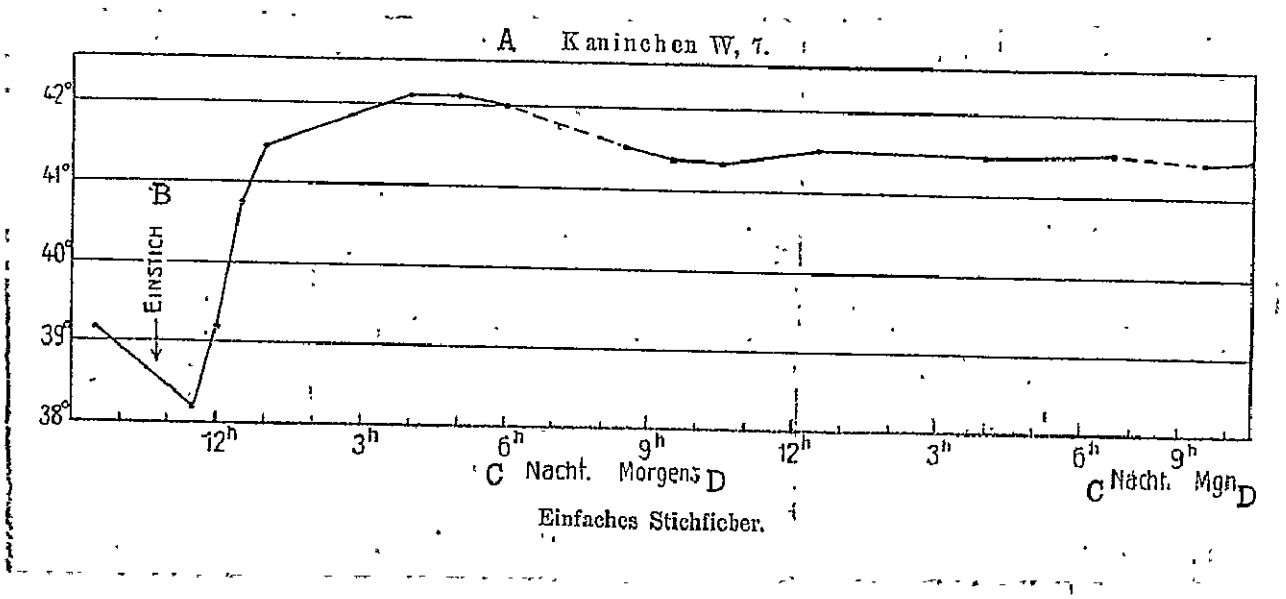
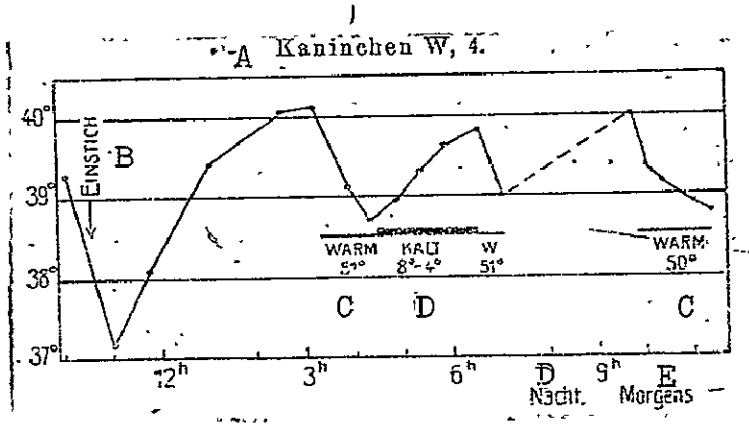


Key: A. Rabbit
B. Puncture
C. Night
D. Morning

effect of the heat undoubtedly allows the puncture effect to reappear. Nevertheless, we see in Curve 4 a difference between simply stopping the inflow of heat and interrupting it by an influx of cold water. The first instance is followed by a further drop (because the brain is not yet cooled to body temperature) and then a rise (due to the puncture effect), while the latter case, as can also be seen in other curves, always /8

Curve 3



Puncture interrupted by the influx of warm water through the puncture tube in the brain: reduced body temperature. The fever returns under the influence of cold.

Key: A.
B. Puncture
C. Warm
D. Cold
E. Night
F. Morning

causes an immediate rise.

An interesting variation of these effects is seen in Curve 6. In the first place, the operation was completed the same in all respects, with the exception of inserting the puncture tube. After partial recovery from shock, the puncture was performed and made with a tube heated by water flowing through it at a temperature of 49°. The inflow of water continued for three hours without the body temperature rising higher than 37.9°, i.e. still 0.65° under the preoperative temperature--a very unusual state. Under the effect of cold, the temperature rose in the next hours by 2.15°. The simultaneous application of heat on the centers is thus capable of preventing the effect of the puncture.

Curve 4

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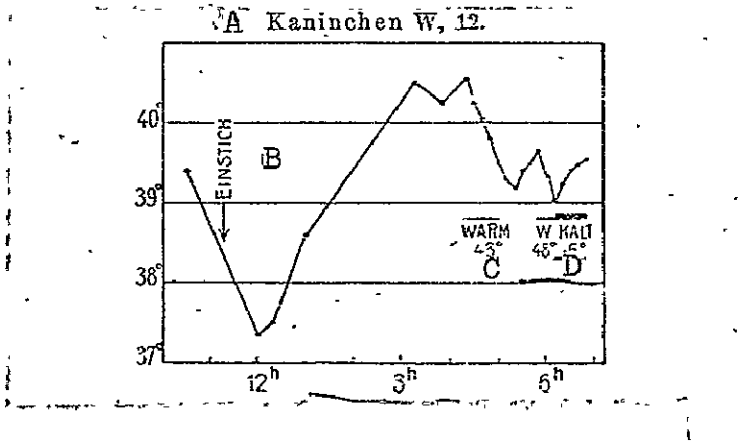
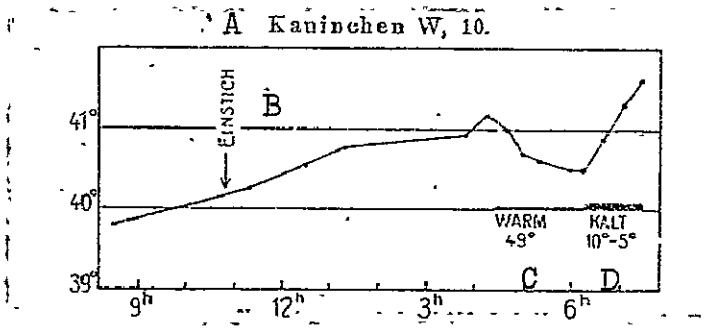


Simple stopping of the heating influence, compared with interruption of the same by an influx of cold water. The latter causes an immediate rise.

Key: A. Rabbit
B. Puncture
C. Warm
D. Cold
E. Night
F. Morning

4. Cooling the temperature centers warms the body. None /9
of the above-mentioned facts is sufficient for deciding whether cold is an active stimulant. Two methods with which I tackled this problem produced satisfactory results. The first method is the one used by Aronson and Sachs to show that electrical stimulus of the centers is adequate to cause the fever. As already mentioned, they waited until the puncture fever had passed. After the temperature had returned to normal, they stimulated the brain electrically and caused a new onset of fever. In a few of our cases the temperature returned completely or almost completely to its initial level on the first day

Curve 5



Effect of heat and cold on puncture fever (caused by a diagonal puncture behind the coronal suture).

Key: A. Rabbit
B. Puncture
C. Warm
D. Cold
E. Night
F. Morning

after the operation. Curves 7 and 8 illustrate the fact that in such cases the fever can be produced again by simply using cold as a stimulant.

It is remarkable that the cold-induced fever never exceeds /10
the point which would be reached by the puncture-induced fever in one and the same animal, assuming, of course, that the latter had an opportunity to show its full intensity. Curve 8 illustrates this point. On the following morning, when the inflow of cold water began, the temperature had dropped to 40°. The maximum point, 40.9°, was reached within two hours, and even using water cooled to 10°C as the stimulant, the fever could not be brought above this point. In the afternoon, after a drop

Curve 6

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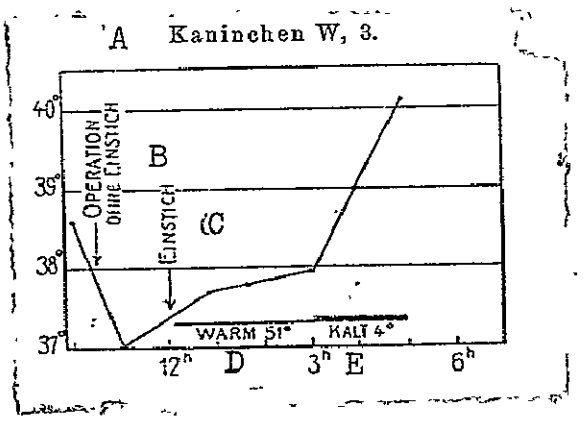


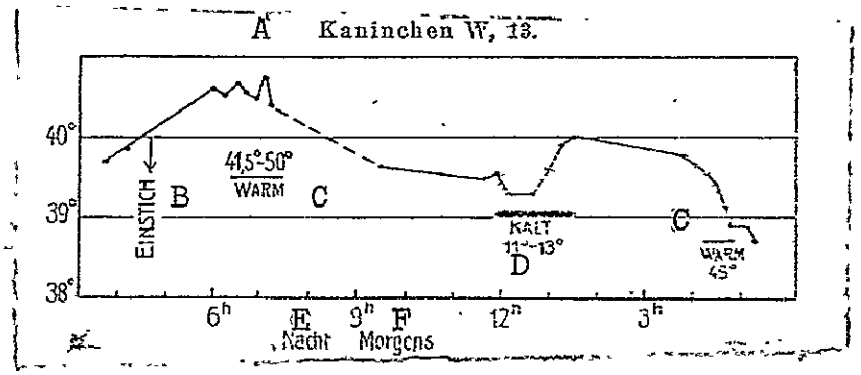
The puncture is prevented by the simultaneously applied heat, but appears immediately as a result of cold.

Key: A. Rabbit
B. Operation without puncture
C. Puncture
D. Warm
E. Cold

to 40.55°, a large dose of adrenaline (1 mg) was given intravenously, and after a temperature of 40.9° was rapidly reached the animal died of convulsions.

The second method of testing the effect of cold as a genuine stimulant of temperature centers was made possible by the observation that during warmer weather the animals react only slightly to the rise in heat. For purposes of reliably preventing the rabbits from reacting to the puncture (without a central effect causing the prevention, as in Curve 6), we performed the puncture on an overheated operating table and made the subsequent observations at a room temperature of 24°. The

Curve 7



After the puncture induced fever had ceased on its own, cold stimulus produced a cold-induced fever.

Key:
A. Rabbit
B. Puncture
C. Warm
D. Cold
E. Night
F. Morning

temperature of this animal rose only by 0.45° after the operation within four hours and 10 minutes. Cold water was then allowed to flow through the brain, and during the next 50 minutes the temperature rose by 0.8°C. Under the continued influence of the cold water, it remained at this level for one hour and 20 minutes, this is probably the temperature which the animal would have reached after a puncture under normal conditions. If the inflow of water was shut off, the temperature fell at once, reaching its earlier level in 40 minutes. Such an experiment obviously shows that cold-induced and puncture-induced fevers are essentially different.

Curye 8

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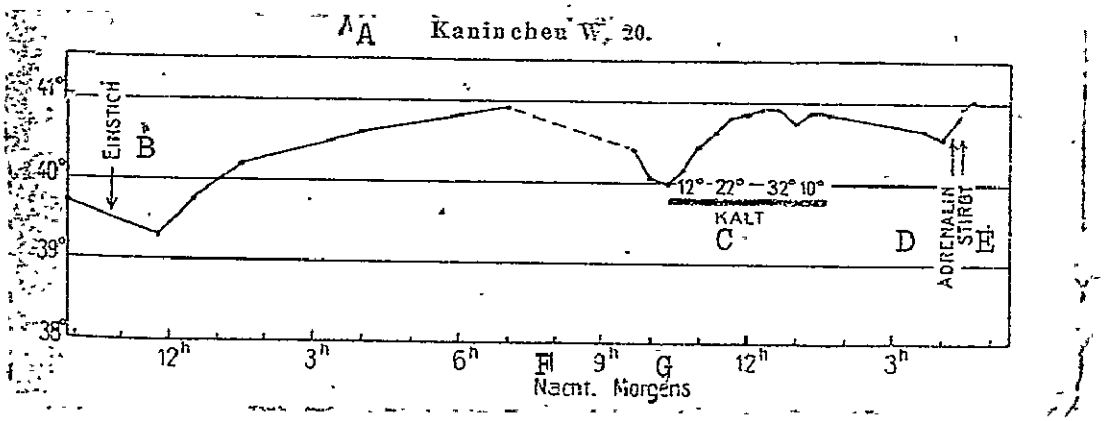
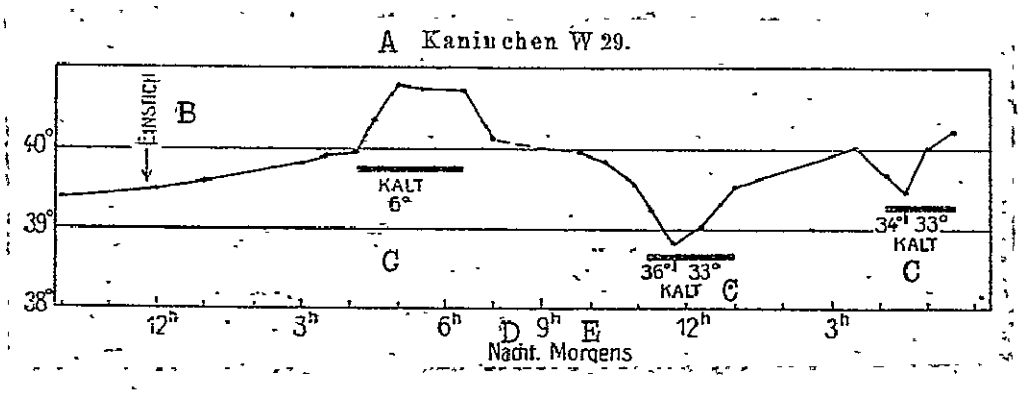


Cold-induced fever produced after the puncture-induced fever had stopped, reached the same level.

Key:
A. Rabbit
B. Puncture
C. Cold
D. Adrenaline
E. Death
F. Night
G. Morning

5. Centrally induced vasoconstriction and vasodilation by cold and heat respectively. The symptoms of temperature regulation which are caused by heating the blood flowing through the carotid artery play a smaller role if one is in a position to observe notable changes in the body temperature itself. A very striking phenomenon showed up, however, was such a consequence in the course of this work that it deserves being mentioned here. This is the reaction of the peripheral vessels in response to the central cold and heat influence. This reaction can easily be studied on the ears of a rabbit. If the puncture-induced fever rises, the ear vessels, as a rule, are completely /11

Curve 9



Puncture-induced fever failed to occur in a hot room. Cold-induced fever is independent of this.

Key: A. Rabbit
B. Puncture
C. Cold
D. Morning

contracted as a result of the mechanical central stimulus. The ears themselves feel cold to touch; the degree of cold naturally depends on the room tempertuŗe. If hot water begins to flow through the brain, then at once we see a striking change. Within two minutes the vessels relax and fill with blood. The entire ear feels warm to touch. It is as if the ear itself had been immersed in hot water. This physical regulation against overheating, in the case of locally applied heat, is a normal empirical fact. It is also easy to demonstrate this on the basis of a reflex process (if one hand is immersed in hot water, vasodilation occurs in both hands).. In the case in question we see the same thing if the heat is applied in a third manner, namely centrally.

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If the cold stimulus is applied in the brain the ear vessels contract and the ear returns to its earlier temperature. Of course, it takes a longer time until the cold state is reached, usually more than ten minutes, because, after the broad blood flow has been contracted, the heat which remains in the ear must gradually radiate into the ear. In order to support these facts we present here the following abbreviated protocols.

May 20, 1912 at 2750 (Rabbit W, 12) /12

Rectal Thermometer

10:30 a.m.	39.4°		
11:15 a.m.	puncuture		
12:00 p.m.	37.35°	Ear cold. Vessels constricted.	
4:20 p.m.	40.55°	Occasional chills.	
4:23 p.m.	---	Start of warm water (48°)	
4:25 p.m.	---	Ears warm. Vessels full.	Ears warm. Vessels full.
4:30 p.m.	40.25	Continuing chills.	
4:40 p.m.	40.05	No more chills.	
5:00 p.m.	39.5	Warm water stopped	
5:10 p.m.	39.3	Ears still warm.	
5:20 p.m.	39.2	Ears lukewarm.	
5:30 p.m.	39.4	Ears cold. Vessels contracted	
5:50 p.m.	39.65	Warm water flowing through.	
6:10 p.m.	39.05	Ears warm after two minutes.	
6:13 p.m.	---	Start of cold water.	
6:20 p.m.	39.25		
6:50 p.m.	39.55	Ears cold.	

Such phenomena are almost constantly observed so that in most cases, without knowing the other conditions of the experiment,

it is possible to predict by the state of the ears whether the nest temperature measurement will show a rise or fall.

6. The effectiveness limits of temperature. After we had shown that heat soothes the temperature centers and that cold stimulates them, we tried to find the effectiveness limits for this temperature treatment, in other words we tried to find the minimum degree of heating which can produce a temperature drop and the maximum temperature which can be used as a cold stimulus.

The hot water was usually applied at a temperature of 48-51°C, the temperature being measured in the water-containing vessel. Before the water entered the head of the animal, it normally lost 2° of heat, so that the heat reaching the centers was normally 46-49°C. The experiments were now done with warm water which was at a lower temperature. This temperature was exactly determined by a small thermometer which was inserted into the line close to the head of the animal, as described above. This yielded the following results:

Curve 10 (Rabbit W, 25), water temp. 43.0°C, rectal temperature dropped. /13

Curve 12 (Rabbit W, 7), water temp. 42.0°C, rectal temperature dropped.

Curve 7 (Rabbit W, 13), water temp. 42.8°C, rectal temperature dropped.

Curve 7 (Rabbit W, 25), water temp. 41.2°C, rectal temperature rose.

The fact that the effect can be produced at so low a temperature--42°C, gives important support to the theory that it is the overheated blood which, in the case of clinical fever, acts as an automatic regulator. In most cases, an increasing temperature--above 42°--is an effective block.

Curve 10

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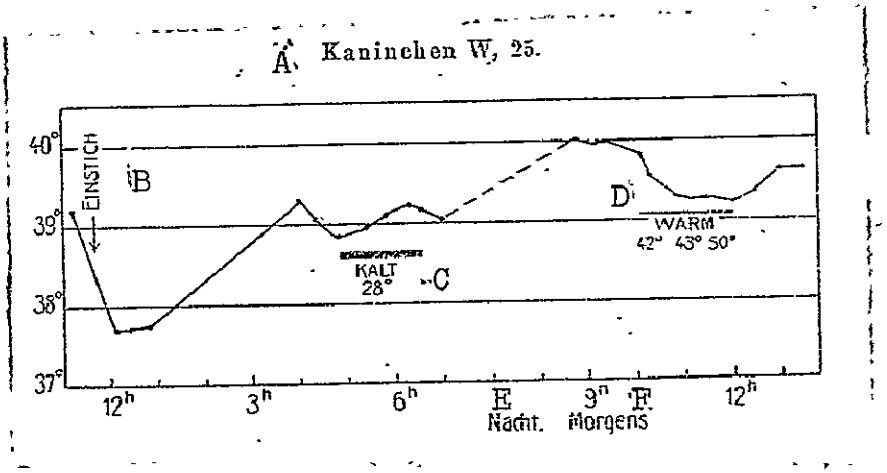


The effectiveness of 28° water as a cold stimulant, and 43° water as a contrastimulant. (Also see Curves 2 and 7.))

Key: A. Rabbit
B. Puncture
C. Cold
D. Warm
E. Night
F. Morning

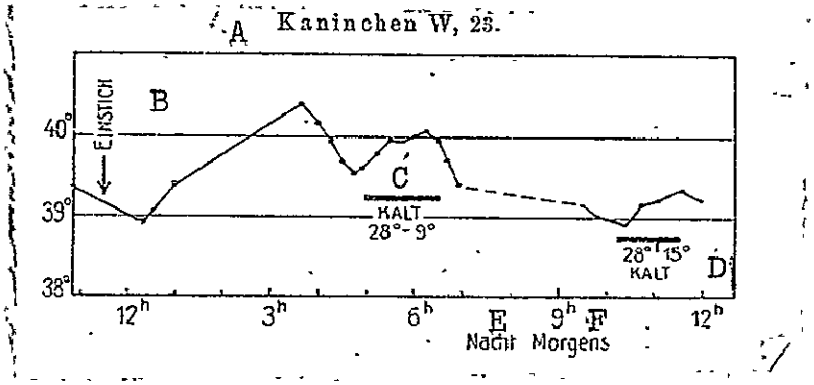
To begin with, ice water was used as the cold stimulus and this usually reached the brain at a temperature around 5-10°C. In determining the warmest temperature which could be used as a cold stimulus, the following results were observed:

Curve 8 (Rabbit W, 20)	Water temp.	12°	rectal temp.	rose
	"	22°	"	"
	"	30°	"	fell
	"	10°	"	rose
Curve 11 (Rabbit W, 23)	Water temp.	28°	rectal temp.	rose
Curve 10 (Rabbit W, 25)	"	28°	"	"
Curve 12 (Rabbit W, 26)	"	33°	"	fell

Curve 10 (Rabbit W, 29)	Water temp.	36°,	rectal temp.	fell
	"	33°	"	" rose
	"	34°	"	" fell
	"	33°	"	" rose

At 33°C the temperature is sufficiently cold to act as a stimulus for the temperature centers to produce the cold-induced fever.

Curve 11



A temperature of 28°C will cause cold-induced fever. (Also see Curve 10).

Key: A. Rabbit
B. Puncture
C. Cold
D. Night
E. Morning

Summary /15

1. The normal temperature of a series of 28 rabbits varied between 38.6° and 38.9°.

2. Simple puncture-induced fever can be maintained at a high level longer than two days or it may show a notable drop within the first 24 hours. The average maximum of six puncture-induced fevers in April and May was 2.65°C above the initial

Curve 12

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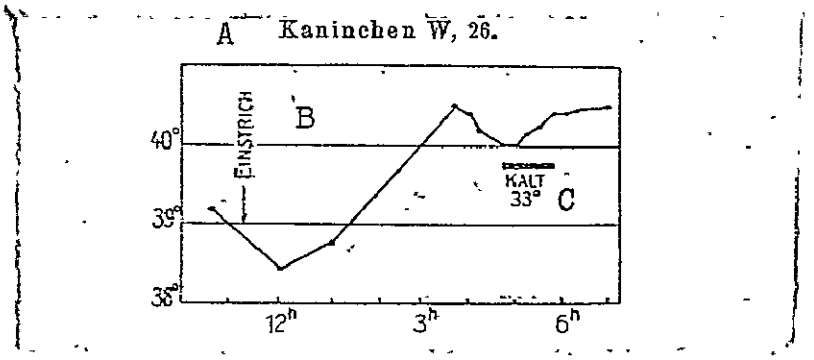

A temperature of 33°C will cause cold-induced fever. (Also see Curve 9).

Key: A. Rabbit
B. Puncture
C. Cold

temperature. In June and July, the average maximum of nine puncture-induced fevers was only 1.1°C above the initial temperature.

3. Heat is a centrally acting antipyretic.

4. Cold is a centrally acting stimulus which produces hyperpyrexia "cold-induced fever".

5. Peripheral vasoconstriction and vasodilation are considerably influenced by centrally applied cold and heat respectively.

6. The limits of the temperature effect are approximately: 42°C, the minimum temperature at which the centers are soothed; and 33°C, the maximum temperature at which they are stimulated.

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Protocol

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A B C Tier-Nummer Gewicht Datum	D Zeit Uhr	E Temperatur Rektum °C.	F Wasser durchgeleitet	G Ohren	H Bemerkungen
I Kaninchen W, 3	10,—	38,6			Operation at first without puncture
2900 g	10,30	—			
24. 4. 12	11,—	37,0	J		
	12,—	—	warmes (51°)		Puncture
	12,50	37,7	„		
	1,40	37,8	„ K		
	3,—	37,95	warmes aufgehört kaltes (4°)		
	3,55	39,0	M „		
	4,55	40,1	„		
	5,—	—	kaltes aufgehört		
25. 4. 12	9,30	39,2			Anatomical finding frontal end of the corpus striatum just contacted
Kaninchen W, 4	10,—	39,3			
26. 4. 12	10,30	—			Puncture
	11,—	37,2			
	11,45	38,1			
	1,—	39,4			
	2,30	40,05			
	3,10	40,1			Flow rate 35 cc per minute
	3,15	—	warmes (51°)		
	3,50	39,1	„	J warm	Ear vessels full
	4,20	38,7	warmes aufgehört		
	4,25	—	kaltes (8°)	M kalt	
	4,50	38,95	„		Ear vessels small
	5,20	39,3	„		
	5,50	39,6	„		Shivering of the lower jaw
	6,—	—	„ (4°)		
	6,30	39,9	kaltes aufgehört		
	6,35	—	warmes (51°)		
	7,—	39,0	warmes aufgehört		
27. 4. 12	9,40	40,0			
	9,50	—	warmes (50°)		
	10,—	39,35	„		
	10,20	39,15	„		
	11,—	38,9	„		
	11,20	38,8			

Key:

A. Animal number
B. Weight
C. Date
D. Time (commas should be read as colons)
E. Rectal Temp. (commas should be read as decimal points)
F. Water passed through
G. Ears
H. Remarks
I. Rabbit
J. Warm
K. Stopped
M. Cold

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Tier-Nummer Gewicht Datum	Zeit Uhr	Temperatur Rektum ° C.	Wasser durchgeleitet	Ohren	Bemerkungen
Kaninchen W, 4	11,25	—	warmes aufgehört kaltes (6°)		
27. 4. 12	11,40	38,75	„		
	12,—	38,7	„		Anatomical finding: frontal end of the corpus striatum just contacted
	12,20	38,7	kaltes aufgehört		
Kaninchen W, 5	9,15	38,75			
2750 g	11,30	38,95			
29. 4 12	5,30	38,85			
2. 5. 12	8,30	38,55			
	9,30	37,4			Tied up on the table
	10,—	—			Punctüre
	10,30	37,1			
	11,—	38,8			
	11,30	39,55			
	12,—	39,7			
	12,30	39,95			
	4,—	41,6			
	5,	41,8			
	6,—	41,85			
3. 5. 12	8,30	40,4			
	9,30	40,5			
	10 30	40,6			
	11,30	40,9			
	12,30	40,7			
	3,30	40,9			
	4,30	40,6			
	5,30	40,4			
4. 5.12.	8,30	40.35			
	9,—	40,05			
	9,30	39,95			
	9,35	—	kaltes		
	9,50	40,4	„		
	9,55	—	kaltes aufgehört		Death.
	10,05	40,3			Post mortem temp.! Anatomical finding: frontal end of the corpus striatum just contacted

Tier-Nummer Gewicht Datum	Zeit Uhr	Temperatur Rektum °C.	Wasser durchgeleitet	Wassertemp. in der Nähe d. Kopfes in °C.	Ohren	Bemerkungen
Kaninchen W, 7	9,30	39,2				
3200 g.	10,45	—				Puncture
8. 5. 12	11,30	38,2				
	12,—	39,2				
	12,30	40,75				
	1,—	41,45	—		kalt	
	4,—	42,1				Shivering of the lower jaw
	5,—	42,1				
	6,—	42,0				
9. 5. 12	8,30	41,5				
	9,30	41,35				
	10,30	41,3				
	12,30	41,5				
	4,—	41,45				
	6,40	41,5				
10. 5. 12	9,30	41,4				
	10,30	41,45				
	10,50	—	warmes (43°)	41		
	10,55	—	„ (44,5°)	42		
	11,—	—	„ (45°)	42,3		
	11,05	41,35	„ —	—		Occasional chills
	11,10	—	„ (45°)	44		
	11,30	41,2	„ (45°)	44		
	11,40	—	„ (45°)	44		
	11,55	—	„ (45°)	44		
	12,—	41,1	„ (46°)	44 †		Anatomical finding: frontal end of the corpus striatum just contacted
Kaninchen W, 9	8,30	39,35				
2600 g	10,10	—				
13. 5. 12	11,20	40,6				Puncture
	12,30	42,3				
	1,20	42,2				
	3,50	42,15				
	7,30	41,4				
14. 5. 12	9,50	39,8				
	10,10	39,4				
	10,30	39,3				
	10,35	—	kaltes (6°)			
	10,50	39,3	„			

Tier-Nummer Gewicht Datum	Zeit Uhr	Temperatur Rektum ° C.	Wasser durchgeleitet	Ohren	Bemerkungen
Kaninchen W, 9	11,30	39,7	kaltes		
2600 g	11,50	39,9	„		
14. 5. 12	12,20	39,9	kaltes aufgehört		
	7,—	39,6			
15. 5. 12	10,—	38,8			Anatomical finding: frontal end of the corpus striatum just contacted
Kaninchen W, 10	8,30	39,8			
2600 g	10,50	—			Puncture, diagonally from the rear and from the side
13. 5. 12	11,20	40,25			
	12,30	40,55			
	1,20	40,75			
	3,50	40,9			
	4,15	41,15			
	4,25	—	warmes (49°)		
	4,40	41,0	„		
	5,—	40,7	„		
	5,20	40,6	„	warm	
	6,—	40,5	„		
	6,15	40,5	warmes aufgehört		
	6,20	—	kaltes (10°)		
	6,40	40,85	„ (5°)		
	7,05	41,3	„	kalt	
	7,30	41,6	kaltes aufgehört		
					Anatomical finding: frontal end of the corpus striatum just contacted
Kaninchen W, 12	10,30	39,4			
2750 g	11,15	—			Puncture
20. 5. 12	12,—	37,35			
	12,20	37,5			
	1,—	38.6			
	3,15	40,5		kalt	Ear vessels contracted
	3,50	40,25			Occasional chills
	4,20	40 55			
	4,23	—	warmes (48°)		
	4,25	—	„	quite warm	

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Tier-Nr. Gewicht Datum	Zeit Uhr	Temperatur Rectum °C.	Wasser durchgeleitet	Wassertemp. in der Nähe d. Kopfes in °C.	Ohren	Bemerkungen
Kaninch.	4,30	40,25	warmes			Continued chills
W, 12	4,40	40 05	„			No more chills
2750 g	4,50	39,8	„		warm	
20 5. 12	5,—	39,5	warmes aufgehört			
	5,10	39,3				
	5,20	39,2			luke-warm	
	5,30	39,4				
	5,40	39,5			kalt	
	5,50	39,65	warmes (48°)			
	6,—	39,35	„		warm	at 5:52
	6,10	39,05	„			
	6,13	—	warmes aufgehört, kaltes (6°)		warm	
	6,20	39,25	„		kalt	
	6,30	39,4	„			
	6,40	39,5	„			
	6,50	39,55	kaltes aufgehört			Anatomical finding frontal end of the corpus striatum just contacted
Kaninch.	3,45	39,7				
W, 13	4,40	—				Puncture
2350 g	6,—	40,6				
22. 5. 12	6,15	40,55				
	6,25	—	warmes (44°)	41,5		
	6,30	40,65	„ (44.5°)	41,8	kalt	
	6,35		„ (45.5°)	42,6	warm?	
	6,42	40,55	„ (45,0°)	42,8	warm	
	6,54	40,5	„ (45,0°)	41,2	„	
	7,05	40,75	„ (46,0°)	41,2	kalt	
	7,10	—	„ (49,0°)		warm um 7,12	
	7,15	40,4	„			
	7.25	40,4	warm. aufgeh. (50,0)			
23. 5 12	9,30	39,65				
	10,45	39,55				
	11,30	39,5				
	11,55	39 55	kaltes (11°)			
	12,10	39,3	„			General chills
	12,40	39,3	„			

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Tier-Nummer Gewicht Datum	Zeit Uhr	Temperatur im Rektum ° C	Wasser durchgeleitet	Oben	Bemerkungen
Kaninchen W, 13	1,—	39,6	kaltes		General chills
2350 g	1,15	39,9	„ (13°)		
23. 5. 12	1 30	40,0	kaltes aufgehört		
	3,50	39,75		kalt	
	4,05	39,65			
	4,18	39,55	warmes (49°)		
	4,24	—	„	warm	
	4,30	39,4	„		
	4,40	39,15	„		
	4,50	38,9	warmes aufgehört		
	5 —	38,9			
	5,10	38,9			Anatomical finding:
	5,20	38,7			frontal end of the
					corpus striatum
					just contacted
Kaninchen W, 20	9,50	39,7			Puncture
3150 g	10,45	—			
10. 6. 12	11,45	39 3		kalt	
	12,30	39 75		„	
	1,30	40,2		„	
	4,—	40,6		„	
	7,—	40,9		„	
11 6. 12	9,40	40,4		„	
	10,—	40,05		warm	
	10,20	40.0	kaltes (12°)	„	
	10,40	40,15	„	kalt	
	11,—	40,45	„	„	
	11,20	40,6	„ (22°)	„	
	11,40	40,8	„	„	
	12,—	40,85	„	„	
	12,20	40,9	„	„	
	12,30	—	„ (32°)	„	
	12,40	40,9	„	warm	
	1,—	40,75	„	„	
	1,05	—	„ (10°)	„	
	1,10	—	„	kalt	
	1,20	40,85	„	„	
	1,40	40,85	kaltes aufgehört	„	
	3,40	40,65		kalt, d. warm	← Cold, then warm
	4,—	40.55		warm	

Tier-Nummer Gewicht Datum	Zeit Uhr	Temperatur Rektum ° C.	Wasser durchgeleitet	Ohren	Bemerkungen
Kaninchen W, 20 3150 g 11. 6 12	4,15	—		warm	Adrenaline, 1 mg intravenously
	4,20	40,8		kalt	
	4,25	40,9		"	Cramps. Death
	4,30	—		"	Post mortem temp.
	4,40	41,0			Anatomical finding: frontal end of the corpus striatum just contacted
Kaninchen W, 23 1700 g 19. 6. 12	10,50	39,35			Flow rate 35 cc per minute
	11,30	—			
	12,20	38,95		kalt	
	1,—	39 4		"	
	3,40	40,4		"	
	4,—	40,15		"	
	4,15	39.95		?	
	4,30	39,7		?	
	4,45	39,55			
	4,55	39,6			
	5,—	—	kaltes (30°) 28°		
	5,15	39,8	"	kalt	
	5,30	39,95	"	"	
	5,45	39,95	"	"	
	5,50	—	" (25°)	"	
	6,—	40,0	"	"	
	6,15	40,05	" (9°)		
	6,30	39,95	kaltes aufgehört		
	6,40	39.7			
	6.55	39,4			
20. 6. 12	9,30	39,15			
	9,50	39.0		warm	
	10,10	38,95	kaltes (38°) 28°	kalt	
	10,25	38,9	"	"	
	10,45	39,15	"		
	11,05	39,2	" (15°)		
	11,20	39,25	"		
	11,35	39,3	kaltes aufgehört		
	12,—	39,2			
	3,30	39,3			
	3,45	39,6			
	4,05	39,5			

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Tier-Nummer Gewicht Datum	Zeit Uhr	Temperatur Rektum ° C.	Wasser durchgeleitet	Ohren	Bemerkungen
Kaninchen W, 23	4,20	39,35			Morphine hydrochloride, 0.002 subcutaneously
1700 g	4.40	39,35		kalt	
20. 6. 12	5,—	39.35			Morphine hydrochloride, 0.003 subcutaneously
	5,05	—			
	5,20	39,2			
	5,30	39,1			
	5 45	38,95	kaltes (14°)		
	5,55	38,85	„		
	6,10	38,7	„ (12°)		Atropine sulfate 0.005 subcutaneously
	6,15	—	„		
	6 25	38,55	„		
	6,45	38,4	kaltes aufgehört		
21. 6. 12	9,30	39,1			
	6,40	38,65			
22. 6. 12	9,15	37,5			Anatomical finding: frontal end of the corpus striatum just contacted
Kaninchen W, 24	10,50	39,45			
1800 g	12,03	—			Puncture
19. 6. 12	12,20	38,4		kalt	
	1,—	39,05		„	
	3,40	40,2		„	
	4,20	40,4		„	
	4,40	40,15		„	
	5,05	40,05			Morphine hydrochoride 0.001 subcutaneously
	5,09	—			
	5,20	40,1			
	5,40	39,85			
	6,—	39,65			Perspiration
	6,20	39,25			
	6,30	—	kaltes (9°)		Narcosis
	6,35	38,85			
	6,45	38,65			
	7,—	38,4	kaltes aufgehört		
20. 6. 12	9,40	26,5			
	9,45	—	kaltes (15°)		Anatomical finding: frontal end of the corpus striatum just contacted
	10,—	26 0	kaltes aufgehört		

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Tier-Nr. Gewicht Datum	Zeit Uhr	Temperatur Rektum °C	Wasser durchgeleitet	Wasserdamp in der Nähe d. Kopfes in °C.	Ohren	Bemerkungen
Kaninch.	4,15	40.2				
W, 26	4.45	40,0	kaltes (35°)	33		
2100 g	5,—	40.0	„			
26. 6. 12	5,15	40,15	„			
	5,30	40,25	„			
	5,50	40 4	kaltes aufgehört			
	6,05	40,4				
	6,20	40,45				
	7,—	40,5				
27. 6. 12	9.40	40,6				
	10,20	40,6				
	10,50	40,6				
	10,55	—	kaltes (8°)			
	11,45	40.9	kaltes aufgehört			Anatomical finding frontal end of the corpus striatum just contacted
Kaninch.	10,—	39.4				
W, 29	11,45	—				Puncture
2700 g	12,—	39.5			warm	Very warm room
4. 7. 12						
	1.—	39,6			„	
	3,—	39,8			„	
	3,30	39.9			„	
	4,10	39,95	kaltes (6°)		„	
	4,30	40,35	„		kalt	
	5,—	40,75	„		„	
	5,30	40,7	„		„	
	6,20	40,7	kaltes aufgehört		„	
	6,21	—			warm!	
	7,—	40,1			„	
5. 7. 12	9,45	39,9			kalt	Warm room
	10,15	39,8			„	
	10,55	39,5			warm	

Tier-Nr. Gewicht Datum	Zeit Uhr	Temperatur Rektum °C.	Wasser durchgeleitet	Wassertemp. in der Nähe d. Kopfes in °C.	Ohren	Bemerkungen
Kaninch	11,15	39,2				
W, 25	11,40	—				Puncture
1850 g	12,10	37,7				
21. 6. 12	12,50	37,75			kalt	
	4,—	39,3			"	
	4 20	39,05				
	4,50	38,85	kaltes (30°) 28°			
	5,25	38,95	"			
	5,50	39,1	"			
	6,20	39,2	"			
	6,35	39,15	kaltes aufgehört			
	7,—	39,05				
22. 6. 12	8,45	40,0			kalt	
	9,10	39,95			"	
	9,25	39,95			"	
	10,05	39,8	warmes (44°)		"	
	10,18	39,55	" (46°)	43,0	warm(?)	
	10,50	39 3	" (46°)	42,3	" (?)	
	11,10	39,25	" (46°)	43,0	" (?)	
	11,30	39,25	" (46°)	43,0	kalt	
	11,35	—	" (50°)			
	12.—	39.2	warmes aufgehört			
	12,30	39,35				
	1,05	39,6				
	1,30	39,6				Anatomical finding frontal end of the corpus striatum just contacted
Kaninch.	10,40	39,2				
W, 26	11,20	—				Puncture
2170 g	12,05	38.45				
26. 6. 12	1.—	38.75				
	3,45	40,5				
	4,—	40,4				

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Tier-Nr. Gewicht Datum	Zeit Uhr	Temperatur Rektum °C.	Wasser durchgeleitet	Wassertemp. in der Nähe d. Kopfes in °C	Ohren	Bemerkungen
Kaninch.	11,10	—	kaltes (38°)	36,3	warm	
W, 29	11,15	39,2	„		„	
2700 g	11,30	—	„ (38,5°)	36,5	„	
5. 7. 12	11,40	—	„		kalt	
	11,45	38,8	„ (35°)	33,0	—	
	12,20	39,0	„		kalt	
	1,—	39,5	kaltes aufgehört		„	
	3,30	40,0		34,0	„	
	4,05	39,65	kaltes (36°)	33,0	warm	
	4,30	39,45	„ (35°)		kalt.	
	5,—	40,0	„		„	
	5,30	40,2	„		„	
	6,30	40,1	kaltes aufgehört		—	Water flow rate 40 cc per min. Anatomical finding: frontal end of the corpus striatum just contacted