erally than Celsius, in spite of the action of the General Conference in 1948. One reason for this is doubtless that they are not aware of the action taken at the 9th General Conference on Weights and Measures. Another reason may be that the end of the quotation from the note appeared to justify the retention of the name centigrade. Habits are not easy to break. On the other hand, the first part of the last sentence: "In the interest of eventual uniformity of practice the use of Celsius appears desirable," has prompted at least two American textbook writers to use Celsius.

Since 1948, two more actions have taken place at General Conferences that make the change to Celsius even more desirable than it was then. The first of these was in 1954 when the 10th General Conference on Weights and Measures redefined the Kelvin thermodynamic scale by assigning a value to the triple point of water. This redefinition takes the place of the old definition wherein the fundamental interval, between the ice and the steam points, was exactly 100 degrees. In 1854, when Kelvin proposed this thermodynamic scale, he said that it was convenient to define the scale by assigning 100 degrees to the fundamental interval in order to retain a connection with thermometry at that time. He said, however, that assigning a value to some definite temperature was the preferable way, and that this "must be adopted ultimately." The old definition of the Kelvin scale had made it strictly "centigrade" because the fundamental interval of that scale "consisted of a hundred degrees." The redefined Kelvin scale is not a centigrade scale because it has only one defined fixed point, which is the triple point of water at 273.16°K. (The zero of the scale is understood to be at the absolute zero of temperature.) The steam point, therefore, is no longer exactly 100 degrees above the ice point by definition, but whether it is more or less than 100 is not yet certain.

The other action came in 1960 when the 11th General Conference on Weights and Measures adopted the "International Practical Temperature Scale of 1948, Text Revision of 1960." All values of temperature on this scale were kept the same as in the 1948 definition within the experimental error of measurement. This scale, therefore, is not a revision of the scale of 1948 but merely a revision of the text. One of the changes in the text revision was in the list of defining fixed points of the scale where the ice point was replaced by the triple point of water with the value 0.01°C. One reason this was done is that the triple point of water is more reproducible than the ice point. Another reason is that it gives the International Practical Temperature Scale of 1948 one defining fixed point in common with the redefined Kelvin thermodynamic scale. The interval between two of the defining fixed points of the scale, triple point to steam point, is thus 99.99 degrees and not 100 degrees. By this definition, therefore, the international scale also has ceased to be a "centigrade" scale.

By these actions at the 10th and 11th General Conferences the concept of exactly 100 degrees for the fundamental interval has been abandoned as basic to either the thermodynamic or the international scale. It was a useful concept in the evolution of the scales, but more precise ways are available now to define them. The adjective centigrade, therefore, has become illogical to describe either scale. The thermodynamic scale is still a Kelvin scale, because it is defined in the way Kelvin said "must be adopted ultimately." The international scale is not strictly centigrade any more, but the name Celsius is as appropriate as ever.

Now the question is, what should be done? In those countries where centigrade was used, the replacement of Celsius is fortunate because the designation "C" remains the same. On many of its thermometer certificates since 1948, the National Bureau of Standards has used the name Celsius with the word centigrade added to parentheses, for example, 37 degrees Celsius (centigrade). This same practice has also been used in scientific papers, the parentheses being used following the first use of the name Celsius. This practice should be continued until the name Celsius, when used alone, is no longer unfamiliar. The editorial policy of the National Bureau of Standards is now to use the name Celsius in all of its scientific publications. If other journals and textbooks will also adopt the policy of using the name Celsius, much will be done to make the nomenclature of temperature uniform in all countries.

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6 December 1961

Reversibility of the Reinforcement Relation

Abstract. Parameters were identified for the rat which both made drinking more probable than running and running more probable than drinking. In the same subjects, depending upon which parameters were used, running reinforced drinking and drinking reinforced running. This relationship suggests that a "reward" is simply any response that is independently more probable than another response.

Food or water are used customarily to reinforce the bar press or running, but it is not asked, Can this relation be reversed? Will the bar press or running reinforce eating or drinking? The traditional account of reinforcement does not generate this question, for it assumes categorical reinforcers, food and water being prime examples (*1*). Furthermore, the traditional account was not changed basically even by the finding that light and sound also reinforce (*2*). To incorporate these "new" reinforcers the reward category was simply enlarged, admitting unforeseen kinds of stimulation, and inferring additional drives and needs. The logic of the traditional account remains one that distinguishes between categories of positive and neutral events; only the events to which this logic is applied have changed.

We have proposed a model of positive reinforcement (*3*) whose major assumption is simply that, for any pair of responses, the independently more probable one will reinforce the less probable one. In this model the traditional vocabulary of drive, reward, and goal becomes either meaningless or misleading, for the model leads to the predictions that (i) the eating or drinking response is itself reinforcible (*4*) and, more important, (ii) the reinforcement relation is reversible.

Are there intervals of time in which eating or drinking are less probable than certain other responses, as well as other intervals in which the probabilities are reversed? Although the present model cannot make such predictions, but predicts only after the response probabilities are given, parameters were recently found in the rat that satisfy both conditions.

With free access to both food and an activity wheel, but access to water for only 1 hour per day, mean total drinking time for a group of six female rats was about 4 minutes, and mean total running time in the same period was only about 0.9 minute. With free access to both food and water, but access to the wheel for only 1 hour per day, mean total drinking time per hour was only about 28 seconds, and mean total running time in the same period was about 329 seconds. Thus it should be possible, according to the present model, not only to reinforce drinking with running but also to reverse the reinforcement relation in the same subject merely by changing from one set of parameters to the other.

Apparatus used to test these predictions was a modified Wahmann activity wheel equipped with a brake and a retractable drinkometer. Joint access to the wheel and water was provided by releasing the brake on the wheel and moving the drinkometer up to a hole on a stationary plate enclosing the open face of the wheel. Drinking contingent upon running was arranged by retracting the drinkometer, freeing the wheel, and making availability of the drinkometer contingent upon running. Conversely, running contingent upon drinking was arranged by locking the wheel, moving in the drinkometer, and making release of the wheel contingent upon drinking.

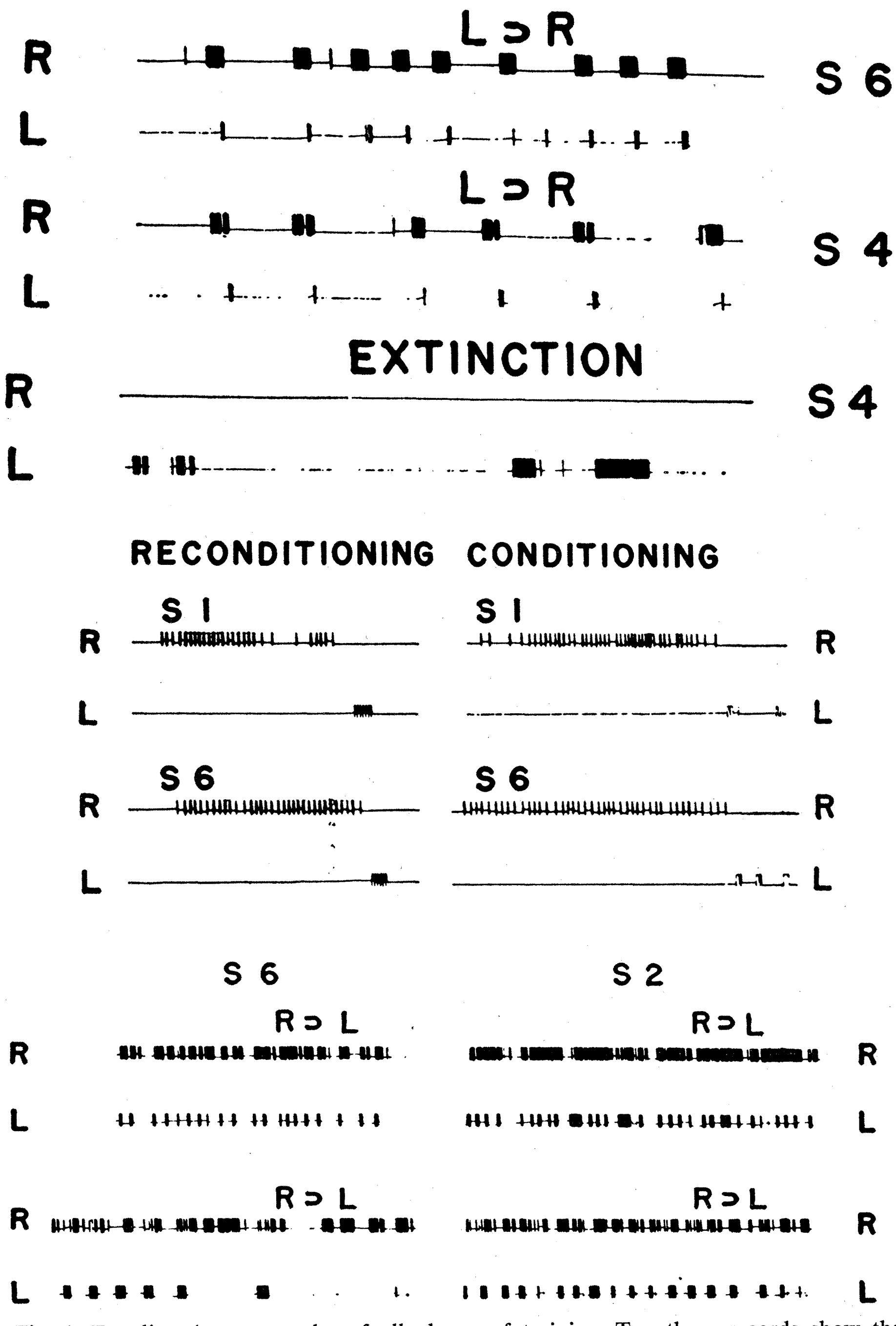

Fig. 1. Esterline Angus samples of all phases of training. Top three records show the reinforcement of drinking by running ($L \supset R$) and subsequent extinction of drinking. Middle records compare the lick pattern for conditioning and reconditioning. Bottom records show the reinforcement of running by drinking ($R \supset L$). *R* designates running, where each 90 degrees of turn deflected the needle, and *L* represents drinking, where each lick deflected the needle. Records read from right to left.

Because the outcome for the conventional experiment was not in doubt, the case of running contingent upon drinking was tested first. Four female albino rats, about 200 days old, Sprague-Dawley strain, were given daily 1-hour conditioning sessions, followed by daily 1-hour extinction and reconditioning sessions. A fixed ratio schedule was used in which each five licks freed the wheel for 10 seconds. Throughout this training, food and water were continuously available in the home cage; after the last reconditioning session, water was removed from the home cage, and on the next day training was begun with the reverse contingency—drinking contingent upon running.

With running contingent upon drinking, total drinking time was increased in all subjects by a factor of from three to five. For operant-level drinking, with only the tube present, mean total drinking time was about 28 sec/hr; with both tube and wheel present, it was 23 sec/hr; and with running contingent upon drinking, 98 sec/hr. Moreover, the first extinction session further increased mean total drinking time to about 175 sec/hr.

Samples of all phases of training are shown in the Esterline Angus records of Fig. 1. The top records show the reinforcement of drinking by running in rats S-4 and S-6, characterized by alternating bursts of licking and running. A representative example of extinction—drinking no longer producing the opportunity to run—is provided by the record for rat S-4; both the atypical periodicity and brevity of the lick bursts have largely disappeared. Of interest in the middle records, which show fine-grain examples of conditioning and reconditioning, is the recovery of the noninstrumental lick pattern that followed extinction. Throughout the original conditioning, the five licks or more that were required for running tended to be dispersed, whereas during reconditioning, licking occurred in bursts typical of routine drinking. The picture is completed by the two bottom records; these provide examples of the evident increase in running subsequently produced by the conventional case, where 450 degrees of wheel turn were required for first, 10 seconds, and later, 5 seconds of tube-time. Hence parameters were demonstrated which made running more probable than drinking, and vice versa, and subsequently, that it was possible not only to reinforce drinking with running, but also to reverse the reinforcement relation in the same subjects merely by changing from one set of parameters to the other (5).

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4. D. R. Williams and P. Teitlebaum [*Science* **124**, 1294 (1956)] have reported the negative reinforcement of drinking—drinking turning off electric shock—but I can find no report of the positive reinforcement of eating and drinking responses.
5. This report is based on a paper read at the meeting of the Psychonomic Society, New York, 1961. This work was aided by grant M-3345 from the National Institute of Mental Health and by grant G-19574 from the National Science Foundation.

20 December 1961

Enhancement of Cesium-137 Excretion by Rats Treated with Acetazolamide

Abstract. Acetazolamide (10 mg/kg, intraperitoneally) increases the urinary excretion of cesium-137 in the rat. Meralluride (6.8 mg of Hg per kilogram, subcutaneously) blocks the effect of acetazolamide on the cesium-137 excretion without any influence on the urine volume and *p*H of the urine. This indicates that acetazolamide increases the urinary excretion of cesium-137 by increasing its secretion through the renal tubule in the same manner as it increases the excretion of potassium and rubidium-86.

As Cs^{137} forms in large quantities during uranium and plutonium fission and ranks high on the list of hazardous by-products of various uses of nuclear energy, we have attempted to find methods of increasing the excretion of this isotope from animals. The agents which have been tested previously include certain diuretics (*1*), steroids (*1, 2*), vitamins (*2*), hormones (*2, 3*) and ion exchange resins (*4*). As Cs is closely related to K in its physicochemical properties, and as acetazolamide increases the excretion of K by increasing its secretion in the renal tubule (*5, 6*), we have studied the influence of acetazolamide on the urinary excretion of Cs^{137} in the rat.

Male white rats of Sprague-Dawley strain weighing between 250 and 260 g were used in these studies. The animals were fed on "Purina Chow" until the day of experiment. The plan of the experiment was to observe the excretion of Cs^{137} during the first 6 hours. This time period was chosen because the duration of action of acetazolamide was about 6 hours ("drug phase") (*7*). A total of 24 animals were divided into four groups and treated as follows: group A, meralluride (6.8 mg of Hg per kilogram, subcutaneously) at 0 hours, acetazolamide (10 mg/kg intraperitoneally) at 2 hours; group B, meralluride (6.8 mg of Hg per kilogram, subcutaneously) at 0 hours; group C, acetazolamide (10 mg/kg, intraperitoneally) at 2 hours; group D, control. All animals received Cs^{137} (11.35 μc/kg, intraperitoneally in normal saline) at 2 hours 10 min. The urine samples were collected at 8 hours 10 min for radio-assay. The Cs^{137} in the urine samples was estimated by standard radiometric methods.

Table 1. Influence of acetazolamide (AZ) and meralluride (ML) on the urinary excretion of Cs^{137} in the rat*. Values are means (of six observations on six rats) ± standard error.

Group	Cs^{137} excreted in 6 hours (% of dose)	Urine volume (ml)	*p*H of urine
Group A (ML + AZ + Cs)	3.98 ± 0.70	10.7 ± 1.3	7.7 ± 0.2
Group B (ML + Cs)	3.28 ± 0.51	9.1 ± 1.3	6.8 ± 0.4
Group C (AZ + Cs)	6.68 ± 1.25	9.7 ± 1.3	8.4 ± 0.2
Group D (Cs only)	2.33 ± 0.27	5.1 ± 0.6	6.6 ± 0.2

*Statistical analysis:

Column	*Mean differences*	*Reliability by* t-*test* (P *values*)
2	C – D	< 0.01
	B – D	> 0.05
	A – D	> 0.05
3	C – D	< 0.01
	A – D	< 0.01
	B – D	< 0.02, > 0.01
4	C – D	< 0.01
	A – D	< 0.01
	B – D	> 0.05

The results in Table 1 indicate that group C, treated with acetazolamide, excreted two to three times more Cs^{137} than did the control group, D. Acetazolamide increased the urine volume and raised the *p*H of the urine. Meralluride did not increase the excretion of Cs^{137} (compare groups D and B). It did increase the volume of urine without altering the *p*H of the urine. The effect of acetazolamide on the urinary excretion of Cs^{137} was blocked by meralluride, but the effect of acetazolamide on the urine volume and *p*H of the urine (compare groups A and B) was not influenced.

Berliner and his coworkers (*5*) have demonstrated that acetazolamide modifies the excretion of potassium in the dog by increasing its secretion into the renal tubules; and this effect of acetazolamide is blocked by mersalyl. Recently, Kunin *et al.* (*8*) found that acetazolamide increases the excretion of Rb^{86} by the dog, and this effect of acetazolamide can be blocked by meralluride. Our experiments suggest that acetazolamide increases the excretion of Cs^{137} in the rat by increasing its secretion in the renal tubule in the same manner as it increases the excretion of K and Rb^{86} (*9, 10*).

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9. There seems to exist a relationship between the activities of the structural analogs of acetazolamide (2-acetylamino-1,3,4-thiadiazole-5-sulfonamide) to inhibit carbonic anhydrase and their efficacies to increase the urinary excretion of Cs^{137}. Ethoxzolamide (6-ethoxybenzothiazole-2-sulfonamide) (10 mg/kg, intraperitoneally) during its "drug phase" of 6 hours and chlorothiazide (6-chloro-7-sulfamyl-1,2,4-benzothiadiazine-1,1-dioxide) (500 mg/kg, intraperitoneally) during its drug phase of 1 hour increase the urinary excretion of Cs^{137}.