oration rates could be monitored continuously, and 1 hour or more was required for stable and minimal rates to be achieved. For all frogs except *P. sauvagii,* rates of water loss were calculated from the lowest stable relative humidity measured. Activity of the animal greatly increased the rate of evaporation, but this method permitted determination of minimal rates during periods in which the animals were quiet. For lizards and for *P. sauvagii*, the relative humidity fell to less than 1.5 percent—below the usable range of the sensors—when the animals rested quietly in the chamber. Their evaporative water losses were then measured from the increase in weight of tubes of Drierite (anhydrous $CaSO_4$) which were connected to the outflow from the chamber for 6 to 18 hours.

Rates of water loss in an aquatic anuran, *Rana temporaria,* were similar to those of two terrestrial fossorial desert species, *Scaphiopus couchii* and *Bufo cognatus*. These results agree with earlier studies that showed a lack of correlation between habitat and evaporative water loss. However, *P. sauvagii* lost water at rates that were only 5 to 10 percent of those measured for other anurans of comparable size; these rates were similar to those of the desert lizards *D. dorsalis* and *Uma scoparia* (Table 2). This result parallels the observation made by Loveridge (*3*) on the African anuran *C. xerampelina*. These animals survived well without water in open jars and lost weight at rates comparable to those of the lizard *Chameleo dilepis,* whereas *Rana angolensis, Bufo regularis,* and *Xenopus laevis* dehydrated rapidly under the same conditions. The nature of the cutaneous barrier in *P. sauvagii* has not yet been determined. The skin appears dry and shiny when the animals are kept out of water, but when the animals are handled their skin becomes moist and evaporative water loss is increased.

P. sauvagii and *C. xerampelina* show similar and unusual physiological and ecological adaptations even though these species are considered to be phylogenetically distinct. The anuran *C. xerampelina* is a member of the family Rhacophoridae, which is restricted to the Old World, and *P. sauvagii* belongs to the Hylidae, which is thought to have originated in the New World (*7, 8*). Nevertheless the species resemble each other in body form, and both are arboreal and lay eggs in vegetation over water (*7*). Although relatively little is known of the ecology of *P. sauvagii,* this species is known to live in semiarid regions. Similarly, *C. xerampelina* is reported to remain exposed in hot, dry areas (*8*). Although terrestrial fossorial anurans from arid regions are not markedly different physiologically from aquatic forms, the exploitation of arid regions by arboreal forms has apparently required novel adaptations for the conservation of water.

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Mapping of Interactions in the Pitch Memory Store

Abstract. *A technique obtaining a precise mapping of interactive effects in the pitch memory store is described. Subjects were required to compare two tones for pitch when these were separated by a 5-second interval during which six other tones were played. In the second serial position of the intervening sequence there was placed a tone whose pitch bore a critical relationship to the pitch of the first test tone. When the critical intervening tone was identical in pitch to the first test tone, memory facilitation was produced. As the separation in pitch between these two tones increased, errors rose progressively, peaked at a separation of 2/3 tone, and declined roughly to baseline at a whole tone separation. It is concluded that the pitch memory store is arranged logarithmically in a highly ordered and specific fashion.*

Investigations into human memory storage have traditionally emphasized the use of verbal materials; in contrast little is known about the retention of unlabeled sensory stimuli. Yet in exploring a memory store there are obvious advantages to the use of stimuli which can be precisely specified and controlled, and which can be varied along one dimension at a time. Tonal pitch represents an example of such a stimulus. The experiment reported here demonstrates that the pitch memory store is laid out in a highly ordered and specific fashion, and that it is possible to map very precisely both facilitatory and disruptive interactions taking place within it.

Previous studies have shown that pitch information decays spontaneously though slowly in the absence of intervening stimulation (*1*). The incorporation of other tones during the retention interval produces considerable memory disruption (*2, 3*). This interference cannot be explained in such general terms as a limitation in general short-term memory capacity, or a distraction of attention, since the incorporation during the retention interval of spoken numbers (which the subjects are required later to recall) produces only a minimal decrement in the same pitch recognition task that is severely disrupted by the interpolation of other tones (*3*). It is clear, therefore, that interactive effects must take place within the pitch memory store itself. The following study represents a mapping of such effects.

Subjects were required to make a series of judgments of the following nature. A 200-msec test tone was played, which was followed 5 seconds later by a second 200-msec test tone. During the retention interval six other tones were played. These were also 200 msec in duration, and were separated by 300-msec intervals, leaving a 2-second pause before the second test tone. The subjects were instructed to ignore the intervening tones, and simply to indicate whether the test tones were the same or different in pitch by writing "S" or "D."

For the test tone stimuli 12 tonal pitches were used. These were taken from an equal-tempered scale, and spanned an octave range from middle C to the B above. For the intervening tones, 24 tonal pitches were used. These were taken from the same scale and spanned a two-octave range from the F# below middle C to the F about an octave and a half above (*4*).

The experiment consisted of eight conditions. In all conditions but the last, there was placed in the second serial position of the intervening sequence a tone whose pitch bore a critical relationship to the pitch of the first test tone. This relationship varied from that of identity to that of a whole-tone separation in the equal-tempered scale (*4*). For each of these seven conditions a unique value of pitch separation was incorporated. These values were placed at equal intervals of 1/6 tone within this whole-tone range. Since the musical scale is logarithmic, these intervals were also logarithmic. In the eighth condition, no such critical tone was incorporated. Instead, the pitch of the tone in the second serial position was chosen in the same way as were the pitches of the other tones in the intervening sequence (*4*). This "null condition" thus provided a baseline for the assessment of the effects of the critical tones.

For each condition, 12 sequences were presented, and the same 12 combinations of test tone pitches were employed in all conditions. The entire set of sequences was presented in random order in groups of 12, with 10-second pauses between sequences and 2-minute pauses between groups of sequences. Subjects listened to the entire tape on two separate occasions, and the results were averaged.

Tones were generated by a Wavetek oscillator controlled by a PDP 9 computer and were recorded on tape (*5*). Twelve subjects were used, selected on the basis of obtaining a score of at least 90 percent correct on a short tape containing sequences designed as in the "null" condition.

The effects of inclusion of tones bearing specific relationships to the pitches of the first test tones are shown in Figs. 1 and 2. It can been seen that these effects can be mapped very precisely as a function of these tonal relationships. When the critical included tone is identical in pitch to the first test tone there results a statistically significant decrease in errors compared with the null condition ($P = .02$, two-tailed on a Wilcoxon test). As the difference in pitch between the first test tone and the critical tone is increased, errors rise systematically and peak at a separation of 2/3 tone, declining to roughly the same value as in the null condition when a whole-tone separation is reached. The increase in errors produced by the critical tone, compared with the null condition, is statistically significant for all values from 1/3 tone to 5/6 tone separation (in each case $P < .01$, two-tailed on a Wilcoxon test).

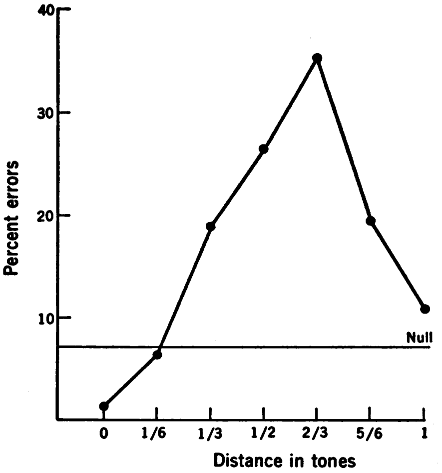

Fig. 1. The percentage of errors in pitch comparisons plotted as a function of the separation in pitch between the critical interpolated tone and the first test tone. The line labeled *Null* shows the number of errors in the control condition where no tone closer in pitch to the first test tone than 1½ tones was included in the intervening sequence. A separation of 1/6 tone, in the range of pitches used here, is equal to 5 cycle/sec at the lowest test tone pitches employed, and 9 cycle/sec at the highest test tone pitches employed.

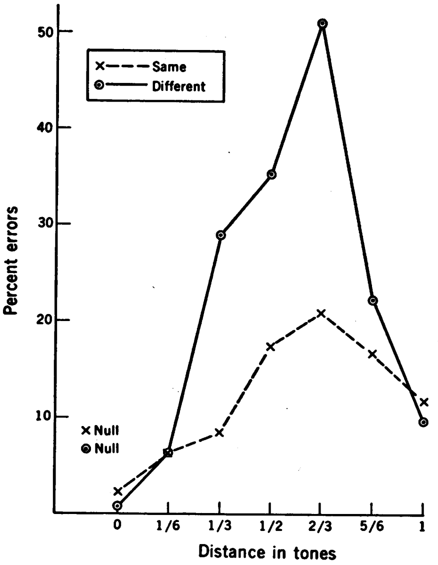

Fig. 2. The percentage of errors in pitch comparisons plotted as in Fig. 1, but separately by whether the test tones were the same or different in pitch. The two *Null* points indicated refer to the same control condition as described in Fig. 1.

The U-shaped function obtained here is not due to response bias, as is shown in Fig. 2. Here, errors are plotted separately by whether the test tones are the same in pitch or whether they are different. It can be seen that the characteristics described above are present for both functions. However, errors rise more steeply and are more sharply peaked when the test tones differ in pitch than when they are the same. Further, when the test tones differ in pitch, the increment in errors compared with the null condition is significant for all values from 1/3 tone to 5/6 tone separation ($P < .01$, two-tailed on a Wilcoxon test for each value). But when the test tones are identical in pitch a significant increment in errors (measured on the same test) occurs only at 1/2 tone ($P < .05$) and at 2/3 tone ($P < .01$) separation. It remains to be demonstrated that the two functions displayed in Fig. 2 are produced by the same underlying process.

The facilitatory and inhibitory interactions displayed here may be related to those obtained in traditional studies on the effect of similarity of interpolated materials on long-term memory for verbal items. Several such studies have also found errors to be a nonmonotonic function of similarity between the test items and interpolated items, with an initial facilitatory component to the curve (*6*). From a different point of view, the findings obtained here may be related to demonstrations of lateral inhibition in various sensory systems, including neural pathways relaying pitch information (*7*).

A further point of interest concerns the precision with which it is possible to superimpose the results obtained from sequences with test tones taken from different positions in the pitch scale. Since the musical scale is logarithmic, an identical musical interval represents an increased difference in cycles per second as the scale is ascended. This difference doubles at each octave, and so virtually doubles over the range employed in this experiment. Therefore, if the pitch memory store were organized in any fashion other than logarithmic, one would expect a systematic shift in peak of errors as the test tone combinations shift in their position along the scale. For instance, if the pitch memory store were laid out in a linear fashion, the peak of errors should appear to move progressively closer to the pitch of the first test tone as the test tone combinations move upward in the scale. However, no such peak shift in either direction is discernible from the data. It would therefore appear that the pitch memory store is logarithmically arranged.

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Δ^9-Tetrahydrocannabinol and Ethyl Alcohol: Evidence for Cross-Tolerance in the Rat

Abstract. *Rats trained in a one-way avoidance situation were made tolerant to the depressant effects of Δ^9-tetrahydrocannabinol. Ethyl alcohol (3.2 grams per kilogram, intraperitoneally) did not greatly affect rats that were tolerant to Δ^9-tetrahydrocannabinol but depressed the behavior of nontolerant rats. Rats made tolerant to ethyl alcohol were less affected by Δ^9-tetrahydrocannabinol.*

Many claims and counterclaims have been made about whether marijuana use leads to abuse of other pharmacological agents. This controversy rages in spite of a paucity of data on cross-tolerance between cannabis derivatives and other drugs of abuse. Two studies that deal with this problem are both concerned with hallucinogenic compounds. These studies indicate a lack of cross-tolerance between (−)-Δ^9-*trans*-tetrahydrocannabinol (Δ^9THC) and D-lysergic acid diethylamide-25 (LSD-25) in man (*1*) and between Δ^9THC and LSD-25 or mescaline in rats (*2*).

Implicit in the conceptualization of these studies is the assumption that cannabis derivatives are hallucinogenic. While it is true that these agents have hallucinogenic properties, there is evidence that the cannabis derivatives have sedative and depressant (*3*) as well as analgesic effects (*4*). It seemed reasonable to look for cross-tolerance to representatives of these classes of drugs. Our results support the hypothesis that there exists a cross-tolerance between Δ^9THC and ethyl alcohol.

Subjects were 40 male Holtzman albino rats that weighed 270 to 440 g at the start of the experiment. They had free access to food and water throughout the experiment. The animals were tested in a one-way shock avoidance apparatus (*5*). The start of a trial was signaled by illumination of a circle of lights. The animal had 5 seconds to jump onto a platform before the onset of 1.0-ma shock administered via the grid floor. The shock remained on for 5 seconds or was terminated when the rat jumped on the platform. The lights also went off at this time. After 30 seconds the animal was automatically pushed from the ledge back onto the grid to await the start of the next trial. The trials were presented on a variable-interval schedule with a 30-second average interval. The subjects were given 50 trials per day and were tested 5 days per week.

The experimental procedures are shown in Table 1. There were ten rats in each group. The criterion of tolerance was 90 percent avoidance or greater 3 out of 5 days. The Δ^9THC (*6*) was suspended in 4 percent Tween-20. (The Tween-20 solution alone is referred to as vehicle.) A 15 percent solution (by volume) of ethyl alcohol in 0.9 percent saline was used. All injections were given 5 minutes before the animals were placed in the avoidance box. The dose of Δ^9THC was 20 mg/kg, and that of ethyl alcohol was 3.2 g/kg. With Δ^9THC the tolerance criterion was met in 13.1 ± 2.7 days. Statistical analyses were performed by orthogonal comparisons with a significance level of $P < .05$.

Administration of saline had no observable effect on avoidance responses (Fig. 1), but ethyl alcohol reduced these responses to 58.7 percent. On the day after alcohol administration the

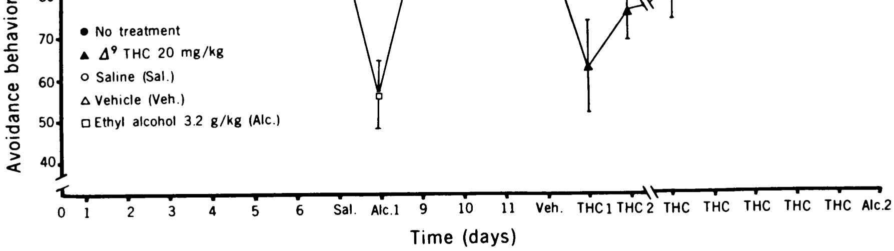

Fig. 1. Effects of ethyl alcohol before and after development of tolerance to Δ^9THC. Ten animals were used. The break in the time scale during Δ^9THC administration is due to the fact that the animals met the tolerance criterion in varying periods of time, with the average time being 13.1 ± 2.7 days.