experiment 1, serum A contains no neutralizing poliovirus antibody. When placed on filter paper, it did not prevent the rise of virus; all of the ten spaces which became wet were shown to contain virus when placed in tissue culture. In contrast, no virus could be detected above space 4 on the paper that had been treated with serum B, which had a neutralizing antibody titer of 1/64. Experiment 2 shows that the "blocking" action is still present when serum B is diluted. Experiment 4 shows that the "blocking" action was demonstrable with as little as 0.025 ml of serum B, a quantity readily obtainable by finger puncture.

For practical purposes, the placing of a single paper space into a single tissue-culture tube gave correct information regarding the presence or absence of poliovirus antibody. This is true of space 7, for example, in each of the 52 successive tests performed. When a pool of types 1, 2, and 3 polioviruses is tested against a serum, only that type against which there is no specific antibody in the serum can be detected high on the paper.

This method requires only one tissue-culture tube and a quantity of blood which is small enough to be obtained readily by finger puncture. The method may be, therefore, a valuable screening test for distinguishing immune from nonimmune persons in a poliomyelitis vaccination program.

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2. This work supported by grant from National Foundation for Infantile Paralysis.

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Concurrent Schedules of Reinforcement in the Chimpanzee

This report (*1*) describes a technique for establishing two behavioral repertoires simultaneously in a single animal subject. This was done by training chimpanzees that had been reduced to about 80 percent of their normal weight to press either or both of two keys that were mounted 6 inches apart. The animals pressed the keys because occasional presses operated a food magazine that delivered 40-kcal. portions of food (reinforcement). The schedule by which the key presses are reinforced determines the rate at which the animal presses the key. Different rates of pressing were established on the two keys by using two schedules of operation of the food magazine (schedule of reinforcement). The schedule of reinforcement on the right key was designed to generate a high, sustained rate of pressing, whereas the schedule on the left key was designed to generate a low rate. The amount of independence between the performances on the two keys could be assessed because of the contrasting rates of key pressing. Any "confusion" between the two keys would result in high rates of pressing on the key normally producing low rates, and vice versa.

The chimpanzee, with its semierect posture and good hand dexterity, was of special interest for this type of experiment because it could operate the two keys simultaneously. Most subprimates would have to alternate between the two keys. The time spent changing back and forth between the keys would interfere with the characteristic performance under the single schedule of reinforcement.

The specific experimental conditions were similar to those already described for the pigeon (*2*). The experiment began with only one key and a schedule in which the magazine operated after a fixed number of responses. This is called a fixed-ratio schedule: "ratio" refers to the ratio of presses to reinforcements (*3*). This schedule generates a high, sustained rate of responding except when the number of responses required for reinforcement is large. Then, a pause develops following each reinforcement; but when the animal again starts pressing the key, it begins immediately at the prevailing high rate. In general, moderate rates or smooth transitions from one rate to another are absent under this schedule. If the animal operates the key at all, it tends to do so at the prevailing high rate.

After a stable performance had developed on the first key, a second key was added 6 inches to the left. Presses of the second key were reinforced on the basis of elapsed time rather than number of presses. The first press after a given interval operated the magazine; but the interval varied from reinforcement to reinforcement, ranging from 3 seconds to 8 minutes, with a mean value of 4 minutes. This schedule, which is called variable-interval reinforcement, produces a moderate rate of responding (*3*). The random spacing of the reinforcements produces a constant rate of responding and prevents pauses from developing after reinforcements. Changes in rate, when they do occur, seldom are abrupt, as they are in the fixed-ratio schedule. The variable-interval performance stabilized quickly. The number of responses required for reinforcement on the right (fixed-ratio) key was then increased to 120 over 27 experimental sessions. The larger number of responses required for

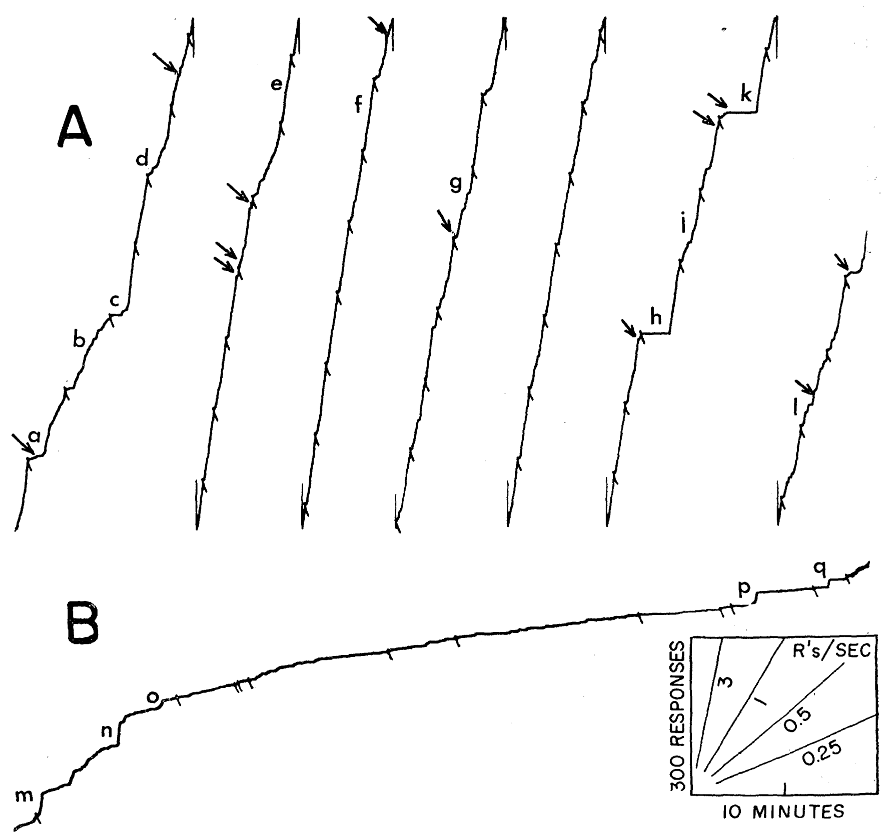

Fig. 1. Cumulative curves of responses on the two keys. Record *A*, responses on the right-hand key; reinforcement was on a fixed-ratio schedule. Record *B*, responses on the left-hand key; reinforcement was on a variable-interval schedule.

reinforcement on the fixed-ratio key provided a longer period of time in which simultaneous presses of the variable-interval key could occur.

Figure 1 is a graphic record of a complete daily performance. Responses cumulated against time give a curve whose slope depicts the moment-to-moment changes in the rate of pressing the key. Presses of the right key are recorded in the top curve (record A), and presses of the left key are recorded in the bottom curve (record B). The discontinuities in the top curve represent the resetting of the recorder pen when it reached the limit of its excursion. In order to give more compact presentation, the parts of the curve in record A are not pieced together. Because both records were taken simultaneously, a given distance along the abscissa represents the same point in time for both curves. The insert in the lower right-hand corner of the figure shows the coordinates and scale of the curves. The four slope lines in the insert indicate reference values for various rates of responding in responses per second. Reinforcements are marked by the short marks oblique to the curve. The lowercase letters above the curves are used to refer to details of the curve.

For the most part, the performances of the animal on both keys are similar to those that would develop singly without interference from the behavior on another key. Presses of the right key (top curve) tend to be sustained at 3 to 4 responses per second, while presses of the left key (bottom curve) occur at about 0.1 per second. The simultaneous reinforcement on the two schedules of reinforcement, however, produced deviations from performances that would emerge if these schedules of reinforcement were arranged singly. Major deviations from a normal fixed-ratio performance occur as low rates of responding, as in the segments marked *a* and *b*. The rate of pressing accelerates gradually in the segments marked *c* and *d*, instead of the normal abrupt shift from a pause to a high rate as in the segments marked *h* and *k*; and bursts of responding separated by brief pauses occur, as in the segments marked *g*, *i*, and *l*, where high rates of pressing are sustained, reaching values as high as six presses per second for brief periods. These performances may be compared with the segments between *e* and *f*, which show a normal fixed-ratio performance. Major deviations from a normal performance on the variable-interval schedule occur as brief bursts of responding at high rates, as at *m*, *n*, *o*, *p*, and *q*. These can be compared with the low, constant rate of responding that prevailed for most of the session, as in the part of the curve between *o* and *p*.

For the most part, the chimpanzee used its left hand on the left key and its right hand on the right key. In many instances, it pressed both keys simultaneously, despite the large difference in the rate of pressing on the two keys. Approximately one-third of the responses on the variable-interval key coincided with presses of the fixed-ratio key. Food that was received from reinforcement of responses on the left key was taken from the magazine and eaten while the animal continued to operate the right key in the characteristic manner. The extent of the disturbance can be seen by examining the top curve in the vicinity of the small arrows, which indicate the exact point of food delivery occurring because of reinforcement of responses on the other key.

The technique used in this experiment demonstrates a method which could be used for studying bilateral independence (as, for example, the hand independence exhibited by a pianist when his left and right hands play at different tempos) in an *animal* subject. The ability to maintain two different kinds of behavior simultaneously could also have application in the study of emotional side effects of some psychological variables. For example, the performance on one key could be used as a baseline for the emotional side effects of a change in the schedule of reinforcement on a second key.

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Fat Weight and Fat Placement in the Female

The measurement of body fat relates to two distinct problems, the amount of fat (fat weight) and the distribution of fat (fat placement). Although considerable information has been gathered on fat weight and fat placement in the male, comparable data on the female are meager. One set of estimates of body fat for adult females was of necessity based on skin-fold measurements of English outpatients and extrapolations from body-fat determinations made on guinea pigs (*1*).

Standardized soft tissue x-rays were taken on 107 healthy, adult, American-born women, aged 20 to 60 years, with a mean age of 39. Comparable roentgenograms were made on 81 clinically healthy adult males, of equal age range and of a mean age of 40 years. The two groups were drawn from the same population. Fat-shadow measurements were made at the following sites: lateral arm, medial arm, deltoid "pocket," iliac crest, mid-trochanteric, lateral leg, medial leg, anterior leg, and posterior leg (*2*). All distributions involving fat were highly skewed: median rather than mean values are therefore reported.

Table 1. Comparison of subcutaneous fat thicknesses in adult males and females. The sex difference in fat thickness is significant beyond $p = 0.01$ except for the deltoid pocket and iliac crest.

Fat measurement	Median values (mm)		Fat ratio female/male
	107 females	81 males	
Lateral arm	6.2	4.4	1.41
Medial arm	6.6	3.5	1.89
Deltoid pocket	17.8	18.0	0.99
Iliac crest	19.0	19.2	0.99
Trochanteric	28.1	15.6	1.80
Lateral leg	7.4	4.8	1.54
Medial leg	10.9	6.0	1.81
Anterior leg	4.1	2.6	1.58
Posterior leg	13.0	7.0	1.86
Stature (cm)	162.5	176.5	
Weight (kg)	58.3	76.4	

The women exceeded the men in seven out of nine fat-plus-skin measurements, with female/male ratios for subcutaneous fat up to 1.89. The actual differences, which were all significant at $p = 0.01$ or better, ranged up to 13.5 mm for trochanteric fat (see Table 1). However, in two thicknesses (deltoid "pocket" and iliac crest) sexual dimorphism was not complete; here male fat thicknesses were absolutely but not significantly greater. This confirms other evidence that for particular subcutaneous fat sites there may be a reversal of the usual trend (*3*).

From the intercorrelation matrices, trochanteric fat emerged as the best single predictor of total fat for adult males, as previously reported (*4*); iliac crest fat had the greatest communality with other fat sites for the female. The weight of fat, fat values, and constants appropriate for each sex were then estimated, on an individual basis, using the prediction formula (*5*)

$$y = r \frac{\sigma y}{\sigma x} x$$

The estimated *median* weight of fat for the females was 13.7 kg, not markedly greater than the median of 12.6 kg for the males. Estimates based on other central fat sites were very similar.