formed and catheters were placed in the femoral and internal carotid arteries for drug infusions and for the determination of blood gases (CO_2 and O_2 pressures) and blood pressure. A left or right craniotomy was then made and the dura was stripped away. Artificial cerebrospinal fluid (155 m*M* Na^+, 137 m*M* Cl^-, 21 m*M* HCO_3^-, 3.5 m*M* K^+, 1.3 m*M* Mg^{2+}, 2.2 m*M* Ca^{2+}, and 6.0 m*M* glucose) maintained at 36° to 37.5°C and *p*H 7.3 to 7.4, was allowed to drip onto the exposed brain surface. The temperature of the brain surface was kept close to 37.5°C, as measured with a thermistor probe. One-tenth of a milliliter of 5 percent $BaCl_2$ was administered as a test for normal vascular reactivity (*14*).

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Drug History Modifies the Behavioral Effects of Pentobarbital

Abstract. *Behavior of squirrel monkeys, maintained by the termination of stimuli associated with electric shock, was suppressed by response-dependent shock delivery. The effects of pentobarbital on this behavior depended on whether monkeys had previously received morphine. In monkeys without experience with drugs, pentobarbital increased responding. In monkeys with recent experience with morphine, however, pentobarbital resulted in a smaller increase or decrease in responding. The rate-decreasing effects of pentobarbital after a history of morphine administration could be reversed by the administration of* d*-amphetamine. These findings suggest that the behavioral effects of abused drugs may depend on previous experience with other drugs, even when those drugs are from a different pharmacological class.*

Although the behavioral effects of many drugs are frequently influenced by the relationship between behavior and its immediate consequences (*1*), several studies have recently found that prior experience can markedly change the effect of a drug on behavior. For example, the usual effects of *d*-amphetamine on behavior suppressed by electric shock can be completely reversed after exposure to a condition in which responding postpones shock (*2*). These and other findings (*3*) have suggested that the behavioral effects of drugs may, under some conditions, depend more on past experience than on either the current environment or the prevailing behavior. We now report that prior experience with one psychoactive drug can determine the behavioral effects of a different drug. Thus, drug history, like behavioral history, can dramatically alter the effects of drugs.

Drug effects were studied in four male squirrel monkeys (*Saimiri sciureus*). All monkeys were experimentally naïve and weighed between 0.8 and 1.0 kg. During 2-hour experimental sessions, the monkeys were seated in a standard Plexiglas restraining chair, which lightly restrained the animal at the waist. The chair was equipped with 7-W white stimulus lamps, a response lever (BRS/LVE 1352), a feedback relay, and brass shock electrodes. Shock (7 mA, 200 msec, 650 V, and 60 Hz) was delivered through series resistance to the tail.

Shocks were initially delivered every 5 seconds; responding postponed shock for 25 seconds (*4*). After responding had been established (approximately 14 sessions), the shock-postponement procedure was replaced with a fixed-interval schedule under which responding terminated the stimulus lights correlated with shock (stimulus-shock termination) (*5*). Under the termination schedule, shocks were arranged to occur every 3 seconds, beginning 3 seconds after the 5-minute interval elapsed. The first response after the 5-minute interval terminated the shock-correlated stimuli and produced a 60-second period during which responding had no scheduled consequences and shocks never occurred. After responding stabilized, an additional consequence was added to the termination schedule: each thirtieth response

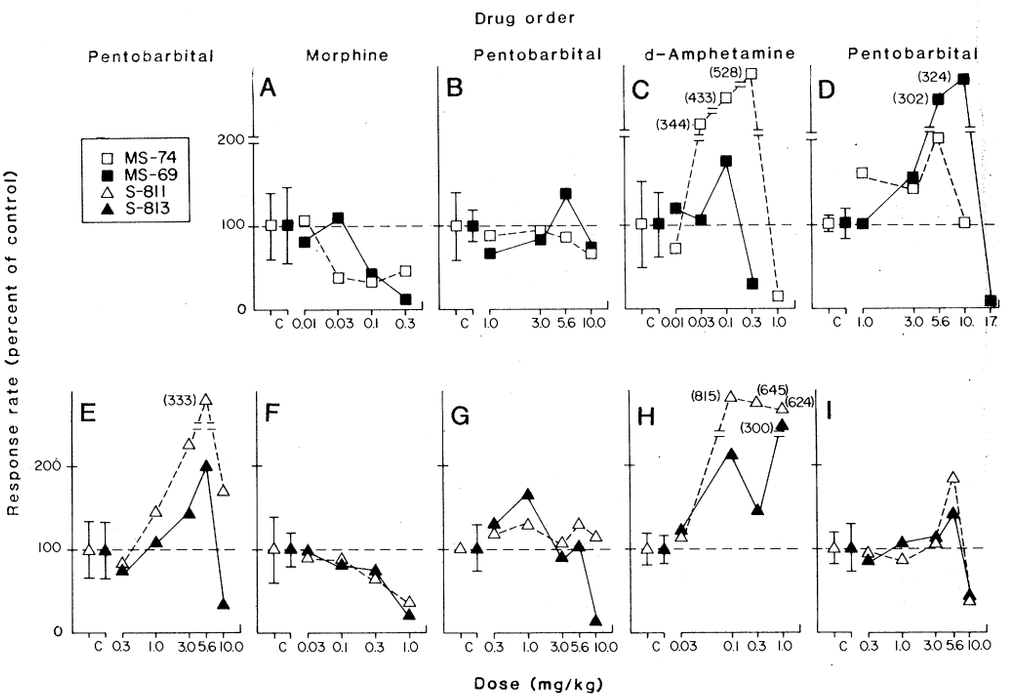

Fig. 1. Dose-effect functions for responding simultaneously (i) maintained under a fixed-interval 5-minute stimulus-shock termination schedule and (ii) suppressed by a fixed-ratio 30-response shock-presentation schedule. Drug effects are expressed as a percentage of control rates (Table 1). Each point represents the mean of two determinations for each subject. Vertical bars represent 1 standard deviation from the mean of all control rates of responding (Thursdays) during the determination of the effects of that drug.

during the 5-minute interval produced a shock. All other features of the stimulus-shock termination schedule remained the same.

The addition of response-produced shock decreased rates of responding at least 75 percent. These suppressed rates were maintained throughout the sequence of drug experiments (Table 1).

Table 1. Individual rates of responding (responses per second ± standard deviations) under the fixed-interval 5-minute stimulus-shock termination schedule. Data before the addition of response-produced shock are from eight sessions immediately preceding the introduction of the shock presentation schedule. Data under the shock-presentation schedule are from control days during each drug determination. Dose-effect curves were determined in the order the drugs are listed.

Drug	Subject			
	MS-69	MS-74	S-811	S-813
	Before response-produced shock			
	0.634 ± 0.013	0.465 ± 0.002	0.261 ± 0.017	0.458 ± 0.086
	After response-produced shock			
Pentobarbital			0.043 ± 0.015	0.083 ± 0.024
Morphine	0.041 ± 0.019	0.045 ± 0.005	0.056 ± 0.005	0.086 ± 0.016
Pentobarbital	0.099 ± 0.018	0.045 ± 0.018	0.030 ± 0.003	0.106 ± 0.015
Amphetamine	0.054 ± 0.020	0.039 ± 0.080	0.033 ± 0.011	0.081 ± 0.011
Pentobarbital	0.078 ± 0.014	0.075 ± 0.006	0.049 ± 0.006	0.052 ± 0.010

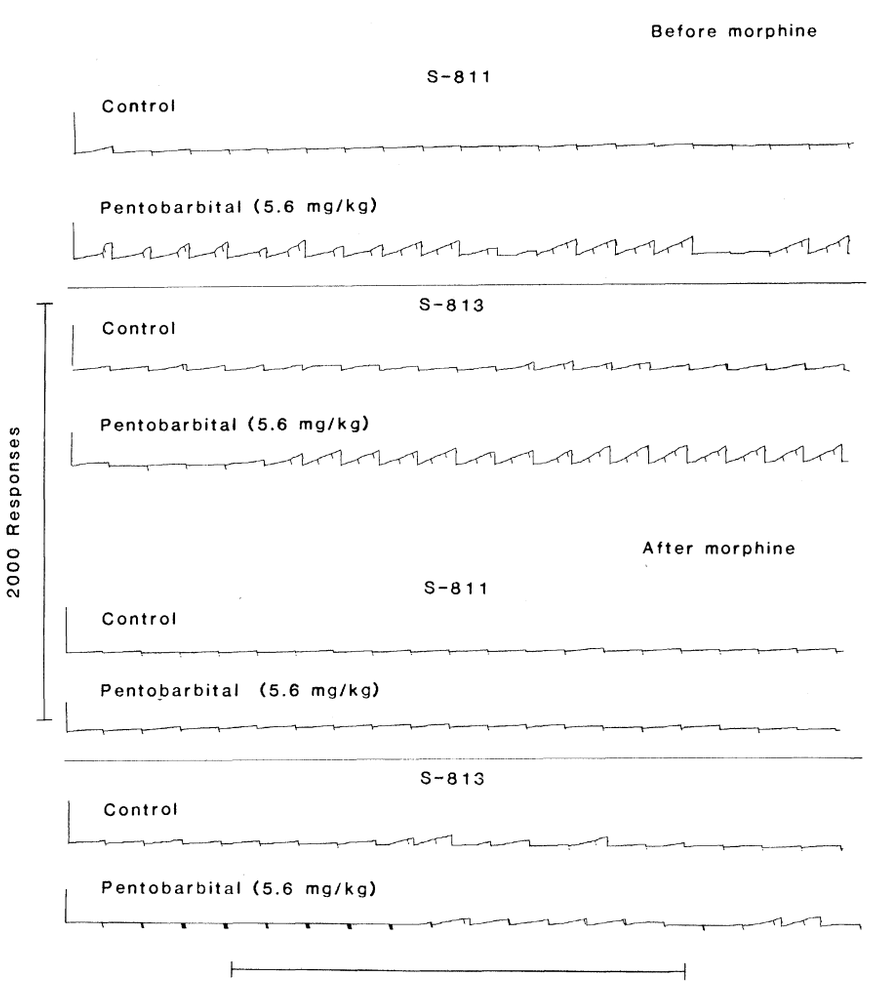

Fig. 2. Cumulative response records of control and drug sessions (5.6 mg pentobarbital per kilogram of body weight) before and after dose-effect functions for morphine were determined. Responding was simultaneously maintained under a fixed-interval 5-minute stimulus-shock termination schedule and suppressed by response-dependent shock. The pen stepped up with each response and reset at the beginning of each 5-minute interval. Shock deliveries are indicated by short vertical deflections on the record. Compare the large increases in rate of responding before morphine to the lack of effect produced by the same dose of pentobarbital after a history of morphine administration.

Drugs were dissolved in a 0.9 percent saline solution and injected intramuscularly immediately before sessions on Tuesdays and Fridays. Responding on Thursdays served as a noninjection control. Each drug dose, expressed as the total salt, was given at least twice; the different doses were given in a mixed order for each dose-effect function. No more than 1 week separated experiments with different drugs.

Figure 1 shows dose-effect curves for each drug in the order in which they were determined. Morphine typically produced a dose-dependent decrease in responding regardless of where in the sequence it was studied (Fig. 1, A and F). In contrast, the effects of pentobarbital depended on whether it was studied before or after morphine. When pentobarbital was first given, it increased responding over a range of doses (Fig. 1E) and increased the number of response-produced shocks delivered (Fig. 2); when pentobarbital was given after monkeys had received morphine initially, however, increases in responding did not occur or were small, and occurred only at one dose (subject MS-69, 5.6 mg per kilogram of body weight) (Figs. 1B and 2).

Experience with morphine also attenuated the large increases originally produced by pentobarbital (Fig. 1G). Thus, the effects of pentobarbital depended on a prior history of morphine administration: initial experience with morphine prevented the rate-increasing effects of pentobarbital, and subsequent experience with morphine attenuated the increases formerly produced by pentobarbital.

Amphetamine increased responding in all monkeys (Fig. 1, C and H). After animals were exposed to amphetamine, pentobarbital increased responding where such increases had previously been either precluded (Fig. 1D) or attenuated (Fig. 1I) by prior exposure to morphine. Thus, both amphetamine and morphine altered the effects of pentobarbital, but in different directions.

The finding that prior drug experience can alter the behavioral effects of a drug from a different pharmacological class has practical and theoretical implications not only for understanding the behavioral effects of drugs, but also for understanding more general issues in the field of drug abuse. Recent experiments with rhesus monkeys have shown that some opiate drugs (such as dextrorphan) will be more readily self-administered after the monkeys are exposed to other compounds (such as ketamine) (*6*). Thus,

prior drug history can influence a drug's behavioral effect and can also determine whether that drug will maintain responding that results in its administration. The likelihood that certain compounds will be abused may be modified by factors other than the pharmacological properties of the drug. Such experimental evidence now suggests that conditions that have existed in the past, as well as conditions in the current environment can play a significant role in determining the behavioral effects of a wide variety of drugs. A focus on these variables may aid in understanding and clarifying basic behavioral and psychopharmacological principles of drug abuse.

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Defense in Thrips: Forbidding Fruitiness of a Lactone

Abstract. *Expulsion of anal fluid from the upturned abdomen was demonstrated to serve a defensive function in the thrips* Bagnalliella yuccae. *An allomone in the anal exudate was identified as γ-decalactone, a fruity-smelling compound that repelled potential predators. Chemical defenses may contribute to the ability of thrips to maintain large aggregations.*

The Thysanoptera (thrips) (*1*) include some 6000 described species, many of which are of economic significance (*2*). Understanding of the chemical ecology of thrips is limited, probably as a result of their small size (many species measure about 1 mm) and cryptic nature. A number of species form aggregations that can be easily detected by predators. Although it has not been shown that such assemblages of thrips are chemically protected, many species raise their elongate abdomens when disturbed, with some exuding odoriferous fecal droplets (*3*). We report that the fruity-smelling component of the anal exudate of the gregarious thrips *Bagnalliella yuccae* is γ-decalactone, a compound that effectively repels small predators such as ants.

Bagnalliella yuccae live in aggregations between the closely appressed leaf bases of its host *Yucca filamentosa* (bear grass). The plant provides two types of protection: (i) many small predators are excluded by the tight confines between leaves, and (ii) the radiating, needle-pointed leaves deter large herbivores that might otherwise consume the thrips along with the leaves.

Thrips-infested *Yucca* leaves collected from Athens, Georgia, were sandwiched between panels of glass and placed under a dissecting microscope. The disturbed insects were allowed 24 hours to reassemble and then were challenged by the introduction of workers of *Monomorium minimum*, a predatory ant found on *Yucca* plants (*4*). Being slightly larger than their prey, the foraging ants were not always able to breach the narrow crevices protecting the thrips. However, when attacks occurred, thrips flexed the tip of the abdomen toward the assailant while exuding a droplet of anal fluid (Fig. 1A). When disturbed, thrips often held the abdomen aloft for several seconds (Fig. 1B), sometimes supporting a droplet of the clear, peachy-smelling anal fluid. From this position, frontal as well as broadside attacks could be rapidly countered with the turret-like abdominal tube. The tube is effective as a liquid applicator since its tip bears elongate setae that form a paintbrush for the exudate (Fig. 1C).

Ants contacting the exudate quickly withdrew, wiping exposed body parts on the substrate and displaying other grooming behaviors. The fluid also seemed to have an indirect effect; untouched ants avoided the vicinity in which the exudate had been released. Under these laboratory conditions, pursuing ants did not subdue adult thrips, although occasionally a few sluggish larvae were captured (*5*).

A preliminary test established that the thrips' discharge can repel predators. Glass tubes with cotton plugs at one end were streaked inside with exudates of thrips or were left empty (controls). The tendency of *M. minimum* workers from laboratory colonies to explore the tubes was compared (*6*). During 15 minutes, a mean ± standard deviation (S.D.) of only 1.6 ± 2.6 workers entered the exu-

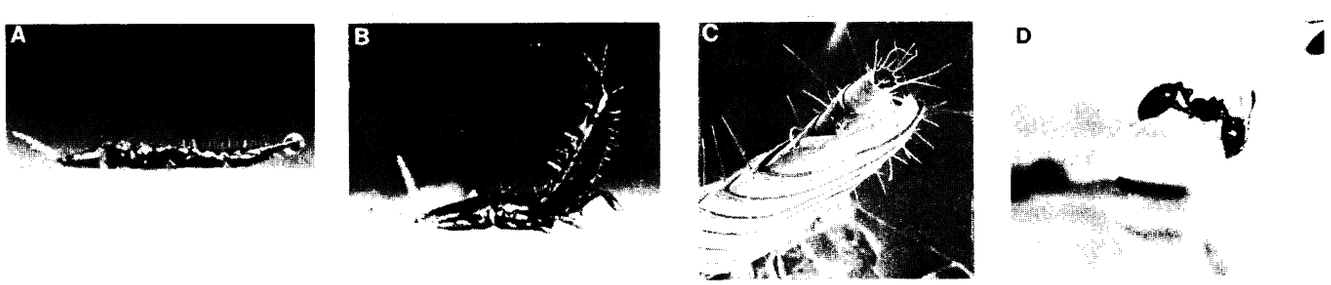

Fig. 1. (A) An unusually large anal droplet held by an adult *B. yuccae*. (B) Typical defensive posture. (C) Turret-like abdominal tube at the tip of the upraised abdomen (× 100). (D) *Monomorium minimum* worker with antennae deflected, standing above opening of a tube containing γ-decalactone.