

Introduction: Complex Schedules of Drug Injection*

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COMPLEX schedules under which alternative responses are maintained by different consequences can be used to estimate the degree of behavioral control exerted by those consequences. Two closely related procedures for maintaining alternative responses have been used in studying drugs that can function as reinforcers. Under the procedures described in the papers by Johanson (6) and Griffiths *et al.* (3), which are often called choice or preference procedures, the occurrence of either alternative response results in the initiation of one of two mutually exclusive schedules of reinforcement. Under the concurrent scheduling procedure described by Iglauer *et al.* (5), each alternative response is maintained by one of two variable-interval schedules of reinforcement that operate concurrently. Although absolute rates of responding are usually measured under these procedures, the primary dependent variable is the relative probability of occurrence of the alternative responses.

An important characteristic of these types of complex schedules is suggested by behavioral studies indicating that the relative probabilities of alternative responses are sensitive to changes in parameters of reinforcement that have little or no effect on absolute rates of responding under simple schedules. For example, Catania (1) compared in pigeons the effect of changes in magnitude of food presentation on responding maintained under a simple variable-interval schedule on one response key with the effect of similar changes in magni-

tude of food presentation on responding maintained under equivalent variable-interval schedules operating concurrently on each of two response keys. Rates of responding on the single key were about the same under all conditions, whereas relative rates of responding on the two keys were generally proportional to the relative magnitudes of food presentation available on the two keys. In the following papers by Iglauer *et al.* (5) and Johanson (6), the use of complex schedules is described for studying the maintenance of alternative responses leading to injections of different doses of psychomotor stimulant drugs. As emphasized by Catania's discussion (2), these studies also indicate the importance of the precise scheduling arrangements as one determinant of both absolute and relative rates of responding in studies of drugs, as well as other consequent events, as reinforcers.

A potential advantage of complex schedules involving alternative responses is the use of relative response measures. As noted previously (7), the relative frequencies of alternative responses should be less influenced by direct effects of drugs than absolute rates of responding. If absolute rates of responding become very low, however, even relative response measures can be affected; for example, in comparisons of different doses, the scheduled relative frequencies of drug injections may be altered (5). Problems that arose in comparing relatively high doses of cocaine are discussed by Johanson (6) and Iglauer *et al.*

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(5). Griffiths *et al.* (3) discuss the value of relative frequency of response as a dependent variable in studies of the effects of drug pretreatment on behavior maintained by drugs or other reinforcers; for example, the effects should be relatively independent of absolute control rates of responding.

Qualitatively different types of reinforcers can be compared by using complex schedules of reinforcement. For example, Hollard and Davison (4) compared in pigeons the relative frequency of alternative responses maintained under concurrent variable-interval schedules of electrical brain stimulation or food presentation. They concluded that there was a relative preference for food over brain stimulation at the parameters of reinforcement they used. In the following papers, Johanson (6) describes the use of relative frequency of responding to compare cocaine with methylphenidate and cocaine with diethylpropion. Griffiths *et al.* (3) describe how pretreatment with methadone or naloxone can alter previously established relative

frequencies of alternative responses leading to injections of heroin or presentation of food. Catania (2) discusses behavior maintained by complex schedules of drug injection in the context of behavior maintained by other reinforcers and notes the potential contribution of studies of drug dependence to the analysis of behavior.

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