suppose that sensors may respond to the products of producers, not only by activating their integrators, but in some cases by becoming altered in their receptivity to some other external stimulus, such as an inducer. This point is of such fundamental importance for embryological development that it needs to be emphasized.

C. H. WADDINGTON
Institute of Animal Genetics, University of Edinburgh, Edinburgh 9, Scotland

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Marihuana and Simulated Driving

The report by Crancer *et al.* (*1*) on the relative effects of alcohol and marihuana on a simulated driving task has limitations which seriously reduce the value of their work. They have designed their experiments carefully and have considered in detail the possible influence of subject bias on the results. They point out that all their subjects were favorably disposed toward marihuana, but that it would not have been easy for them to deliberately perform better during the marihuana trials. However, many marihuana users have a bias against alcohol, and Crancer *et al.* do not explain what safeguards were used to prevent this from influencing the results. Even if the subjects did not know the details of the scoring procedure, was it not possible for them to deliberately do badly on the simulated driving test in the alcohol trials? The finding of normal results in the trials before administration of the drug on alcohol days is of no help in this connection, since there would be no incentive for the subjects to do poorly before taking the alcohol. Since placebo controls are of little value in such a situation, it would have been desirable to include a second group of subjects who were experienced drinkers and probably biased in favor of alcohol.

My major criticism of the work of Crancer *et al.* is the arbitrary choice of a single dose of each substance for the comparison. The subjects, who were experienced marihuana users, smoked enough to achieve "a normal social marihuana 'high.'" In contrast, they consumed alcohol at a dosage of 112 ml of 95 percent ethanol (equivalent to 8 ounces of 86 proof liquor) for a 150-pound subject in a 30-minute period. This is far more than the amount required for a normal social alcohol "high" and would probably produce a peak blood ethanol concentration of about 0.15 percent (*2*). The objective was to achieve a concentration of 0.10 percent, but the authors do not indicate what values they actually observed. The finding that a heavy dose of alcohol caused more impairment than a mild dose of marihuana is neither surprising nor helpful in assessing the relative effects of the two drugs in the respective doses in which they are normally used.

If the authors had used three or more dosages of each drug with adequate numbers of subjects, the comparison of dose-response curves would have been a most satisfactory way of establishing the relative potencies of the two drugs; at the same time it would permit some inferences about the similarity or dissimilarity of their mechanisms of action. The studies by Goldberg (*3*) illustrate the sort of dose-response relations which are easily established for alcohol. Crancer *et al.* would have added greatly to our knowledge of *Cannabis* effects if they had obtained similar data with marihuana. They state that in four subjects the use of a tripled dose of marihuana did not result in any increase in error. They recognize that this was "a cursory investigation of dose response," and they do not indicate what measures were taken, if any, to ensure that the larger dose was effectively absorbed by their subjects. Therefore they would have been well advised not to draw from such limited observation the conclusion that "impairment in simulated driving performance is apparently not related to dose." Isbell *et al.* (*4*) have shown that changes in pulse rate as well as in subjective effects provided good dose-response curves for Δ^9-tetrahydrocannabinol (THC) in man, and Dagirmanjian and Boyd (*5*) have observed dose-dependent impairment of polysynaptic reflexes by other THC derivatives. It is most likely, therefore, that the effects on complex performance tests in man will also prove to be dose-dependent when full studies are done.

A final note of caution must be sounded against making unwarranted extrapolations from this study. While performance on a simulated driving task may correlate well with actual driving performance, it does not follow automatically that lack of effect of a drug on the simulated task will correlate with lack of effect on the actual task. The simulation applies only to specific sensorimotor skills, and motivational factors may be quite dissimilar. Crancer *et al.* correctly drew no conclusion that use of marihuana will not impair driving or that it is safer than use of alcohol. It is to be hoped that their readers will also refrain from drawing unjustified conclusions.

H. KALANT
Department of Pharmacology, University of Toronto, Toronto, Ontario, Canada

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The fact that the test subjects did not improve in their performance (unlike the same subjects under control conditions) was not surprising. The average concentration of alcohol in the blood was 0.07 percent prior to their taking their third and last simulator test. Only 3 hours elapsed between the first and third simulator test. Average concentration of alcohol in the blood for our subjects before the first simulator test was 0.10 percent.

Comparison of normal usage of both alcohol and marihuana was not an objective of this study. As indicated in our report, we thought possibly that smoking marihuana may lead to impairment and that it would be of value to compare its effect to a recognized standard of impairment—the presumptive limit of 0.10 percent of alcohol in the blood.

Replicating the experiment with the same subjects would have provided us with information on the variability of the treatments within the subjects. This information is not necessary when our interests are primarily in comparing the effects of several treatments. This we did by obtaining a single score for each treatment for 36 subjects.

ALFRED CRANCER, JR.
Department of Motor Vehicles, Olympia, Washington 98501

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