Decision Theory in Law, Science, and Technology

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A. The Two Ways of Thinking

The aim of science, traditionally put, is to search out the ways in which truth may become known. Law aims at the just resolution of human conflict. Truth and justice, we might venture to say, having different aims, use different methods to achieve them. Unfortunately, this convenient account of law and science is itself neither true nor just. For law must know what the truth is within the context of the legal situation; and science finds itself ever engaged in resolving the conflicting claims of theorists putting forward their own competing brands of truth. In the face of this obvious dialectic, can we still cling to our device of the two ways of thinking? I believe we can, for a while at least. For if we were to ask a scientist to make a cool appraisal of legal methods for ascertaining truth, whether in decision, legislation, or executive order, we might well expect him to throw up his hands in despair and call for the aid of the anthropologist as a specialist in primitive folkways, if indeed he did not go immediately to the paleontologist. On the other hand, the scientist's *apparently* irresponsible attitude toward the destructive monsters he creates—what is often taken to be his wholesale disregard for or even downright antagonism toward art, morality, and religion—strikes many members of the legal profession as callous. Worse than that, there is strong evidence at hand that the scientist, in league with the businessman and the soldier, intends to rule the world of tomorrow—and intends to make both businessman and warrior as scientifically knowledgeable as they will need to be in order to fulfill their function in a world grown monstrously technological. For many scientists, the lawyer is merely a necessary evil—necessary, that is, for sweeping away archaic legal obstacles in the path of scientific enterprise. The lawyer, it needs hardly be added, is often suspected of creating these obstacles in order to remove them later for a fee. The two antagonistic ways of thinking then, if they do exist, certainly have sufficient reason for having come into being. Do they in fact exist?

A lawyer is taught early to look for the human *interest* behind all phenomenology. It is not expected that a plaintiff's account of a series of events will be in agreement with a defendant's account of the same series. More than that, plaintiff's attorney's account is not expected, or certainly not always expected, to be the same as defendant's attorney's. On the other hand, not only is a scientist's account of a set of events expected to be the same as that of another scientist's, but an elaborate methodology exists and must be followed to assure that all competent to undertake the investigation will arrive at relatively similar results. What the scientist is expected to avoid, as *scientist*, is preferring his own biases over those of his fellows. These biases must wash out in the course of the work, leaving results that are public, verifiable, general, and in accordance with truth, as current scientific methodology sees that commodity. The lawyer deals with human interest, bias, greed, falsehood, or just plain temperamental difference. The scientist, when he comes to deal with the same material (as psychologist or sociologist) proceeds to process it by taking out the bias. The lawyer does not do this and usually does not believe that the scientist can do it either.

The scientist *generalizes*; the lawyer *individuates*. It would take a lifetime to substantiate this bald assertion, but since none of us has a lifetime to give to it, I shall confine myself to a summary statement: *Litigation aims to individuate, and the judicial process is most at home when it disposes of a unique conflict situation uniquely*. What then of precedent? What of the universal or at any rate the general rules of law that govern human conduct? What of standards to which "all or almost all" must adhere? Worse still, what of legislation that may fall upon 180 million people at one time? And finally, what of executive order, decree, or ruling that may be addressed to one, many, or all subject to the jurisdiction? I know about these objections. I know them only too well. All I can say now is this: somehow or other a generalization such as "Every one who breaks and enters the dwelling, etc., shall be guilty of burglary" is different, vitally different, from a generalization such as, "Masses attract each other directly as their product and inversely as the square of the distance between them." Both are laws, both are general laws, but whereas the first is addressed to unique individuated subjects in such a way as to preserve as much as possible their unique individuality, the other subsumes the particularity of the *objects* concerned in the grand sweep of its generality. You will notice that I resisted the temptation to say of the first that it was a "prescription" and of the second that it was a "description." I happen to believe that both are prescriptions, the legal one being addressed to all subject to the law; the scientific, to all scientists "whom it may concern." The second, that is, is not really a *description* of nature but rather a *prescription* for scientists to act in certain ways rather than in others (*1*).

One way of putting the matter of *individuation* is to say of it that individuation invokes that autonomous function of the human mind which, following Carl Gustav Jung, we call *feeling* (*2*). The law is primarily interested in feelings—for example, feelings of justice; the *right* disposition of the dispute; the *best* ordering of human relations so as to attain a minimum

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amount of pain, suffering, loss; and the *optimal* procedures for attaining these results. And I believe that the law will warp and twist the facts, sometimes in an apparently shameless manner, if necessary, to obtain what it thinks of as the *just* result. To be sure, justice for one is justice for all. To discriminate unfeelingly is unjust. But equality before the law is not the same as uniformity for the scientist. True equality in law might almost be said to consist in the maxim: *no two cases are ever really alike.*

If you will allow me now to assume as established what you might have been willing to grant at the outset—namely, that there really are two ways of thinking—perhaps I can get on to what I think the lawyer might do about it.

In the first place, I believe that the legal community has little to gain from emphasizing existing differences between the scientific and the legal ways of life. Indeed, I believe that the two ways are different in a peculiarly helpful fashion; that is, I believe that they complement each other. Each is strong where the other is weak. This does not necessarily assure us that they will get along together. It is rarely the two individuals who perfectly complement each other who get to the altar. Therefore, a nudge from the shotgun may eventually be necessary. But first, let us see how far patient inquiry may take us.

Suppose we begin by admitting that the law's own scientific endeavors are woefully archaic—for example, that its fact-finding process is a relic of the childhood of Western culture. Should we not blush to say that our jury system is designed to find facts? This does not mean that our juries do not serve a vital function. It means that we can hardly call that function "fact-finding" in an age whose scientific devotion to sophisticated methods of experimental fact-finding is so steadfast. Fact-finding as a preliminary to executive order is still less apt to be "scientific"—that is, controlled, impartial, dispassionate, objective. And when we come to the methods by which legislators find facts, it is best to draw the curtain and move silently away from the mess. Fact-finding, the scientific side of law, is evidently nothing for law to be proud of.

On the other hand, law is highly skilled in making value judgments or, as I shall call them here for sake of greater precision, *feeling-value judgments.* By "feeling" (*2*, p. 64) I very definitely do not mean emotion, for emotion colors all mental states and functions. I mean the process by which the distinctive worth of an individual is brought into view—the focusing or concentrating on a special object, or the selecting of one among a group of alternatives (decision making). This mental function is the opposite of the function by which the human mind sees similarities and generalizes from them.

Law discriminates on the basis of such feelings. It follows the great tides of community feeling and channels them by rules and processes whose purpose is to lessen conflict between man and man. In this massive undertaking, law uses of necessity a fact-finding process, but that process is subsidiary to the main great undertaking, the peaceable ordering of human relations according to principles based on feeling. Equity, equality, reasonableness, good faith, due process, mutuality, form, the speedy and efficient disposition of conflict, and the rest are principles based on feeling. To be sure, if they are based on misconceptions of fact, or, worse still, upon perversions of fact, the law finds itself perpetuating injustices. For indeed the right ascertainment of the facts upon which a legal disposition rests is itself a prime feeling-value of all advanced cultures. And if the culture in question also happens to be highly advanced in technological and scientific ways, the conflict may become intolerable. Still, the strength of the law lies in its feeling life.

How fares science in this respect? Feeling is precisely the area in which modern science is weakest. I should not like to have to press this delicate issue too hard. It is one which the scientific community scarcely needs to be reminded of. Put in the form of a question it is this: Do scientists have any responsibility for the power which they create, power which today may easily destroy all life on earth? Put it another way: Is science responsible for the apparent fact that modern technology causes the sources of artistic inspiration and of craftsmanship to dry up; that it aborts the instinct for workmanship by automating and thus trivializing the efforts of myriads of working people? What of the great surges of human feeling, inchoate and suppressed, which well up in protest at the technological way of life? Are all these overwhelming problems to be dumped into the lap of law to be solved?

Religion and morality seem slowly to be marshaling their immense forces against the technological juggernaut. But law seems to be standing aside, unwilling to adopt an antiscientific attitude, and apparently unable to lend science any aid in its disastrous slide toward the abyss.

I am not sure that any rising sector of humanity (the so-called power élites) can pause to consider what may happen to them if they attain to a full power position. Certainly, science and scientists, even the social scientists, the lawyers' nearest scientific neighbors, seem to lawyers to show little concern for this danger. This is not surprising. Law created and guided the great revolutions of the 18th and 19th centuries without a moment's concern for the help that science could give it. For instance, one can search the Constitution of the United States in vain for even a reference to science, beyond the patent clause. However, now that the great legal revolutions of the 19th century seem somewhat spent, and the vast world-wide impetus to change is scientific rather than legal, perhaps it behooves the legal community to take stock and to search for ways and means to understand, if not actively to cooperate with, the new scientific society. If the mountain of technology will not come to the law, perhaps the law should consider going to the technological mountain.

I end this section with the correction of its title. There are not two ways of thinking, the legal and the scientific, but there are two fundamental and, I hope, complementary modes of orientation to human problems—that is, to think one's way into them or to feel one's way out of them. Each needs the other.

B. Law and Science in History

In the beginning of Western culture, law and science were one. The great cosmogonies of the pre-Socratic philosophers were not only bold scientific speculations on the physical nature of the universe which directly challenged the old sacred myths of the gods as world-builders. They were also reaffirmations of the timeless conviction that justice rules the world.

Socrates himself, though the focus of Greek interest had shifted from the

physical universe to the nature of man, proclaimed that to know the good is to do it. Science and morality have identical aims. Vice and injustice are ignorance.

It is not necessary for me, in this brief sketch, to dwell upon Western man's increased preoccupation with religion in the centuries before and after Christ. In order to create his new religion, Western man apparently found it necessary to turn away from the physical universe. A result was the collapse of Greek science. And Roman civilization, with empire-building as its object, raised the arts of law and administration to heights scarcely ever to be attained by later European cultures. The break-up of the Roman world brought with it the thousand-year task of Christianizing the barbarian peoples. This meant not only teaching them the tenets of the common religion but also inculcating in them the principles of law and order. When, at the Renaissance, attention was once more turned to the physical universe, it seemed necessary for the new scientists not only to break with established religion but also to turn resolutely away from the study of man and the ways by which he governs himself in order to concentrate attention on the physical environment and the ways in which it is governed. *It became necessary to challenge the very meaning of the word Law.* Henceforth, for the scientist, the word *law* would come to mean a law of physical nature. And the laws of nature were once more thought not only to be independent of man's will but also to be the rules by which man's destiny is governed. Western science, emulating the pre-Socratic models, issued the fiat that, far from being the very pinnacle of the universe and the only reason for its existence under God, man is among its lowliest creatures. His true nature and that of all other things is to be explained by the blind ordinances of a vast machine, the whole physical universe itself. These conceptions were and still are in direct opposition to the idea that, by the exercise of his free will, man gives laws to himself and determines his own destiny.

It would be too much to say that the conception of law (legal law) remained uninfluenced by the ideas or motifs of Western science. After all, science was clearly remaking the world. Its interstitial effect upon law was immense. Roscoe Pound has devoted much time and attention to the rise and development of "mechanical jurisprudence." It will suffice here to call attention to his studies (see appendix) and to the vast literature upon which they are based.

More important even than this was the fact that these developments forced a split between science and law. When, therefore, the philosopher Kant followed this with the bold assertion that the domain of existence is separate from that of obligation, that the "is" is separate from the "ought," it seemed to many that that separation was the most natural thing in the world.

We know that law did not long remain shackled even in theory to the "mechanical ideal." A century ago, jurisprudence became openly and avowedly a "teleological science"—that is, law came to be recognized as a consciously contrived mode of social control. This not only completed the emancipation of law from religion, it also put law in direct opposition to the mechanical science of the day. Henceforth law was to be sharply distinguished not only from religion and morality (by reason of law's secular emphasis) but also from mechanical science (by reason of law's insistence that it is a conscious product of human wit and endeavor).

What is the present prospect? Science has not yet won through to the Kantian insight that the laws of nature are human necessities. Scientists still purport to be describing, or at least to be attempting to describe, the overall general principles by which the cosmos governs itself. It is not yet good form to call these laws the products of human invention. To do so seems to contemporary scientists to be running the risk of ascribing to the scientist the power to make into a "law of nature" anything which idle fancy might dictate. Yet it does not occur to the lawyer to maintain that, because he recognizes that law is consciously made, therefore anything may be made law which "idle fancy" suggests. This madness is reserved for the absolute dictator.

I have now given reasons why law and science are not one. I have not of course attempted to justify this state of affairs. Indeed, I feel that I should not be at all justified in setting out the differences if there were no possibility of lessening them. It is therefore encouraging to note that newer developments in science lead to the belief that the two disciplines may be able at long last to draw a little closer together.

C. The Scientist as Decision Maker

The origin of modern science seems almost to coincide with the invention of instruments of precision, notably the telescope and the microscope. These instruments multiplied man's power of observation, bringing into his ken objects hitherto beyond the range even of his imagination. After the first phase of sheer wonderment and joy at the new toys, it was realized that what these instruments really meant was that man could now perform the act of *measurement* with an accuracy not possible to him in the past. And when more accurate measurements became possible they also became, *ipso facto*, necessary. *The grand enterprise of science was seen to be the perfection of the art of measurement.* Carefully and still more carefully to measure the speed at which metallic balls roll down an inclined plane, at which a pendulum swings, at which planets revolve about the sun—this and kindred operations are to be the means by which the scientist is to wrest from nature her secret laws. With measuring, of course, goes counting, but it was necessary to wait for contemporary instruments to demonstrate how sophisticated that latter art could become. At any rate, the Renaissance ideal was clear: to measure the measurable and to reduce the hitherto unmeasured to the measured.

It is by no means unanimously agreed by the scientific community that the ideal of measurement has lately undergone subtle and far-reaching modification. In the first place, the ordinary working scientist pays little attention to the implications of this ideal. For, if the legal community is able to do its daily work without regard to the philosophical implications of law (leaving legal philosophy to a small group of specialists), scientific, as distinct from philosophic, participation in the development of the philosophy of science is still less in evidence. I do not mean to say that the part which measurement plays in the scientific process is not the object of current investigation. I do mean that the focus of scientific inquiry is seen to be shifting, and that the shift is in a direction that has exciting possibilities for rapport between science and law. *The scientist, in brief, is being recognized as a decision maker.* The body of lore currently called decision theory represents an attempt to understand how a scientist does and should make scientific

decisions. This is not the present avowed major concern of decision theorists. If you ask them what they are doing they are very apt to say that they are studying the ways in which decisions can be made rationally, and, in the broader framework, that they are interested in the way decisions are actually made, whether made rationally or not. This learning, though new, is proliferating rapidly. And it is only a matter of time before the process turns to the work of science itself, at which time it will be perceived that scientists, too, spend their time making decisions.

It might surprise anyone but lawyers to find that current effort directed toward investigation of the process of decision making almost ignores the vast body of legal learning on the decision process. The fact is that law, and particularly judicial administration, does possess this body of knowledge, and the realization that the very essence of law is decision is just barely breaking through the consciousness of the present-day decision theorists.

Perhaps it would be helpful at this point to interpolate a brief account of the research activity which calls itself decision theory. The movement can be said to have started in this country with the appearance in 1944 of a book by John von Neumann, mathematician extraordinary, and Oskar Morgenstern, mathematical economist. The book was called *Theory of Games and Economic Behavior* (*3*). In it the authors worked out a proposal for studying conflict situations in a highly formalized and rigorously mathematical manner. Sophistication consisted in reducing the conflict elements to a skeletonized formal model (their mathematically most simplified structure) and then in working out in detail and in strict mathematical fashion the way the players of the game must play if the outcome is to have the best possible chance to conform to an ideal of rational behavior accepted by the players in advance. It will be noted that the simplicities and sophistications of this game are exactly the opposite of those attending the "games" the legal community plays. For with lawyers, sophistication lies primarily in the complexities which the fact situations present. Human temperament in all its intricacy and human conflict in all the variegated shapes it may take are the *matter* of the lawyer. His formal model—the body of his principles, rules, precepts—and his ways of processing this rich conglomerate are themselves relatively simple. Consider the "fundamental principles" of negligence law: one must act with reasonable care; contributory negligence bars recovery. Consider attractive nuisance, last clear chance, voluntary assumption of risk, *res ipsa loquitur*. These are metaphors, allegories, catch phrases. But the manifold forms in which they come up are often enough to break the hardest judicial head.

Lawyers have no body of first principles from which the solution of specific cases can be deduced by rigorous rules of procedure. In fact, they consider the very ideal of rigorous deductive processes in law to be outmoded. The whole burden of 20th-century legal realism was taken to be the dismantling and junking of the system of "legal certainties" upon which, from time immemorial, law had been thought to rest. And yet, game theory prides itself precisely upon its claim to deductive rigor. Conflict, we have been told, is fitted into a mathematical mold distinguished from earlier attempts at formalizing conflict situations by virtue of its mathematical rigor.

Thus, law and science are curiously out of phase respecting one of the most important aspects of their methodology. Law can only regard the scientist's pursuit of formal rigor as outmoded and unsophisticated. This means that the hard-headed American legal realist instinctively dismisses the claims of modern scientific decision theorists as naive. And naive they do look, it must be admitted. Yet, it is also undeniable that the wonders of modern contemporary culture rest precisely upon such scientific naiveté. It may turn out that this is the kind of naiveté which eventually shows itself to be a deeper sophistication.

In any event, scientific decision theory is not irrevocably aligned with game theory, anymore than it is necessarily tied to game theory's analog in the realm of hardware, the computer. Decision theory is more general than either game theory or computer technology. There is a great deal of experimental work going on in an effort to learn how and why people make the everyday decisions they do. This work is broad enough to cover every aspect of the decision process. It encompasses learning theory, because it views the process of learning as a course of decision making. It has invaded foreign policy making because it sees this activity as primarily a series of decisions. In fact, once one puts on decision-theory glasses he sees decision making in all phases of human behavior. And if the glasses are turned upon the behavior of scientists, it is seen that the practice of science is itself a long and complicated process of decision making.

D. Law as a Decision Process

So thoroughly immersed is law in the business of decision that one might easily be tempted to say that decision is its sole activity. Passing over the administration of justice for the moment, we might examine legislation briefly to see what part decision plays in it. The major part, we might be tempted to say. Legislative law is the reconciliation of competing pressure groups in formulas that aim to reduce tension and compromise differences, and that represent the best interests of the subjects, as the legislators see and weigh these interests. And when judicial and legislative law presents itself for execution, the executive action under such law is one long series of decisions to enforce or not to enforce.

The body of learning on the subject of decision in the legal process staggers the imagination. If, to the literature on how agencies of the law do decide, one adds the stupendous quantity of literature on how legal decisions *ought* to be made, and then if one buries the mass in the avalanche of reports on decisions actually made, it becomes necessary to forget the whole nightmare in the simple interests of self-preservation. Needless to say, since so much of the law's variegated life consists of decision, there exists no *authoritative* body of learning or generally agreed upon ideas on the subject of how legal decisions are actually arrived at, to say nothing of how they ought to be arrived at. Still, it is possible to see that much of the dispute revolves about one overall subject. This is the question of *whether and to what degree the legal decision is based upon rational considerations*. If we were to adopt the lingo of the system theorists for a moment we could put the matter this way: There is an immense and complicated Input into the judicial Decision Maker which we can observe. We also can observe the Output in the form of the Decision and all its effects that we care to observe. The judicial Decision Maker is the Black Box between Input and Output. Does the Black Box operate according to rational principles, and if so, what are they?

A century ago many thoughtful observers of the judicial process would have said that the Black Box is indeed governed by rational principles. In reply to the question of what these are, the answer would have been: "Logic." The principles themselves which form the basis of the legal system are rational intuitions of the nature of justice, revealed to our minds by a merciful and just God, or analyzed out of the nature of the mind itself by the process of reason. These, when supplemented by the facts of the particular case to be decided, then yield valid conclusions, provided the rules of logical reasoning are adhered to.

Curiously enough, something like the above description lies at the foundation of contemporary game theory and indeed of much of general decision theory to boot. But a century of jurisprudential theory in both Europe and America has subjected the above *rational* account of the nature of judicial decision to searching criticism, in the course of which almost all elements of the explanation have been superseded. The first element of the theory to go was the assumption that the processes of logic govern the course of judicial decision. German jurists of a century ago, following the lead of the early sociologists and Marxian economists, began to construct a theory of law as a consciously chosen and purposefully devised agency of social control. This imposed on the theory the first important element of nonrationality. The decision need no longer be *consistent* (a logical demand) with the set of rational principles that furnish the body of existing law. Social necessity may dictate a change, however irrational the change might appear in the light of existing rational principles of law. Not the rational principles of the mind but the wholly nonrational demands and interests of society came to be recognized as the foundation of the decision.

We know how, in the 20th century, theories of the irrational nature of judicial decision grew. Sociological jurisprudence and then the new American legal realism purported to expose the contents of the legal Black Box. It turned out that the Black Box operates irrationally, or at least nonrationally. The decision maker appeared to be subject to the manifold influences of a hopelessly complicated Input. In addition, the Box could add on its own irrationalities. The judgment was seen to be the result of completely unpredictable intuition, or even of blind chance. Currently, a reaction against these excesses has set in. Jurists once more reaffirm their faith in the ultimately rational character of judicial decision. But this present rationality or "reckonability" is itself a fearfully complicated thing, vastly different from the few simple, general principles which our forefathers took to be the rational bases for the decision of cases.

Lawyers might well hesitate to suggest to modern scientific decision theorists that they take a look at the jurisprudential literature of the past century if they want to see what *can* happen to a rational theory of decision making. It seems entirely too cruel. Yet if the theorists *did* happen upon this body of learning they could easily conclude that perhaps the nonrational elements of decision making are at least as important as the rational ones. They could learn that the decision maker is more interested in the *effects* of the decision than in its form; that the teleology of decision making is more powerful than its logic in shaping the course of decision; that intuition has a more important role to play in even simple and apparently trivial decisions than the rational constraints of present-day decision procedures allow. I should add, for myself, that since it seems to me that every true *decision*, as distinct from an *inference*, involves an element of individual choice, the constraints imposed by general logic and generalizing mathematics upon decision procedures virtually rule out the study of truly creative decisions and tend to restrict decision science to mechanical, and therefore dull and repetitive, instances of decision making—to those which allow themselves to be bunched together and processed in accordance with the generalizing demands of logic, set theory, probability, and the universalizing effects of randomized processes. How these processes can be remade to deal with the individual event, I of course cannot say. But unless they can be, they will not handle the interesting cases of decision —which is precisely what the legal decision process does. It might therefore be appropriate to close this section with the suggestion that the scientific decision makers have available to them a sophisticated body of learning on the making of highly consequential individuated decisions which are explained and defended by "reason," a process that has had a fairly consistent history since the time of Roman law. For a starter, they might try the late Karl Llewellyn's *The Common Law Tradition.* Study of the manifold ways in which the relatively highly controlled doctrine of precedent (itself a rational constraint on the decision process) may differentially influence decision should be most enlightening.

At any rate, whether the scientists do or do not study legal decision making is hardly the lawyer's responsibility. It is enough for him at present to try to understand the scientists. If, following the tenets of realistic jurisprudence, he watches these scientists in action instead of listening to their theories, he finds that, like other artisans, they are constrained more by the nature of their tools than by poverty of the imagination. In the case of law, much of what happens is due to the limitations of political institutions rather than to any narrowness of legal vision. So, too, with decision scientists. Their major instrument is the computer, and in order to understand what is actually happening in decision theory and in its most modern offshoot—namely, *systems science*—it is necessary to watch what is being done with computers.

E. The Character of the Computer

There is so much ado about modern computer technology that what one has to say about it is apt to reveal more about the personality of the writer than about the nature of the instrument. This is not surprising, for if only a fraction of the claims of computer enthusiasts are accepted as realizable, it is quite evident that vast sectors of the population which hitherto have watched the growth of technology with complaisance, if not with enthusiasm, are bound to experience a more intimate concern.

Until the advent of the computer, automation affected in the main the less articulate sections of the population. Moreover, the effects of automation processes seemed (and they still seem) to be in the direction of progress. They spare mankind tedious repetitive processes of an essentially impersonal character which from time immemorial it has been the part of good sense to get done the easiest way possible. Even a horse is glad to be relieved of the harness. Man willingly substitutes mechanical energy for muscle power wherever he can. But the computer saves brain power, and this is a much more serious matter. For one thing, no one can foresee how much or what kind of brain power the computer can be made to

substitute for. In the second place, no one can foretell whose job is at stake, and what kind of an economy will result from the substitution. These considerations are basic. From them flow a third set of considerations. No one knows what the cultural and spiritual effects of a heavily computerized society will be.

Many people believe that computers are nothing but high-speed calculating machines. They base this belief on the fact that the present-day digital computers ultimately rest on a single dichotomy represented by the numbers 1 and 0. The foundation of a computer is a row of bits, each one of which can be 0 or 1 and nothing else. But to imagine that this fact limits them to simple mechanical operations is ingenuous. It is the same kind of homely folk wisdom as the observation that the most exquisite violin music is nothing but the rasping of horsehairs on catgut.

It is true that the modern digital computer is an awesome adder, subtracter, multiplier, and divider. And these operations (they are all one) are precisely the kind of tedious and repetitive "finger work" that it is well to relieve mankind of. Let us say at once, however, that this is only a small part of the story, even if we throw in the more formidable types of computation which the scientist is interested in.

Going one step farther, we note that the computer is a logic machine. It performs very elementary and very fundamental operations of logic. It performs the operation of *disjunction*, the operation of choosing this *or* that. It knows conjunction (this *and* that); inference (if this, then that); negation (not this). These logical operations need have nothing to do with computation, although they can of course be used in combination with it. The arithmetical and logical operations give the computer an immense versatility. But they by no means exhaust its capabilities. For example, the computer can perform the operation of *comparison*. (Is this the same as that? If so, do x; if not, do y.) So far, we have said nothing about the computer's fantastic storage capability. These powers are well known. It has in fact what might as well be called infinite storage potential, with virtually instantaneous and highly accurate recall. Data retrieval is an art whose applications can be indefinitely proliferated. It is quite evident that the recall of much stored knowledge can be efficiently computerized.

At this point—the point of considering the potentialities of the computer in data retrieval—a very important policy question comes into view. It is one which none of the data-retrieval people that I know of have grappled with, and one which intimately concerns the legal community, though of course not the legal community alone. I refer to the fact that it is a prime policy matter to determine what data shall be preserved, and, among those that are preserved, which it is politic in any instance to suffer to be recalled. Data-retrieval experts make the blithe assumption that data are, *ipso facto*, good. And if this is ascribing to the experts a naiveté not many of them possess, then it is fair, I think, to say of them that they feel that all data which are preserved should be subject to instant recall. It is the unavowed working assumption of information theorists that information is a good in itself and that more, or more accurate, information is better than less, or less accurate, information. *However, in a situation involving conflict, information is armament.* And the paradox of more and better armament quickly begins to operate. It is simply not true that the practicing attorney would welcome all relevant information on a case, and this whether his opponent has or has not equal access to the data or information.

It might almost be said that skill in the art of advocacy and the deciding of cases consists in the ability to ignore vast quantities of even relevant data or information. To sum up this point: nothing exists in the computer analogous to the power of the human mind to forget, to ignore, to pass over as irrelevant matters obviously but inconveniently relevant, and the like. I do not say that a computer could not be designed and then programmed to forget as efficiently as it now remembers. I do say that computer designers currently ignore this problem. They are concerned with computers that can learn, but they apparently do not yet wish to tackle the much more difficult problem of creative unlearning. In the parlance of psychoanalysis, the computer has not yet got an "unconscious." Until this fantastically difficult task is accepted and the processes of purposeful forgetting are better understood, I really believe that data retrieval will remain for lawyers (and for all others whose use of stored knowledge must be highly selective) something to be taken or left as interest dictates.

F. Data Processing

With the limitations of computerized data processing already admitted, it is only fair to go on to say that if the law wants to use electronic data retrieval, the hardware already exists, waiting to be adapted to the job of storing and efficiently retrieving, upon command, the bulk of stored legal information.

The prospect is exciting and induces utopian dreams. Let us indulge this fancy for a bit. Suppose a movement similar to that which produced the Roman *Corpus Juris* seized the legal community. Suppose, that is, that the lawyers decided to get rid of the accumulated clutter of centuries that now gathers dust in law libraries. They could preserve one set of these legal remains intact, junk and all, in central archives. For the rest, only matter of lasting significance would be preserved on card or tape. Though the question of relevance might invite instant disagreement, there would be a surprising amount of agreement, I suspect, on the clearly obsolete and irrelevant. Thereafter—and this is the point—great restraint could and should be exercised in the matter of accumulating unimportant legal effluvia: routine judicial decisions, prolix and redundant legislation, and ephemeral administrative rulings. What remained could very efficiently be processed electronically, and retrieved with maximal effect. The prospect is so inviting that I had almost forgotten that the most important problem facing the legal community in the matter of data retrieval is what not to retrieve.

G. Streamlining the Courts

The sheer mechanical inefficiency of the business of court administration is well known. One can only sympathize with the anguished protests of Judge Hayden (*4*) of the Los Angeles Superior Court at the obstacles which beset the efficient disposition of judicial business. Such ineptitude could not have been contrived. It would be foolish to blame anyone or any group for the disorder. It is simply the evil genius of the profession at work.

I do not believe that many judges would actively oppose the introduction of efficient business machines and routines into the administration of justice. What to do with the army of faithful servants who now tend the antiquated machinery of justice is perhaps the

chief obstacle that confronts compassionate judges contemplating a modernization program for court business. I know of no answer to this distressing human perplexity. I can only say that the machines and the procedures now exist to relieve court personnel of much of the tedious and repetitious work that they spend so much time on. The court could, if it would, be run much more efficiently by letting the business machines, including computers, take over a considerable part of what are now thought of as matters of legal expertise and discretion.

H. The Computer as a Scientific Instrument

Heretofore we have been considering the computer as a labor-saving machine, a device for avoiding dissipation and waste of the brain power available to businessman and scientist for routine tasks. In this context, the computer is not different from the whole multitude of mechanical contrivances whose avowed purpose is to make life easier. We know that the paradoxical character of human nature can result in the quick conversion of these machines into overpowering monsters that can make life a hideous burden by their exigence or in their being rendered innocuous simply through being ignored.

When we turn to look at the computer as a scientific instrument, however, a radical change takes place. The computer then assumes the character of a vital new scientific instrument whose capabilities resemble those of the telescope and the microscope in the history and development of physical and biological science.

Let us stay with this analogy for a few moments. We know that to say of the Renaissance telescope that it merely multiplied human vision by a factor x is to miss the whole point of its crucial role in the birth of modern science. The telescope literally remade the whole universe. Now, it would be idle to claim that a long cylinder and a couple of lenses in and of themselves revolutionized the world outlook. This claim is not being made. The telescope was made by men when they needed it. But once having made it, and having used it to provoke a scientific revolution, man could not thereafter abandon it and go back to his older and more comfortable ways of observing the working of the universe. The microscope revolutionized the life sciences in much the same way. It would be unthinkable to try consciously to abandon it.

There is reason to suppose that the computer is the same sort of breakthrough instrument *that must be used if it can be used.* And its potential range of application over the whole field of scientific activity is infinitely greater than that of either the telescope or the microscope, or of any other instrument in the history of science. For the computer multiplies *brain power*, not merely the power of one or of several of the sense receptors of man. In a very general way, the computer makes *inferences*. It performs this task with such quantitative efficiency that the result is a real qualitative change in the business of scientific inference making. Given a set of presuppositions, the computer tells instantly what follows from the presuppositions within the range of its inherent logic and the programming capabilities of the machine and its manipulators.

If now we reflect that conscious decision making always, or at least usually, involves the making of inferences, we see the part that the computer plays in the process of decision making. We can ask it questions of the following kind: "Keeping thousands of facts of a certain kind in your memory, what will happen if I decide to do X?" The answer comes back immediately, "Y, then Z, then W, . . ." Or, the computer might say, "You can't do X, unless you want to give up a former constraint Q, which you imposed on my answers. Do you want to give up Q?" Briefly put, the computer imposes order on what used to be impossibly complicated fact situations and keeps the facts in tow so that mistakes may be minimized, potentialities that hitherto were obscure may be brought to light, and the consequences of proposed actions dramatically displayed.

The computer can manufacture a thousand banal variations on a musical theme in a matter of minutes. The would-be composer may draw inspiration from a few of them or throw the print-out into the wastebasket. It can teach children logic or French, reinforcing each correct answer, correcting each wrong one, and patiently reiterating wise admonitions that teachers throughout the ages have found to be effective. If you don't like to learn this way, flip the "off" switch and the machine will go to sleep.

The computer enables psychologists to investigate the learning process by noting the interaction of human beings and machines. Psychologists also study the way the machines learn, and they check these results against human learning processes. Information theory is a branch of learning that today would be lost without computers. Computers are highly versatile tools for all kinds of quantitative and qualitative repetitive investigations. Are they more than that?

I. The Computer as Focus of Social Experiment: Simulation

Yes they are. They enable investigators to simulate real-life situations in a fraction of the time the events consume, and they enable investigators to detect and erase errors and miscalculations and even catastrophies. Computers and accompanying display apparatus can play out simulated or caricatured features of a proposed metropolitan airport for the year 1970 in real time sequences. These capabilities are now in existence and are now operating.

We come now at long last to a phase of computer research which is of prime importance to law. This is the capability of the computer to simulate large-scale social interactions. Groups of individuals face batteries of closed-circuit televisions governed by computers and make decisions on policy matters that enable investigators to check the effects of decisions as well as lay a foundation for predicting what the decisions will be. This type of investigation is in its infancy. The methodological difficulties are immense. Large amounts of computer time are necessary, and the constraints on the freedom of choice exercised by the subjects of the experiment are still painfully severe. Still, the tool, simulation, gives bright promise of enabling social science to advance from its present state of empirical data collecting to the next stage of a truly experimental science. It provides social science with a true laboratory. And if social science is thus enabled to achieve an experimental status, then the experimental investigation of legal decision making is in the offing. I use the term *legal decision making* in the broadest sense, to include every means by which legal business gets done. This assumes that every legal disposition is in some sense a legal decision. I am not here speaking of the art of predicting

judicial decision. From the point of view of present technology, the notion of predicting the highly specialized and subtly complex factors that enter into the judicial decision of a case is in the realm of wishful thinking. It is one thing to offer to show correlations between the past actions of a set of persons (such as members of the Supreme Court of the United States) and their probable future behavior within a narrow range of situations whose possible variations have already been severely constrained by known rules of decision. But since the present art and science of decision making would fail before the simple task of deciding which chance customer would buy one of two possible newspapers, it is easy to see that neither in practice nor theory do means exist to account for the infinitely ramified facets of even the simplest legal disposition. Indeed, there is nothing in present technology or theory, or even in the minds of the investigators of decision making, that suggests that the *individual decision* will ever become the object of scientific investigation. I should like to be able to report that some scientific interest in this matter does exist. But if it does I have not come upon it. The interest that does exist is an interest in general experimental methods designed to disclose with what degree of probability certain general aspects of social behavior will conform to assumed norms.

I have elsewhere suggested (see appendix) that law and social science might get together on a program of social experiment, law to provide the controls and social science to design and implement the model. But this is quite far from prediction in the *individual case*. Nearly a century ago Oliver Wendell Holmes, Jr., indulged the fancy that law is nothing other than a prediction of what courts will in fact do. There was then no scientific basis for that view, and there is little more today. As Roscoe Pound has often pointed out, this definition of law fails at the crucial point. It is of no use to those who need it most—that is to say, the judges. A judge struggling with a difficult case who asks help as to what the law is that governs it does not want to be told: the law is what you in fact will decide. And this would be just as true with a perfected technique as it was when Holmes offered it as the basis for a science of law. Indeed, reflection has taught us that Holmes's famous saying was not a prescription for a science of law at all. It was rather a homely hint to practical-minded people to study judicial administration in action. That it was also an exaltation of judge-made law above law from all other sources merely means that it was in accord with the best legal thinking of the time. The word *prediction* could not then, and still cannot, be understood in its scientific sense. In what sense can it be said that recent efforts to apply decision theory to court rulings are more scientific than the efforts at legal realism which Holmes inspired?

There is nothing wrong with the attempt to try to bunch together factors observed in the opinions of a highly disciplined body like the Supreme Court of the United States. Then hypotheses can be framed and "predictions" made as to future decisions. The more training, perseverance, and flair the investigator possesses, the better his results are apt to be. I assume that this is also true of a skilled horseplayer, but it may not be. Just as one might well wonder whether to trust a political scientist who has studied all the civil rights cases decided recently by the United States Supreme Court to come up with the correct decision in a pending case. One might rather trust the court clerk or the bailiff or counsel for one of the parties, depending on how well one knew him. The point I am trying to make is that these so-called scientific studies of court behavior are really very tentative (*5*). They are to be encouraged, but also understood. In the absence of a general body of agreed-upon scientific principles of decision making, they can hardly be more than mere beginnings. The motives for undertaking them, however, are unimpeachable. This practice is in the very best scientific tradition. It therefore behooves the members of the legal profession not to treat these serious efforts to develop an embryonic legal science with amused indulgence. Heated opposition, however impassioned, is actually in better taste.

J. Conclusion

I hope that the foregoing survey of decision theory in science and in law will do two things: first, that it will acquaint a wider audience with the fact that scientific decision theory is concerned with much more than the use of electronic data equipment, that it is in fact a branch of knowledge whose domain is that broad range of human behavior that is decision making; second, that the survey will make it apparent that the scientific study of decision making must sooner or later be faced with the dilemmas that legal practice has encountered in its perennial grappling with the problems of decision. From this follows the hope that the common problems inherent in decision making may some day soon draw law and science a little closer together.

In view of current controversy on the subject, it might be helpful to summarize a few homely truths on the relation of scientific decision theory to the actual decision of cases by judges. No one could be more startled than the specialists themselves at the claim that computerized justice is right around the corner. If it is, or if anything even remotely resembling it exists, they would like to see it. Among the "homely truths" to be borne in mind are the following:

1) No general theory of social action exists that has received widespread acceptance even among social scientists. No one knows why groups (peoples, armies, churches, judges) decide to act as they do.

2) No general theory of human motivation in the individual exists. No one knows why the individual decides to do what he does.

3) Not even a rudimentary scientific apparatus exists for studying any *individual* entity, whether person, event, state, or decision. The arts and the applied sciences are concerned with individuals, but no general scientific theory can handle them yet.

4) *Factor analysis*, which is the attempt to isolate behavioral traits and to bunch them by means of mathematical statistical techniques, has important clinical applications. *But it is not scientific investigation.* It is protoscientific, in the sense that it is useful in digging up hypotheses which, however, must be submitted to experimental verification. There is no reason why the past performances of the Supreme Court should not be subjected to factor analysis. But we are hardly prepared to turn that august body into a group of experimental subjects to test the results of factor analysis!

All this being admitted, it is still hard to understand why some members of the legal community should get so aroused at the extravagant claims of computer enthusiasts. These people have a new and exciting instrument to play with. It allows them to spend days and nights in the laboratory and to

emerge exhausted but happy in the conviction that they are remaking the world. The legal community could match such extravagances with its own "one world, one law" enthusiasts, though frankly I do not see why it should bother.

Appendix

This appendix has two purposes: (i) to contain supporting references to the text, and (ii) to enable the reader to undertake further investigation into the subject matter.

A. The Two Ways of Thinking

There is much more on the two ways of thinking in the following articles of mine.

"What law can do for social science," *Law and Sociology*, Evan, Ed. (1962).
"Disarmament in the intellectual age," in "Proceedings of the Columbia University Conference on Disarmament" (1961), in press.
"Experimental jurisprudence: Science, morality, law," *Archiv für Rechts- und Sozialphilosophie* **38**, Suppl. (1960).
"Notes on the teaching of jurisprudence," *J. Legal Educ.* **15**, 1 (1962).

B. Law and Science in History

1) *Early Greek cosmology*:

The following statement of the virtual identity of law and science in this early age is taken from Kahn, *Anaximander and the Origins of Greek Cosmology* (1960), p. 192.

The earliest civilizations had no notion of the distinction between Nature and Society which has become habitual to us. In Homer, for example, no boundary is recognized between human usage and the order of the universe. In front of man stands not Nature, but the power of the gods, and they intervene as easily in the natural world as in the life of men. Poseidon is lord of the sea, shaker of the earth, but he stands in battle next to the Greeks before Troy. Zeus is god of the storm, and was once the personified power of the sky itself, but when he casts his thunderbolt, it is to exact punishment from perjurers.

2) *Generally*:

Not only the writings of Roscoe Pound but also his voluminous references to the literature are the natural beginning for a more extensive study of the subject of law and science in history. His recent five-volume *Jurisprudence* (1959) contains much bibliographical material on this subject. See especially, vol. 3, p. 512, on "mechanical jurisprudence," also vol. 1, p. 10; vol. 3, p. 20.

Actually, a historical study of the relation of law and science would require one to go to the history of jurisprudence, which is a massive body of work, and to the history of science, which is only in its infancy. The subject would lead one inevitably to the history of philosophy. In modern jurisprudential or philosophical writings there are bits and pieces scattered about everywhere. Among modern American writers on jurisprudence the outstanding exception is F. S. C. Northrop. See, particularly, *The Logic of the Sciences and the Humanities* (1947) and *The Complexity of Legal and Ethical Experience* (1959), chap. 15. W. Friedmann deals very suggestively with the relation of science to law, so far as natural law, Kant, and positivism are concerned, in *Legal Theory* (ed. 4, 1960), pp. 128–130, 205–206, 251–253.

On the other hand, scientific investigators seem generally to ignore law. I have looked in vain in George Sarton's two-volume *History of Science* (1952, 1959) for references to the relation of law and science in the period covered by this work. The same is true for Charles Singer's *A Short History of Scientific Ideas to 1900* (1959).

If one goes to the historians of philosophy, the field is wide open. I suspect that the reader will have to do the synthesizing for himself. George Boas, *The Inquiring Mind* (1959), might serve as a starting point.

C. The Scientist as Decision Maker

1) *On measurement*:

Ackoff, *Scientific Method: Optimizing Applied Research Decisions* (1962), chap. 6 and bibliography, pp. 216–217.
Churchman, *Prediction and Optimal Decision* (1961), chap. 5 and references, pp. 135–136.
Singer, *Experience and Reflection*, Churchman, Ed. (1959), chap. 15.

2) *Scientific decision making*:

The starting point should be Churchman, *Prediction and Optimal Decision* (1961), and Ackoff, *Scientific Method: Optimizing Applied Research Decisions* (1962). These two works contain very extensive references to the subject.

3) *Decision theory*:

(i) *Value theory*:

Churchman and Ackoff, works cited.
Churchman, "Decision and Value Theory," *Institute of Industrial Relations, Univ. of California, Berkeley*, working paper No. 9 (1959).

(ii) *Decision theory in behavioral science*:

Behavorial Sci. **1** (1956 to date).

This article is not directly concerned with the very important movement for incorporating into legal research the empirical methods of present social science investigations.

For a recent excellent survey of this situation, see Jones, *J. Legal Educ.* **15**, 121 (1962). See also Fahr and Ojemann, *Iowa Law Rev.* **48**, 59 (1962). It is to be supposed that as this work progresses it will become evident that it will stand in need of decision theory. As an example, see *System Development Corporation Research Technical Memorandum No. 597/101/00* (1962), pp. 73, 145, 171, 193.

D. Law as a Decision Process

This section is directed to the philosophical bases of decision theory. The text does not contain a discussion of a movement in legal circles which may sooner or later come to be called decision theory.

I refer to the recent literature that attempts to establish rational grounds for judicial decision in reaction to the open-ended or "free jurisprudential" character of much of the writing of the American legal realists. There follows a very limited bibliography of that material.

1) *Rational bases of judicial decision*:

Llewellyn, *The Common Law Tradition: Deciding Appeals* (1960).
Wasserstrom, *The Judicial Decision* (1961).
Clark and Trubek, *Yale Law J.* **71**, 255 (1961).
Wechsler, *Harvard Law Rev.* **73**, 1 (1959), reprinted, with some introductory remarks, in Wechsler, *Principles, Politics, and Fundamental Law* (1961).
Golding, *Columbia Law Rev.* **63**, 35 (1963). This is a discussion of Wechsler's article and the reactions it has provoked.

2) *The logic of obligation*:

Symbolic logicians are beginning to attack seriously the logic of obligation as that concept exists in ethics and law. This newer brand of learning is often called "deontic logic." It holds forth great promise for a formal connection between law and decision theory and computer technology. I hope soon to give an account of this very important development.

A list of articles by professional symbolic logicians on the subject of obligation follows.

Von Wright, *An Essay in Modal Logic* (1951); *Mind* **60**, 1 (1951); *ibid.* **65**, 507 (1956).
Prior, *Logic and the Basis of Ethics* (1949); *Formal Logic* (ed. 2, 1962); *Time and Modality* (1956); *Australasian J. Phil.* **29**, 137 (1951); *Mind* **63**, 64 (1954).
Apostel, *Logique et Analyse* n. s. **3**, **70** (1960).
Berg, *Mind* **69**, 566 (1960).
Dawson, *Analysis* **19**, 73 (1959).
Geach, *ibid.* **18**, 49 (1958).
McLaughlin, *Mind* **64**, 400 (1955).
Rescher, *J. Symbolic Logic* **19**, 133 (1954); *Phil. Studies* **9**, 24 (1958).
Sellars, *Methodos* **8**, 227 (1956).

The more recent American work is discussed in the following articles.

Hofstadter and McKinsey, *Phil. Sci.* **6**, 446 (1939).
Menger, "A logic of the doubtful," in *On Optative and Imperative Logic, Reports of a Mathematical Colloquium* (Notre Dame Univ. Press, 1939), p. 53.
Bohnert, *Phil. Sci.* **12**, 302 (1945).

For discussion of the logic of obligation in this country we naturally turn to the work of Hohfeld in the field of basic legal conceptions [*Fundamental Legal Conceptions*, W. W. Cook, Ed. (1923)]. The most important papers in the area of deontic logic are those of Alan Ross Anderson of Yale. The best work for anyone trained in the law to begin with is Anderson and Moore, "The formal analysis of normative concepts," *Am. Sociol. Rev.* **22**, 9 (1957), in which the logical symbolism is kept very simple. Anderson's other papers are more difficult. They include the following: *J. Computing Systems* **1**, 211 (1954); *J. Symbolic Logic* **20**, 302 (1955); *ibid.* **21**, 255 (1956); *Rev. Metaphys.* **11**, 446 (1958); *J. Symbolic Logic* **22**, 241 (1957); *Mind* **67**, 100 (1958); *J. Symbolic Logic* **24**, 177 (1959); *Logique et Analyse* n. s. **1**, 84 (1958); *J. Symbolic Logic* **24**, 177 (1959); *ibid.*, p. 107; *J. Phil.* **56**, 448 (1959); *J. Symbolic Logic* **24**, 301 (1959); *Phil. Studies* **10**, 23 (1959); *J. Symbolic Logic* **25**, 79 (1960); *J. Phil.* **58**, 713 (1961); *Rev. Metaphys.* **15**, 409 (1962); *ibid.* **16**, 62 (1962). See also Castañeda, *Phil. Studies* **10**, 17 (1959); *ibid.* **6**, 1 (1955); *Phil. Phenomenol. Res.* **17**, 339 (1957); *Methodos* **9**, 209 (1957); *J. Phil.* **57**, 791 (1960); and *Phil. Phenomenol. Res.* **21**, 21 (1960).

A rigorous logical treatment of Hohfeld's categories appears in *Structure of Laws as Represented by Symbolic Methods* (1961) by Ward Waddell, Jr., a member of the California Bar and a student of symbolic logic. The study does not attempt to carry the Hohfeldian categories into a modal logic.

3) *Law and electronics*:

Modern Uses of Logic in Law, quarterly newsletter of the American Bar Association Special Committee on Electronic Data Retrieval, headed by Layman Allen, Yale University Law School. This very lively group is pioneering the electronic processing of legal data.
Brown, *Yale Law J.* **71**, 239 (1961).
Johnson, *J. Legal Educ.* **14**, 385 (1962).
Lawlor, *Modern Uses of Logic in Law* **1959**, 47 (1959).
Loevinger, *Minn. Law Rev.* **33**, 455 (1949); *ibid.* **46**, 255 (1961).

The American Bar Foundation, under the editorship of an attorney, Glenn Greenwood, uses computers to publish an "Index to Legal Theses and Research Projects."

4) *Miscellaneous*:

A sparse literature on the subject of decision theory in relation to law exists.

Shubik, *Stanford Law Rev.* **8**, 594 (1956).
Comment, *Yale Law J.* **65**, 660 (1956).

E. Character of the Computer

1) *Dangers of the computer*:

Not much insight can be gained from the various extollers and depreciators of this new facility. One can gain much insight from the paradoxical figure Norbert Wiener, who first created cybernetics and then solemnly warned us all to beware of computers [*Science* **131**, 1355 (1960)]. There are lawyers' briefs for and against the computer. More benefit perhaps can be obtained from the appraisals of people working with this equipment. See Johnson and Kobler [*Science* **138**, 873 (1962)] and Neisser [*ibid.* **139**, 193 (1963)]. (The view that machines will think as man does reveals misunderstanding of the nature of thought.)

2) *Computer capability*:

The selections here presented merely reflect my own acquaintance with this enormous field of activity. They are only a few out of a multitude.

Davis, Carpenter, and Missler, "A Game for Studying Arms Control," *System Development Corporation Publ. No. SP-779* (1962).
J. Conflict Resolution **6**, 1 (1962).
Kleinmuntz, *Science* **139**, 416 (1963).
Wilson, "Automated Data Processing for a Modern Hospital," *System Development Corporation Publ. No. SP-812* (1962).

Current bibliographies appear continuously in the trade journals *Computers and Automation* and *Journal of the Association for Computing Machinery*.

G. Streamlining the Courts

1) *Generally*:

The only large-scale effort in this direction that I know of is the project currently under way in the Superior Court of Los Angeles County, the largest trial court of general jurisdiction in the world (121 judges). This is a joint project of the System Development Corporation (headed by Eldredge Adams) and the U.C.L.A. Committee for Interdisciplinary Studies of the Law and the Administration of Justice (chairman, Edgar A. Jones, Jr.) [see *Modern Uses of Logic in Law* **1962**, 238 (1962)]. There are, of course, many other projects in law and electronics. Information about these may be obtained in the pages of *Modern Uses of Logic in Law*.

2) *Law enforcement*:

In this field, efforts are being made to adopt an integrated state-wide system of records and communication under the cosponsorship of the University of Southern California and the System Development Corporation, in conjunction with the Peace Officers Association of California [see Isaacs, *System Development Corporation Magazine* **6**, 4 (Feb. 1963)].

H. Simulation

Simulation is at once an art and a science. The computer can be used in an indefinite number of ways to simulate real-life situations and to study what would happen if a variety of alternative choices are made. Such use may fall within the area of application. Wider and more ambitious uses may be classed as development. When the uses range higher in the realm of theory, simulation becomes an applied science. The following publications are a sample of the literature.

Data Processing and Simulation Techniques, Guenther, Ed. (Department of City Planning, Pittsburgh, 1962).
Grundstein, "Computer simulation of a community for gaming," paper pre-

sented at the annual meeting of the AAAS in Denver, 1961.

Harman, "Simulation: A Survey," *System Development Corporation Publ. No. SP-260* (1961).

Isaacs, "System Considerations in Building a Metropolitan Data Bank for Urban Research," *System Development Corporation Publ. No. SP-862* (1962).

Simulation and Urban Planning (Urban Renewal Administration and Department of City Planning, Pittsburgh, 1962).

Shubik, *ibid.*

Of very special interest to the social sciences is a project with which I have some familiarity. It is called Leviathan. It permits use of the computer, with or without man-machine interface, to simulate fundamental social processes involving a large number of variables. This capability, when developed, should be of special interest to the legal community.

Kagdis, "Selected Bibliography of Project Leviathan," *System Development Corporation Tech. Manual No. TM-837* (1962).

Rome and Rome, "Leviathan: An Experimental Study of Large Organizations with the Aid of Computers," *System Development Corporation Tech. Manual No. TM-744* (1962); "The Leviathan Technique for Effecting and Monitoring Live-Artificial Communications," *System Development Corporation Tech. Manual No. TM-761* (1962); "The Leviathan Technological System for the Philco 2000 Computer," *System Development Corporation Tech. Manual No. TM-713* (1962).

I. Legal Experiment

Cowan, *Rutgers Law Rev.* **9**, 404 (1954); *Univ. Penn. Law Rev.* **96**, 484 (1948); *J. Legal Educ.* **6**, 520 (1954).

J. Political Scientists and Decision Theory

Schubert, *Quantitative Analysis of Judicial Behavior* (1959). This is a recent well-documented study which reviews the effort of political scientists to introduce decision theory into the study of the judicial decision process.

Hayakawa, *Kobe Univ. Law Rev.* **2**, 1 (1962).

Schubert, *Behavioral Sci.* **7**, 448 (1962); *Stanford Law Rev.* **14**, 284 (1962).

Buchanan and Tullock, *The Calculus of Consent* (1962).

Administrative Science Quarterly and *Behavioral Science.* These periodicals contain very recent articles on this subject.

K. System Analysis

An offshoot of decision theory that is attracting the attention of specialists is the notion of system analysis. From the humble experience of introducing "system" into the short orders of a diner [see Porter, *Harvard Business Rev.* **1962**, 58 (May-June 1962)] to the theoretical systematic structure of a national economy or a historical process, the notion of "system" serves as an integrating concept to guide thought and practice. On the philosophical side are Churchman's two papers entitled "On inquiring systems" [*System Development Corporation Publ. No. SP-877* (1962) and *Center for Research in Management Science, Univ. of California, Berkeley, Working Paper No. 2* (1962)]. See also Lackner, "Toward a general simulation capability," *Proceedings of the 1962 Spring Joint Computer Conference* (1962). I have in preparation a general study of equilibrium systems, which is to appear in *General Systems*, publication of the Mental Health Research Institute, University of Michigan.

L. Analog Computers

Let me add a word on analog computers. It might be said that a digital computer is a *counter*, while an analog computer is a *measurer*. The art of measuring and the art of counting, although clearly interrelated in the practice of science, are easily differentiated in thought. Measurement is based on establishing an isomorphism between the object to be measured and the measuring instrument. The instrument must possess, preferably in a conspicuous degree, the quality that is to be measured in the object. There must then exist some numerical correspondence between the object and the instrument with respect to the quality in question. If the measurer purports to range over a large number of qualities of the object and if the object is taken to represent a sample of a larger (perhaps infinite) population, the measurer becomes a model, with appropriate arithmetic, geometry, probability, and so on, either written in or understood. An analog computer can be generalized from computer to model, and finally to "system."

The ordinary digital computer counts. This means that its function is to include in, or exclude from, appropriately defined numerical classes the objects proffered to it. The quality it tests is inclusion or exclusion. Each object, to be well defined, must present to the machine the character, and only the character, of being in or out of the numerical class in question. The question of what inclusion or exclusion means in any given case is for the programmer to determine. The virtue of the machine is that inclusions or exclusions can be proliferated indefinitely, and an immense array of data can be ordered and interchanged on this simple branching or two-way operation. In general, any data that can be usefully classified in this fashion are susceptible of digital computer treatment.

The analog computer, on the other hand, being a measurer, is or can be much more complex. Indeed, all, or at least much of, the sophistication of measurement theory can be built into it. But the dilemma that arises is this: the more sophisticated the computer, the more specialized the uses to which it can be put. It is essentially a special-purpose machine. There is no such thing as a general measurer in the sense that a digital computer is a general-purpose counter. Hence, the job may very well call for both machines, with specially devised converters to tie them together. It is easy to see that when this happens, an overall theory is necessary to fit the parts together. This is one of the tasks of what is coming to be called "systems science."

References and Notes

1. "[The] logic of contemporary science is the logic of imperatives."—C. W. Churchman, in E. A. Singer, *Experience and Reflection* (Univ. of Pennsylvania Press, Philadelphia, 1959), introduction, p. ix.
2. C. G. Jung, *Psychological Types* (1938).
3. J. von Neumann and O. Morgenstern, *Theory of Games and Economic Behavior* (Princeton Univ. Press, Princeton, N.J., ed. 2, 1944).
4. Judge Richard F. C. Hayden, paper presented at the National Law and Electronic Conference, Los Angeles, 1962.
5. "It should go without saying that we look upon the specific substantive findings that result from our analyses as being highly tentative; such an attitude is the necessary consequence of the exploratory and experimental nature of the work that we have undertaken. To the extent that subsequent work by others may require modification, or even rejection, of methodological formulations that we propose (to say nothing of our specific substantive findings), our primary objective will have been realized."—G. A. Schubert, *Quantitative Analysis of Judicial Behavior* (Free Press, Glencoe, Ill., 1959).