LAW IN COMPUTERS AND COMPUTERS IN LAW: A LAWYER'S VIEW OF THE STATE OF THE ART

William E. Boyd*

For almost 10 years, computers and computer technology have been receiving increasing attention in the legal literature.[1] The American Bar Association,[2] state and local bar associations,[3] and, more recently, law schools[4] have been exhibiting an active interest in law and computers. For many, the emergence of such an interest is a matter of great mystery or considerable misunderstanding, fre-

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* Professor of Law, University of Arizona. A.B. 1963, University of Michigan; J.D. 1966, Wayne State University; LL.M. 1967, Harvard University. Member of the Michigan and Arizona bars. Professor Boyd spent the year 1970-71 at Stanford University as a Law and Computer Fellow.

1. *See, e.g.*, Allen, *Beyond Document Retrieval Toward Information Retrieval*, 47 MINN. L. REV. 713 (1963); Buchanan & Headrick, *Some Speculation about Artificial Intelligence and Legal Reasoning*, 23 STAN. L. REV. 40 (1970); Eldridge & Dennis, *The Computer as a Tool for Legal Research*, 28 L. & CONTEMP. PROB. 78 (1963); Kayton, *Retrieving Case Law by Computer: Fact, Fiction and Future*, 35 GEO. WASH. L. REV. 1 (1966); Loevinger, *Jurimetrics: The Methodology of Legal Inquiry*, 28 L. & CONTEMP. PROB. 5 (1963); Nagel, *Simplified Bipartisan Computer Redistricting*, 17 STAN. L. REV. 863 (1965); Comment, *Automated Legal Information Retrieval*, 5 HOUS. L. REV. 691 (1968); 65 MICH. L. REV. 987 (1967).

The Jurimetrics Journal, formerly *Modern Uses of Logic in Law* (M.U.L.L.), a journal of scientific methods in law, has been including an increasing number of articles on computers. Two new legal journals devoted to the subject of law and computers have recently appeared. See RUTGERS J. COMPUTERS & L.; L. & COMPUTER TECH. For a bibliography of law and computers, see M. DUGGAN, LAW, LOGIC AND THE COMPUTER (1965), reprinted from 7 COMPUTING REVIEWS 95 (1966).

2. *See* AMERICAN BAR ASSOCIATION, COMPUTERS AND THE LAW (2d ed. 1969) [hereinafter cited as COMPUTERS AND THE LAW (2d ed.)]; Eldridge, *The American Bar Foundation Project*, 1965 MOD. USES LOG. L. 129.

3. *See* 65 MICH. L. REV. 987, 989-90 (1967).

4. Best known, perhaps, is the work of the University of Pittsburgh Law School which, in cooperation with the Allegheny Bar, has explored the use of computers in legal research. *See* Horty, *Use of the Computer in Statutory Research and the Legislative Process*, in AMERICAN BAR ASSOCIATION, COMPUTERS AND THE LAW 48 (1st ed. 1966) [hereinafter cited as COMPUTERS AND THE LAW (1st ed.)]. The Denver Law School, the George Washington School of Law and Case Western Reserve School of Law, to name only a few, have also done work in the retrieval area. *See* Kayton, *supra* note 1; Wilson, *Case Law Searching by Machine*, in COMPUTERS AND THE LAW (1st ed.), *supra*, at 55, 58; 65 MICH. L. REV. 987, 987-89 (1967). More recently, law schools, including Virginia and Stanford, have begun to offer courses in law and computers. The Stanford Law School has introduced a largely open-ended law and computer program designed to acquaint lawyers and law professors with the variety of ways in which computers can affect law and the legal profession.

quently accompanied by no small degree of skepticism.[5] Thus, on the one hand, the mention of computers and law usually suggests automated storage and retrieval of decisions and statutes. On the other hand, it may conjure up images of machines replacing lawyers, judges and legislatures, images that are at once intriguing and unsettling.[6] As will be seen, automated legal research is a legitimate and important part of the subject of law and computers, but only a part. Similarly, while the subject of computers in law includes investigating the prospects for accomplishing with machines those tasks now performed by men, replacement of men by machines is neither a primary focus of the research nor likely to be realized in any substantial sense for the foreseeable future. This article will examine the emerging interest, attempt to dispel some of the misunderstanding surrounding it, and suggest that while there is room for skepticism, interest in the subject is justified and worthy of expansion.

It is not the purpose of this article to analyze exhaustively any particular application of computers in law, but rather selectively to highlight efforts to date and indicate what appear to be the most worthy avenues of investigation and research. The scope of the article will be narrowed by omitting consideration of the important legal problems generated by the use of computers in nonlegal enterprises, such as the drafting of contracts involving the use of computer systems in business,[7] questions of liability arising when computers malfunction or fail to perform as warranted,[8] and the knotty problems related to patenting computer hardware and copywriting computer software.[9] Similarly, the potential invasion of privacy inherent in the widespread use of computers,[10] and the ethical problems of unauthorized practice of law associated with many computer projects, espe-

5. *See* R. BOGUSLAW, THE NEW UTOPIANS: A STUDY OF SYSTEM DESIGN AND SOCIAL CHANGE (1965).

6. There has always been a rather pervasive, and sometimes strange, fascination with the idea of getting machines to do what men do. *See, e.g.*, J. DIEBOLD, MAN AND THE COMPUTER (1969); A. HUXLEY, BRAVE NEW WORLD (1932). This presumably is because men frequently do not like what they do or perhaps because it is assumed that if machines could be made to do what men do they would necessarily do it better. *See, e.g.*, N. ANDERSON, WORK AND LEISURE (1961); J. PIEPER, LEISURE, THE BASIS OF CULTURE (1952); Stone, *Man and the Machine in the Search for Justice*, 16 STAN. L. REV. 515 (1964).

7. R. BIGELOW, GUIDE TO NEGOTIATING A COMPUTER CONTRACT (1969); Awalt, *A Lawyer's Concern with a Computer Installation*, 21 BUS. LAW. 381 (1966).

8. Carley, *Computer Companies are Hauled into Court by Flurry of Lawsuits*, 3 L. & COMPUTER TECH. 286 (1970).

9. Hardware refers to the machinery, software to the computer systems. Columbus, *Basic Computer Concepts*, 2 L. & COMPUTER TECH. 2 (1969). The problems of patenting and copywriting referred to in the text are discussed in Bigelow, *Legal Aspects of Proprietary Software*, 14 DATAMATION, Oct. 1968, at 32; Irwin, *The Computer Utility: Competition or Regulation*, 76 YALE L.J. 1299 (1967).

10. *See generally* A. MILLER, THE ASSAULT ON PRIVACY: COMPUTERS, DATA BANKS, AND DOSSIERS (1971).

cially in the area of automated legal research,[11] will not be mentioned further.[12]

Attention will be focused only on those areas where computers have a direct impact on law making and law practice. The high-speed storage and retrieval of legal materials in aid of legal research, which has been under more or less sustained investigation,[13] is such an area. Certain more novel avenues of inquiry that so far have not received the attention warranted, and which may well prove to be the most profitable, will also be examined. In particular, prospects for the employment of computers in the actual tasks of "lawyering," computer-based empirical research, and computer simulation in aid of legal decision making will be explored.

Some Technical Considerations of Computers in Law

For those who have not had previous exposure to computers, understanding of this article may be facilitated by a brief overview of computer operation[14] and some of the inherent limitations. Computers perform in response to "programs," which are instructions in algorithmic form that carefully designate the operations the machine is to perform and the "logic" or order of those operations.[15] Programs may be written in any one of a growing number of "user" or source languages, the most familiar of which is probably FORTRAN,[16] and are entered in the computer through either a card-reading device or a terminal.[17] A compiler program, previously stored in the computer's

11. Comment, *Computer Retrieval of the Law: A Challenge to the Concept of Unauthorized Practice?*, 116 U. Pa. L. Rev. 1261 (1968).

12. For a detailed treatment of many computer and law interests beyond the scope of this article, see R. Freed, Cases and Materials on Computers and the Law (3d ed. 1971).

13. *See* Loevinger, *supra* note 1.

14. Most research with computers today involves digital computers which represent data in the form of digits and operate by counting, as contrasted with analog computers in which data are represented as physical quantities. Furth, *Computers*, in Computers and the Law (2d ed.), *supra* note 2, at 26. An important operative distinction between analog and digital computers is that the former are continuous function devices while the latter have a discrete function. *See* Computer Applications in the Behavioral Sciences 23-41 (H. Borko ed. 1962) [hereinafter cited as Computer Applications]. For a more detailed discussion of that aspect of digital computers, see Turing, *Computing Machinery and Intelligence*, in Computers and Thought 11, 14-19 (E. Feigenbaum & J. Feldman eds. 1963). *See generally* B. Green, Digital Computers in Research (1963). A desk calculator is a simple example of a digital computer, while a slide rule, thermometer or automobile mileage indicator are simple examples of analog computers. *See* Furth, *supra.* For a fascinating and useful treatment of the history and development of modern computers, see J. Bernstein, The Analytical Engine (1964).

15. *See* R. Cole, Introduction to Computing (1969) (ch. 4); W. Davisson, Information Processing 46-55 (1970).

16. *See* R. Cole, *supra* note 15. Other examples of source languages are COBAL, ALGOL and PL/1. *Id.* at 67-71.

17. *See* Furth, *supra* note 14, at 17-18, 31-32. *See generally* W. Davisson, *supra* note 15, at 56-63.

internal "memory,"[18] then converts the user's program into a code to which the machine can respond.[19] After compilation the computer is ready to perform the operations indicated in the user's program. Ordinarily the operations requested will be performed on data previously stored in the machine's external memory[20] on magnetic tapes or disc files, or inputted with the program.[21] The performance of the operations on the data, known as a "run," is achieved by a command given at a terminal or by an appropriate signal on one of the cards submitted to the card reader. The computer will indicate the results of the run on a "print-out."[22]

This brief outline, though necessary, at once says too much and too little. On the one hand, employment of computers for many purposes is becoming increasingly easy; so easy that the user need not concern himself with learning a source language, writing programs, compilation, or even the sometimes complicated process of inputting data.[23] Thus, in many instances it is sufficient to treat a computer as a "black box" capable of performing many remarkable feats with equally remarkable speed. For more analytical purposes, however, it must be kept in mind that a computer is an advanced electronic machine that manipulates symbols[24] internally in accordance with instructions more or less permanently stored in machine language and user instructions that have been converted to machine language. It must also be remembered that machine language is fundamentally a rudimentary code adapted to the electronic on-off circuitry that is at the heart of the computer's operation.

The internal operation of the computer and the manner in which it responds to a user's instructions impose certain limitations on its ca-

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18. The computer's internal storage area is often referred to as its memory. R. COLE, *supra* note 15, at 49-50; W. DAVISSON, *supra* note 15, at 57; B. GREEN, *supra* note 14, at 24-27.

19. See R. COLE, *supra* note 15, at ch. 3; B. GREEN, *supra* note 14, at 277-85. Originally all programs were written in machine language and later in assembly language, but this greatly limited the use of computers. The source languages referred to, note 16 *supra,* were introduced to overcome this problem. Compiler programs can be written which remove virtually all the restraints imposed on the user; thus the compiler will even accept user instructions given in the form of English statements. *See, e.g.,* Green, Wolf, Chomsky & Laughery, *Baseball: An Automatic Question Answerer,* in COMPUTERS AND THOUGHT, *supra* note 14, at 207 [hereinafter cited as Green *et al.*]. See text accompanying notes 27-31 *infra.*

20. *See* Furth, *supra* note 14, at 30-31. For a more detailed explanation, see W. DAVISSON, *supra* note 15, at 37-45.

21. That is, fed into the computer according to program instructions that will locate the materials and give the locations or "addresses" by which they can be accessed later. Furth, *supra* note 14, at 30-31.

22. *Id.* at 32. Alternatively, the computer may indicate the results of the run at a terminal or on a cathode ray tube. See text & note 57 *supra.*

23. *Id.* at 34. *See generally* W. DAVISSON, *supra* note 14, at 81-105.

24. *See* Armer, *Attitudes Toward Intelligent Machines,* in COMPUTERS AND THOUGHT, *supra* note 14, at 389, 392-93; COMPUTER APPLICATIONS, *supra* note 14, at 12-21.

pabilities. One limitation that has particular significance in the area of computer simulation is that computers are capable of performing only one primary operation at a time. This raises doubts concerning the ability of machines to duplicate behavior, such as man's cognitive processes, especially in the area of pattern recognition, that may involve parallel operations.[25] There are ways of minimizing the effect of the "sequential processing" limitation, but doing so is not always possible, is almost always a challenging problem in itself, and frequently produces less than satisfactory results.[26]

Among the most important limitations on computer capability, and one that will be referred to frequently throughout this article, is the "natural language barrier."[27] One simply cannot give an instruction to or ask a question of a computer in natural language, for example, English, and expect the computer to understand in any meaningful sense of the word "understand." Nor can the computer be expected to consider the question or instruction and search or read through its memory as a matter of natural language processing.[28] This is not to say that computers cannot sometimes accept instructions or questions expressed in natural language; they can.[29] The means of communicating with computers have been increasingly refined to the point that instructions or questions may closely approach or even be equivalent to the English statement of the question or instruction. As a result computers frequently may *appear* to understand and respond as a matter of natural language processing.[30] Acceptance of the English statement of an instruction or question, however, is very different from understanding the statements. The statements must be converted by means of the compiler program into machine language be-

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25. *See, e.g.*, Selfridge & Neisser, *Pattern Recognition by Machine*, in COMPUTERS AND THOUGHT, *supra* note 14, at 237, 244-47.

26. *Id.* at 245-46.

27. *See* Lindsay, *Inferential Memory as the Basis of Machines Which Understand Natural Language*, in COMPUTERS AND THOUGHT, *supra* note 14, at 217; Simmons, *Synthex: Toward Computer Synthesis of Human Language Behavior*, in COMPUTER APPLICATIONS, *supra* note 14, at 360.

28. The extent to which natural language is involved in human thought may well be the only practical sense in which computers may be said to be unable to "think." *See* Armer, *supra* note 24, at 390-93; COMPUTER APPLICATIONS, *supra* note 14, at 12-22. The relationship of language to thought generally is discussed in L. WITTGENSTEIN, PHILOSOPHICAL INVESTIGATIONS (3d ed. 1968). The relationship between law and language is explored in H. HART & A. SACKS, THE LEGAL PROCESS 125-31 (1958).

29. *See, e.g.*, Green, *supra* note 19.

30. Perhaps the most impressive illustration of this is a program that simulates paranoid symptomology and may be "interviewed" and "questioned" in the English language. *See* Colby & Enea, *Heuristic Methods for Computer Understanding of Natural Language in Context Restricted On-Line Dialogues*, 1 MATH BIOSCI. 1 (1967). Ease of communication and the appearance of understanding also characterize most of the automated legal research systems. These systems are discussed in text & notes 33-83 *infra*.

fore the machine can perform any of the operations requested.[31] Similarly, while computers may produce English language output, this is possible only to the extent that a compiler program has instructed the computer to convert the numerical or symbolic output into English language equivalent. The machine only appears to have responded as a matter of natural language processes.

Finally, computers are limited to the extent that they can operate only upon information already stored in the machine's memory in machine-usable form. The materials must be inputted by means of programs that store the materials so that they may be accessed when needed.[32] Inputting needed information can be an intricate process that has special importance in data storage and retrieval projects and in empirical research. It is essential to bear in mind that while great improvements have been made with respect to data conversion and computer storage capacity, the capacity is nevertheless finite and both conversion and storage can be very expensive.

Computers as Super-Automated Libraries

Traditional methods of recording, storing, and especially of accessing needed information from the rapidly proliferating quantities of legal materials[33] are incredibly antiquated and are largely responsible for the admittedly high, if not exorbitant, cost of legal services today.[34] It was quite natural and fitting, therefore, that computers would make their earliest, or at least most notorious, impact on the law in the area of storage and retrieval.[35] Much energy and money has been expended in the effort. Unfortunately, after 10 years of investigation, experimentation and optimistic prediction, the great promise that seemed to be offered by computerizing basic legal research remains unfulfilled.[36] This is not to say that useful things are not being done in the area; they are.[37] Nor is it to say that efforts to

31. See note 19 *supra; cf.* Buchanan & Headrick, *supra* note 1, at 44.
32. See notes 20 & 21 *supra.*
33. As early as 1924 Cardozo remarked that "the fecundity of our case law would make Malthus stand aghast." B. Cardozo, The Growth of the Law 4 (1924).
34. See Kayton, *supra* note 1, at 5-7.
35. *See* Loevinger, *supra* note 1, at 9-30; notes 36-38 *infra.*
36. *See* L. Berul, Information Storage and Retrieval, A State of the Art Report 249 (Auerbach Corp. 1966). Furth, *Automated Retrieval of Legal Information: State of Art,* in Computers & Automation Dec. 1968, at 25. *See also* Nycum, *Looking Ahead—Law and the New Technology,* 64 L. Lib. J. 119 (1971); Smith, *Computer Application to Legal Documentation: What Is Not Being Done,* 64 L. Lib. J. 114 (1971); *cf.* Dennis, *Shall We Put Law into the Computer,* 1 L. & Computer Tech., Jan. 1968, at 25.
37. A number of projects that have been in existence for some time continue to provide services, especially in specialized areas for specialized clientele. An example is LITE (Legal Information Through Electronics) which is government-owned and operated and services federal government agencies, primarily the defense department.

exploit fully the methods now employed should not be continued. Rather it is to say that a closer look at the problems involved in such methods is in order and that thought should be given to the exploration of other avenues of approach.

The reasons underlying the relatively limited success are not far to seek; however, the solutions to the problems encountered are not at all apparent.[38] A basic problem is the storage of materials making up the data base to be searched. This problem involves the important question of the materials, statutes, decisions, regulations, agency opinions, and secondary materials[39] that ought to be stored and the period of time those materials should cover.[40] It also involves the equally important process of inputting materials selected for storage, which in turn is dependent upon data conversion, that is, inputting materials in machine useable (or readable) form.[41] The latter problem is particularly acute with respect to existing published materials. As to these materials, conversion has been accomplished by entering the materials on punch cards for input through a card-reading device.[42] More recently, the trend has been to encourage publication on machines whose output can be both converted to a traditional printed product and introduced to computers directly.[43] Such an approach, while not yet perfected, can eliminate the costly intermediate step of converting published materials to machine useable form.[44]

See Davis, *LITE: Legal Information Through Electronics*, 1965 MOD. USES LOG. L. 138; McCarthy, *LITE (Legal Information Through Electronics)—a Progress Report*, 64 L. LIB. J. 193 (1971). Other examples, including the ASPEN system, see Horty, *supra* note 4, are referred to throughout the literature. Perhaps the most ambitious effort to date is that of the Ohio bar in cooperation with Mead Data Central Corporation. Efforts were begun in 1970 to implement a large scale operation (OBAR) aimed eventually at serving the entire Ohio bar. *See* Harrington, *Computers and Legal Research*, 56 A.B.A.J. 1145 (1970). Mead Data apparently plans on expanding its operations into other states. See Harrington, Wilson & Bennett, *The Mead Data Central System of Computerized Legal Research*, 64 L. LIB. J. 184, 186 (1971). *See also* Preston, *OBAR and Mead Data Central System*, 64 L. LIB. J. 190 (1972).

38. For a general discussion of some of the problems, see Eldridge & Dennis, *supra* note 1, at 78-82; 65 MICH. L. REV. 987, 992-93 (1967).

39. One of the difficulties with storage and retrieval of secondary materials, including many loose-leaf services, is that they are privately copyrighted and distributed and the publishers will probably not permit such use of the materials unless they are assured of compensation for the financial loss incurred as a result of diminished circulation of printed materials.

40. *Cf.* Kayton, *supra* note 4, at 7; Reimers & Hamilton, *Systems Analysis and the Law*, 64 L. LIB. J. 137 (1971).

41. See Furth, *supra* note 14, at 31-32; Kayton, *supra* note 4, at 14-19.

42. Kayton, *supra* note 4, at 15-16.

43. *Id.*

44. *Id.* It has been argued, however, that such machines, including especially IBM's MT/ST, are not yet ready for practical employment. See Memorandum of Combined Computer Committee (New Jersey Bar Association, New Jersey Supreme Court and Essex County Bar Foundation; Vincent Biunno, Chairman, 550 Broad St., Newark, N.J. 07102, March 10, 1972). Optical scanners may ultimately resolve the problems involved, but their perfection for this purpose has yet to be accomplished. See Kayton, *supra* note 4, at 15-16. *See also* Furth, *supra* note 14, at 32.

A more fundamental, though related problem concerns the retrieval of materials that have been stored. If materials are properly stored, the computer can be instructed to search its memory and output certain materials by providing the machine with a proper "link" between the question posed and the materials sought. The link in present systems is a "keyword," that is, a word (or combination of words) that occurs both in the question and the stored materials. The earliest efforts involved indexing of materials according to manually assigned keywords. Under such systems, the researcher posed a question that would be examined by the computer for the existence of keywords. The machine would then search its index and output references to all materials containing key words found in the search request. An advantage of such sytems was that only indexes were stored rather than the materials themselves. The difficulty of such systems was that the success of the search depended on the completeness of the index and the ability of the researcher to "divine" the keyword or words assigned to particular materials by the indexer. Failure to formulate properly the search request so as to include the appropriate keyword or words would abort the search or fail to produce relevant materials.[45] To enhance reliability and assure more exhaustive searches, expanded indexes were introduced. In such systems, keywords selected by indexers were expanded by the machine to include a range of words, primarily synonyms,[46] all of which would be assigned to particular materials. The likelihood that the machine would output references to all relevant materials was correspondingly increased. Unfortunately, the output of references to irrelevant materials, all of which had to be examined manually by the searcher, was also increased.[47] In short, such systems involved an inherent stress between the need for reliability and overproduction of irrelevant materials.

Because of those shortcomings, system designers began to move away from the primitive indexing approach toward a full text approach.[48] These systems involve the input of the entire text of re-

45. *See* Horty, *The Computer in the Practice of Law*, in COMPUTERS AND THE LAW (2d ed.), *supra* note 2, at 46, 49; Kayton, *supra* note 4, at 21. For a more complete discussion of such an approach, see Loevinger, *supra* note 1, at 10-17; Morgan, *The "Point of Law" Approach*, 1962 MOD. USES LOG. L. 62.

46. See Loevinger, *supra* note 1, at 17-19.

47. See Kayton, *supra* note 4, at 22. The usefulness of such an approach simply as a device of indexing documents should be apparent. *Id.* at 21-22.

48. The ground-breaking effort was the University of Pittsburgh Health Law Center project under the guidance of John Horty. See Horty, *supra* note 4. The project was concerned with the storage and retrieval of statutory law. *Id.* Despite the qualitative differences between statutory and case law, which required the introduction of supplementary techniques, efforts soon were being made to employ the full-text approach to storage and retrieval of decisional law. See Wilson, *supra*

search materials. Indexing is still involved, but it is of an entirely different order. Each word, exclusive of recurring conjunctions and pronouns, is entered into a dictionary or index and becomes a keyword. Every word so entered becomes a reference to materials stored in the machine's memory.[49] Such full text systems became feasible only with the advent of "direct access" storage capabilities, through which the machine could go directly to materials in which the keyword appeared without searching the entire data base of stored text.[50] The reliability of a search is obviously enhanced, but the potential for output of irrelevant materials also is increased.[51]

To counteract this undesirable feature various techniques are employed. The searcher, for example, can narrow the search by using conjunctive combinations of keywords, such as "oral" *and* "contract" rather than "oral" *or* "contract." He may impose, in addition, a requirement that the keywords be separated by no more than a stipulated number of other words.[52] Refinements in the systems also have diminished the problem of excessive output. For example, the index may incorporate a statistical test of relevancy. In its simplest form this means that the machine will record the frequency of occurrence of particular words in particular materials and rank the materials according to the frequency of occurrence of keywords.[53] Another de-

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note 4, at 55. *See also* Eldridge & Dennis, *supra* note 1, at 89. Virtually every system now being offered referred to in note 37 *supra,* including OBAR and LITE, utilizes the full-text approach. *See generally* Fay, *Full-Text Information Retrieval,* 64 L. LIB. J. 167 (1971). A compromise between the primitive index approach and the full text approach, namely the storage of abstracts of materials, has been proposed at times. *See, e.g.,* Melton, *The "Semantic Coded Abstract" Approach,* 1962 MOD. USES LOG. L. 48. Such systems suffer from the intervention of human interpreters between the researcher and the materials and have not been pursued vigorously. *See* Loevinger, *supra* note 1, at 15-16.

49. See Fay, *supra* note 48, at 168; Harrington, Wilson & Bennett, *supra* note 37, at 186. The full-text index may be supplemented by a synonym index or may have the ability to expand roots of words in order to further increase the scope of the search. Fay, *supra* note 48. *See also* text & note 36 *supra;* Kayton, *supra* note 4, at 10, 24-25.

50. *See* Fay, *supra* note 48, at 168. *See also* W. DAVISSON, *supra* note 15, at ch. 4; Kennedy, Newcombe, Okazaki & Smith, *List-Processing Methods for Organizing Files of Linked Records,* in COMPUTER METHODS IN THE ANALYSIS OF LARGE SCALE SOCIAL SYSTEMS 45 (J. Beshers ed. 1968) [hereinafter cited as COMPUTER METHODS].

51. The only necessary relationship between materials retrieved and the answer sought is the presence of a keyword in both. Given the nature of language, that is a rather broad relationship. Such systems do not even employ those simple techniques that lawyers rely upon to reduce the scope of a search such as the age of a case, the state or circuit in which it was decided, or the procedural posture in which the case arose. *See* Buchanan & Headrick, *supra* note 1, at 43.

52. *See* Fay, *supra* note 48, at 168; Horty, *supra* note 4. The "and"-"or" capability (and sometimes the proximity capability) are designated as Boolean algebra routines. *Id.* For a rather sophisticated nonlegal example, see Simmons, *supra* note 27, at 384-88.

53. This capability is an important feature of the Quic/Law system being developed by Professor Lawford at Queen's University in Kingston, Ontario. *See* Fay, *supra* note 48, at 169. *See also* Loevinger, *supra* note 1, at 19-21. It seems, however, that such statistically based search routines involve an inherent risk to the reliability of the search. See Buchanan & Headrick, *supra* note 1, at 42.

vice for reducing output is to link words to particular portions (sentences, paragraphs) of particular materials, in which case only the linked portion is outputted, rather than the entire document.[54] A feature of most such systems that allows the researcher to designate a set number of words preceding and following the key word also reduces the amount of material outputted.[55] More important has been the development and employment of interactive "on-line" capabilities, through which the researcher can get virtually immediate response to a search request.[56] This feature is indispensable because a thorough search inevitably involves a series of requests and request modifications before any or all of the relevant materials are outputted. The introduction of cathode ray tube devices that produce a video display of materials on a screen rather than printing them out for perusal also speeds up the search and diminishes the effects of over-output.[57]

Despite the refinements, doubts persist as to the advisability of widespread introduction of the systems. The storage and retrieval strategy on which they are based was introduced over 10 years ago and appears to remain essentially unaltered.[58] The shortcomings of that approach, including especially its failure to cope adequately with the stress between the need for an exhaustive and hence reliable search and the need to diminish the scope of the search in the interests of time and expense, have not been overcome. The refinements, many of which are ingenious and impressive in appearance, do much to relieve the stress. It continues to be true, however, that the searcher is succesful only if and when, by reiteration and modification of his search request, he finally formulates the "correct" requests to establish the necessary links between the requests and the data base.[59] Such a search strategy represents little more than automation of pres-

54. Presentation by Mr. Stephen Furth, First National Conference on Automated Law Research, Atlanta, Georgia, March 1972.

55. See Preston, *supra* note 37, at 191.

56. See Harrington, Wilson & Bennett, *supra* note 37, at 187; Nycum, *supra* note 36, at 122. Most computer services are performed in "batch." That is, a user submits his "job" to the system, the job is put into a queue and performed along with the jobs of other users in the order in which it falls in the queue. There is an inevitable delay, the length of which depends on the number of users and jobs submitted, between the submission of the job and the output of the results of the operations requested. In the interactive mode, the great internal speed of the computer is exploited in such a way as to allow it to work on many programs at once (timesharing) and allow each user to get virtually immediate response to his instructions. *See* Furth, *supra* note 14, at 32.

57. See Harrington, Wilson & Bennett, *supra* note 37, at 187; Nycum, *supra* note 36, at 122.

58. This statement would certainly be debated vigorously by promoters, especially commercial promoters, of systems now being pushed. One need only compare, however, the basic operation of the system developed by John Horty, see note 33 *supra*, with the present systems to see that the similarities are greater than the differences.

59. *See, e.g.*, Harrington, Wilson & Bennett, *supra* note 37, at 187.

ent manual search efforts. Certainly a speeding up of existing methods is in itself a worthy goal. But given the present high costs and the correspondingly small clientele to whom the services can be made available, it must be asked whether more attention should not be given to changing the storage and retrieval strategy.[60]

It is arguable that the deficiencies in the present strategy stem from the fact that they represent an effort to circumvent rather than come to grips with the natural language barrier. The systems rely not on the meanings of words or sentences or even, for the most part, on the structure of sentences as a clue to meaning, but rather on the occurrence of words or at most the frequency of their occurrence or their occurrence in conjunction with other words.[61] Two very different approaches, although involving greater difficulty of implementation, seem more promising because they confront the language barrier more directly. As was indicated, existing full text systems are based on an attempt to store materials, after conversion to machine-useable language, in the form in which they are published. Thus, the written text of a decision or statute is translated, either at the time of publication or later, directly into machine language. No alteration of the materials stored takes place prior to their conversion to machine language. The materials so translated are then stored in the computer's memory. When retrieved, the materials stored in machine language are reconverted to natural language and outputted in that form.

Layman Allen has for some time advocated a "normalization" of the language of the law, the language used in legal materials.[62] The approach requires that rules of law, particularly as found in statutes, be written in a more precise and uniformly-structured form. The implication form derived from symbolic logic is the norm he suggests. According to his approach, every case decision and statutory rule would be written in terms of specified conditions or premises, and conclusions or consequences following therefrom. If certain conditions hold, then certain consequences follow.[63] Were legal materials so written, the data bases of computers then would consist of implicative-normal form statements of legal rules. To search them a user

60. *Cf.* materials cited in note 14 *supra.*
61. See note 51, *supra.*
62. *See* Allen, *Normalization Approach to Information Retrieval in Law,* in LIBRARIES AND LIBRARIANSHIPS (1967) [hereinafter cited as Allen, *Normalization*]. Allen uses the gross estate provision of the Internal Revenue Code as an illustration and considers both its form deficiencies and how that form could be improved by normalization. *See also* Allen, *Better Organization of Legal Knowledge,* 1969 U. TOLEDO L. REV. 491.
63. Allen, *Normalization, supra* note 62. *See also* Allen & Caldwell, *Modern Logic and Judicial Decision Making: A Sketch of One View,* 28 L. & CONTEMP. PROB. 213 (1963). *See generally* P. SUPPES, INTRODUCTION TO LOGIC 6-17 (1968).

would stipulate the conditions implicit in his question, and the computer would output the rules or consequences following from the stipulated conditions, assuming that the rules existed and had been stored.[64] The advantage of the approach, of course, is that computer searching is rendered much more systematic. The relationships between the searcher's question and the materials stored are defined with far greater precision. They no longer consist only of the presence of a word or combination of words in both the search request and materials stored. The savings in time and expense should be apparent.

There are, however, difficulties and disadvantages associated with the approach. It success depends on the willingness of members of the legal profession to learn and use the language of symbolic logic. Given the notorious reluctance of lawyers to assimilate new techniques, the prospects of getting them to learn a new language would appear dim at best. Apart from this important practical difficulty, it is not clear that the law can or ought to be reduced to precisely stated implicative-normal form rules which assume there is only one correct statement of and answer to a particular question. While this assumption may have some validity with respect to statutory law, it is much more questionable as regards decisional law. A direct result of normalization would be the elimination of many of the ambiguities and inconsistencies that frequently characterize, and are essential to, the development of law.[65] As for the normalization process itself, *can* a case decision be stated in implicative-normal form? What exactly are the premises or conditions? The facts? If so, which facts? All the facts? Only the operative facts? What does that mean?[66] What exactly is the consequence? The result in the particular case? It is not decisions as such that are sought, but something more akin to rules derived from a series of decisions. Whatever legal "rules" are, if indeed the notion of a rule itself has any useful meaning in this context,[67] it is not apparent that they can be stated in "normal" form without distorting their meaning, concept and content.[68] Thus,

64. Allen, *Normalization, supra* note 62.
65. Ambiguities may be created or left unresolved in order to permit later reformulation of decisions to reflect changing ideas and conditions. *See, e.g.*, H. HART & A. SACKS, *supra* note 28, at 396-400; E. LEVI, AN INTRODUCTION TO LEGAL REASONING 3 (1950); Holmes, *Law in Science and Science in Law*, 12 HARV. L. REV. 443 (1899).
66. *See, e.g.*, H. HART & A. SACKS, *supra* note 28, at 384, suggesting a distinction between the facts of the particular case and the facts somehow controlling in cases of the type involved.
67. See the materials cited in note 65 *supra*, and the more complete discussion in text & notes 99-105 *infra*.
68. What is intended by the concept of a rule of law? The rule of the case at hand? The rule as elaborated by other decisions? *See* E. LEVI, *supra* note 65, at 2-3. Note especially the reference to a logical fallacy inherent in legal reasoning. *Id.*

at least as regards decisional law, normalization may not only be undesirable, but may not even be possible. Moreover, since statutes take on meaning largely as a result of judicial interpretation, the same difficulties may also extend to statutory law.[69]

To make these observations is not at all to deny the power of symbolic logic as an analytical technique. Nor is it to say that the language of the law is not less precise than it could or should be. Rather it is merely to suggest that despite its intuitive appeal, both in terms of its effect on law-making generally and its promise of facilitating the use of computers, the normalization approach could be employed only with difficulty and then perhaps only at the risk of distorting the concept of a legal rule, whether derived from the common law or judicial interpretation of statutes.[70]

Despite the doubts raised here, efforts along the lines suggested by Allen are being made and some success in the context of statutory law has been reported.[71] Moreover, if the nature of the language of the law is the major difficulty preventing computerization of legal research, then refinement of that language is a worthy goal. If the language of law could be normalized, computer-assisted research would move from primitive document retrieval to something more akin to an answer service or information retrieval.[72]

A second approach to improving storage and retrieval systems seeks to overcome the natural language barrier itself by making computers understand natural language. This is, of course, an ambitious undertaking.[73] An oft-cited example will serve to illustrate what is involved. Consider the two sentences: "The pen is in the box," and "The box is in the pen."[74] To a man encountering these sentences, it is quickly apparent that the word "pen" must denote a writing instrument in the first sentence and a fenced-in enclosure in the second.

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at 3 & n.5; Goodhart, *Determining the Ratio Decidendi of a Case*, 40 YALE L.J. 161, 162 (1930). *See generally* H. HART & A. SACKS, *supra* note 28, at 125-31, 160-71; J. STONE, THE PROVINCE AND FUNCTION OF LAW 149-204 (1950). Decisional law includes, of course, both the common law and judicial interpretation of statutes.

69. *See* E. LEVI, *supra* note 65, at 3. *See generally* H. HART & A. SACKS, *supra* note 28, at 1144-1417.

70. Thus, the concepts important to law and especially to the developmental quality of law may be subverted in order to render them susceptible to the treatment advocated. *Cf.* Baade, *Foreword*, 28 L. & CONTEMP. PROB. 1, 4 (1963); Berns, *Law and Behavioral Science*, 28 L. & CONTEMP. PROB. 183, 211-12 (1963); materials collected in notes 49-53 *supra*. *See also* Selfridge & Neisser, *supra* note 25.

71. *See* Maggs & de Bessonet, *Automated Analysis of Systems of Legal Rules*, 12 JURIMETRICS J. 158, 166-69 (1972).

72. *See* Allen, *supra* note 1; Maggs & de Bessonet, *supra* note 71, at 165-69.

73. *See* text accompanying notes 27-31 *supra;* authorities collected in note 27 *supra*. *See also* Hays, *Automatic Language Data Processing*, in COMPUTER APPLICATIONS, *supra* note 14, at 394.

74. Lindsay, *supra* note 27, at 218.

Getting a machine to accomplish this seemingly elementary process of denotation and distinction, however, is another matter. At the very least the task requires the availability of information to the computer which indicates that the word "pen" has more than one meaning. When this need is amplified to reflect similar ambiguities throughout the English language, the strain on the storage capacity of the machine becomes significant indeed. Moreover, having this necessary information is only the beginning. If it is to understand the sentence, the machine must somehow choose between the two dramatically different meanings of the word "pen." For a man, the word "box," and more particularly its size relative to each object denoted by the word "pen," and the relationship of the other words in the sentence to the words "box" and "pen," espectially the word "in," are controlling features of the process of understanding. These features are not simply a function of information about word meanings, but are dependent upon the grammar of the language, including the rules governing sentence composition and structure, "parts of speech" and syntactic rules. In short, the machine would need the ability to "parse" sentences; that is, to reduce them into their basic components.[75]

If machines or rather programs having these semantic and parsing capabilities could be developed, the final step of reconstructing sentences so as to derive meaning from them would be relatively easy.[76] As one might expect, the work in this area has been almost exclusively outside the field of law, and the results have been somewhat disappointing. Sentence parsing by machines has probably been most widely investigated in connection with machine translation of texts from one natural language to another.[77] Progress in this effort has been stymied by the inability, on the one hand, to identify the rules governing sentence structure and, on the other, to develop from among these literally thousands of rules, a set of rules that may practicably be implemented on and employed by a machine.[78] The rules governing syntax have presented a major obstacle in these respects.[79] Advances

75. *See* Hays, *supra* note 73, at 401-04; Lindsay, *supra* note 27, at 221-27; Simmons, *supra* note 27, at 373-74.

76. Simmons, *supra* note 27, at 361-65. *See also* H. Dreyfus, Alchemy and Artificial Intelligence 30-37 (1965). The final step of putting the sentence back together in such a way as to derive meaning from it has been referred to as language synthesis.

77. Hays, *supra* note 73, at 395-417; Simmons, *supra* note 27, at 367-70.

78. Lindsay, *supra* note 27, at 224.

79. Simmons, *supra* note 27, at 368. Another difficulty has been a largely unjustified assumption that semantics are not really important to machine translation. *Id. Compare* Lindsay, *supra* note 27, at 218, *with* Hays, *supra* note 73, at 403-04. It has been observed that the area of machine translation "had the earliest success, the most extensive and expensive research, and the most unequivocal failure." H. Dreyfus, *supra* note 76, at 12.

in the area of semantics seem more promising, but it may be that the progress is more apparent than real. Although some interesting and even exciting programs which seem to display marked semantic capabilities have been developed, they have been so severely oriented to specialized subject matters that any hope of generalizing the techniques employed to a field as diverse as law must certainly be qualified.[80]

The manner in which the language synthesis, or natural language, approach might be employed in the computer retrieval enterprise is suggested by what have been referred to as "question answering programs." One such program, using grammatical rules and semantic capabilities which have been machine implemented, seeks to convert a question posed by the user from the interrogative to an incomplete expositive form and then search for corresponding materials in the data base with which to complete the reformulated statement.[81] Existing programs of this type are quite primitive and much refinement will be needed before they can be generalized to the field of law.[82]

Although there are many difficult problems inherent in the quest to surmount the natural language barrier, many useful and interesting things have already been done, both in and out of law, short of actually penetrating the barrier.[83] The benefits to be derived, should the efforts ever prove successful, are many and apparent. The language of the law, with its ambiguities, inconsistencies, and flexibility for development would be left intact. Machines would literally be capable of communicating with users, and of understanding and responding to search requests. Legal research would be fast, and inexpensive in relation to present costs. The benefits to not only the legal profession but also the consuming public are clear. These potential benefits, therefore, appear to justify the long, difficult and expensive research necessary to overcome the natural language barrier and provide truly automated law libraries.

MACHINES THAT DO WHAT LAWYERS DO, WHATEVER THAT IS

The focus of much of the discussion of document and information retrieval systems, indeed of the systems themselves, has been on

80. *See* Buchanan & Headrick, *supra* note 1, at 40, and authorities collected therein. Nonetheless, Professors Buchanan and Headrick seem to find much hope in the efforts they discuss. *Cf.* Hays, *supra* note 73, at 419-20; Lindsay, *supra* note 27, at 229-32.

81. *See* Simmons, *supra* note 27, at 384-88. *See generally* Simmons, *Natural Language Question-Answering Systems: 1969*, 13 COMMUNICATIONS ASS'N COMPUTING MACH. 15 (1970). *See also* Green *et al.*, *supra* note 19.

82. *See* Hays, *supra* note 73, at 419-20.

83. *See, e.g.*, Colby & Enea, *supra* note 30; Green *et al.*, *supra* note 19.

getting machines to provide research materials in response to properly formulated legal questions. Posing the proper questions and employing the materials outputted in such a way as to resolve the legal problems prompting the questions are tasks left to the lawyers. The more imaginative investigator will inquire whether these tasks need be left to lawyers. Can machines participate in the actual processes of "lawyering"? At the present time the answer quite clearly is no.

Professors Buchanan and Headrick, however, have argued in a provocative article[84] that advances in artificial intelligence research[85] could and should provide the foundation for participation by machines in the actual processes of lawyering.[86] Postulating two models[87] intended to be suggestive of what lawyers do, first, in formulating an argument supporting a client's interest given certain facts, and second, in giving a client planning advice, these authors seek to identify the mental processes[88] involved and then point out those advances in artificial intelligence research that are promising with regard to efforts to replicate those processes on machines.[89]

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84. Buchanan & Headrick, *supra* note 1. Bruce Buchanan is a computer science professor at Stanford. Tom Headrick is a lawyer, formerly an assistant dean of the Stanford Law School and now Vice-President of Lawrence University. *See also* Stone, *supra* note 6.

85. The goal of artificial intelligence research is "to construct computer programs which exhibit behavior that we call 'intelligent behavior' when we observe it in human beings." COMPUTERS AND THOUGHT, *supra* note 14, at 3. The question of whether machines can "think" is not a focus of the research. *Id.* Rather the concern is whether machines can be designed which could imitate certain intelligent or "thinking-type" human behavior. *See* Turing, *supra* note 14, at 11.

86. Behavior which has been given attention includes chess and checker playing. The learning of heuristics, which are rules of thumb that simplify problem solutions and offer solutions which tend to be good as a general rule, inductive inference, especially as it involves hypothesis formation and pattern recognition, and understanding natural language are particularly important areas of behavior research in preparing for the participation of machines in the processes of lawyering. COMPUTERS AND THOUGHT, *supra* note 14, at 3-8.

87. Buchanan & Headrick, *supra* note 1, at 47-50. Utilization of models is characteristic of scientific work in general and essential to artificial intelligence research and computer simulation. A less obvious observation is that much, if not all, thought employs model-building techniques. This fact will have peculiar importance throughout this article. *See, e.g.,* W. DAVISSON, *supra* note 15, at 16-18; Forrester, *A Deeper Knowledge of Social Systems,* TECH. REV., Apr. 1969, at 21, 24-26.

88. Buchanan & Headrick, *supra* note 1, at 51-53. The reference to mental processes is sometimes troublesome. On the one hand, it does not refer to bio-physiological processes involved in lawyering, that is, how the brain (as distinguished perhaps from the mind) works, although that presumably would be a legitimate area of inquiry, even for the computer-minded. *See, e.g.,* Samuel, *Some Studies in Machine Learning Using the Game of Checkers,* in COMPUTERS AND THOUGHT, *supra* note 14, at 71-72. "Mental processes" seems to refer to the internal processes of problem solving; the ways in which a lawyer first recognizes, characterizes and solves a problem. It is questionable whether the authors have accurately characterized the lawyer's mental processes, which arguably defy any explicit statement, let alone that required for machine implementation. *See* H. DREYFUS, *supra* note 76. What the authors may have succeeded in identifying is the external method by which lawyers tend to solve a problem and later justify their solution. This may frequently correspond to, resemble, or even aid the mental processes involved and in that sense it is responsible for the solution of the problem.

89. Buchanan & Headrick, *supra* note 1, at 53-60.

While the article is truly impressive, with regard to both identification of the various processes in which a lawyer is said to engage and the description of advances in artificial intelligence research, one is nevertheless left with certain doubts. First, the authors appear to assume that the general activity of lawyers is that of identifying a goal, comparing it with an existing state of affairs, legal and factual, and then reducing the discrepancy between the goal and the existing state by the application and manipulation of discoverable "rules." To this extent the authors are accepting a problem-solving strategy postulated relatively early by Newell and Simon and known quite simply as the General Problem Solver.[90] Unfortunately, the postulation has been criticized as being neither an accurate description of human problem-solving behavior nor amenable to the solution of problems beyond those successfully submitted to the General Problem Solver to date.[91]

Second, the general problem-solving strategy largely assumes the ready description of the problem to be solved. In many instances the identification of a goal, and especially of an existing state of affairs, is a most complex first hurdle.[92] In law, at least, the difficulty stems largely from the need to recognize and characterize facts in such a way as to reveal the problem.[93] The process of fact recognition and characterization is one of the most perplexing constituents of man's

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90. Newell & Simon, *GPS, A Program that Simulates Human Thought*, in COMPUTERS AND THOUGHT, *supra* note 14, at 279, 284-86. The theory of GPS has heavily influenced artificial intelligence research. It is based on the notion that if an individual verbalizes his behavior as he solves a given problem—in the GPS research, a problem in symbolic logic, *id.* at 281-82—a program can be written that will describe symbolically that individual's behavior and simulate it on a machine. *Id.* at 282-84. From this type of research, the authors concluded that all human problem-solving behavior is essentially similar; hence the name General Problem Solver.

91. *See* H. DREYFUS, *supra* note 76. *See also* Redmount, *A Conceptual View of the Legal Education Process*, 24 J. LEGAL EDUC. 129, 131-32 & n.8 (1971), in which the author points out that problem solving tends to reduce itself to two lines of theory. The first is that problem solving is a matter of acquiring certain habits of thought by means of discrete, sequential operations. The GPS postulation reflects such a theory. The second theory tends to view problem solving as a matter of problem structure contributing to an all-at-once organization of ideas that ultimately forms insight. To the extent that legal problem solving is of this latter, gestalten character, the GPS postulation is deficient. It should be pointed out that the Buchanan and Headrick study refines the GPS concept to the extent that it incorporates a discussion of the Heuristic Dendral Project, a program currently in progress at Stanford. The Heuristic Dendral program is a fascinating program which seeks to formulate hypotheses that explain data resulting from the fragmentation of organic chemical molecules in a mass spectrometer. The program is explained in detail in Buchanan, Sutherland & Feigenbaum, *Rediscovering Some Problems of Artificial Intelligence in the Context of Organic Chemistry*, in 5 MACHINE INTELLIGENCE 253 (B. Meltzer & D. Michie eds. 1970). A summary of its basic features is set forth in Buchanan & Headrick, *supra* note 1, at 20 & n.20. This article cannot do justice to the considerable amount of effort and creativity that has gone into the development of the program. Because the Heuristic Dendral Project is a refinement of the basic GPS strategy, however, the criticism made in the text is essentially sound.

92. *See* note 72 *supra*. It is revealing that in the Buchanan and Headrick study, as to both models postulated, the identification of problems to be solved is assumed. Buchanan & Headrick, *supra* note 1, at 47.

93. *Id.* at 51.

problem-solving behavior.[94] There is much less of a problem in the physical sciences where facts or data are amenable to identification by means of known and easily expressed physical characteristics.[95] Legal facts, or data, are not so easily labeled.[96] A related difficulty is that while data or facts in the physical sciences may be arranged in accordance with an essentially finite number of predefined and therefore, for the most part, anticipated data arrangements,[97] in law factual arrangements, and therefore the rules thought to govern the arrangements, are neither fixed nor finite in number, except perhaps at some very general levels.[98]

These difficulties suggest that efforts to treat legal problems in the manner in which problems in the physical sciences are treated will at best be difficult. There is, however, a more fundamental difficulty involved. Efforts to identify and arrange facts according to legal rules assumes that "lawyering" is essentially a search for legal rules as more or less definite and unchanging functions of particular fact patterns. This basic assumption is certainly open to doubt. Much energy has been expended in the quest to discover the nature of legal rules. The efforts have disclosed that whatever legal rules may be, they cannot realistically be viewed as mere logical or quantitative derivations from facts.[99] They reveal rather that a legal rule is often merely a distil-

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94. The process involves a complex interplay between rules and facts and has been described in jurisprudential circles as the "chicken and egg" dilemma. *See, e.g.*, H. HART & A. SACKS, *supra* note 28, at 383.

95. The Heuristic Dendral program apparently does have some fact recognition and characterization capability as manifested, for example, by its ability to receive data and "organize" it into basic patterns by eliminating "spurious" data and filling in missing data which are reasonably inferred to fit the pattern, seemingly much in the way a statistician might employ a scatterplot. Buchanan & Headrick, *supra* note 1, at 53 & n.20. Spectrometer analysis, however, involves physical matter that may be identified and arranged according to mass, density, color or any one of many other criteria.

96. Professors Buchanan and Headrick acknowledge the difficulties in this regard as a general proposition, but seem to minimize the difficulties when considering a specific process. *Compare* Buchanan & Headrick, *supra* note 1, at 40, *with id.* at 57-58.

97. This again is a characteristic of chemical analysis and work in general in the realm of the physical sciences. The physical substances of which the data presented to the Dendral program consist have been identified and classified and are for the most part finite in number. Notice especially the discussion of the control over the generation of hypotheses as candidate answers, which eliminates reliance on "intuition," in Buchanan & Headrick, *supra* note 1, at 53-54 & n.20.

98. Thus, the range of claims that may be made by a criminal defendant are in large part predefined by the Constitution and the general composition of these constitutional claims has been indicated by the Supreme Court. But the predefinition and finiteness of claim is often more apparent than real. Presumably it is the absence of predefinition and finiteness that supports the existence and recognized function of the Supreme Court.

99. *See, e.g.*, B. CARDOZO, THE NATURE OF THE JUDICIAL PROCESS (1921); E. LEVI, *supra* note 65; K. LLEWELLYN, THE BRAMBLE BUSH 156-60 (2d ed. 1951); J. STONE, *supra* note 51; Goodhart, *supra* note 68; Holmes, *The Path of the Law*, 10 HARV. L. REV. 457 (1897). *See also* Holmes, *supra* note 65; the earlier discussion of a similar difficulty with the Allen proposal, at text & notes 65-70 *supra*. To the extent that one has in mind case results expressed as rules of cases, the search for rules as part of

lation of numerous complex, changing interrelated legal policies, interests and conflicts that may be fully comprehended, if at all, only in the *ratio decidendi* of a decision or series of decisions.[100] In short, it is that which underlies the rules as they appear at a given point in time, and not the rules as such, that is important. Edward Levi expressed it very well when he observed that "rules change as the rules are applied."[101]

Accordingly, the one area of artificial intelligence research which seems most worthy of lawyers' interest is that of rendering machines capable of analogizing—discerning basic similarities despite apparent differences, especially by generalizing from a particular rule or fact situation.[102] Buchanan and Headrick acknowledge that analogies are indeed an essential element of legal reasoning,[103] but they fail to ac-

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lawyering is meaningful. But then the focus becomes that of law searching rather than legal problem solving. Finding cases is, of course, part of legal problem solving and to the extent that cases can be expressed as relationships between facts and results or legal consequences, machine searching is facilitated. The point being made here is that legal problem solving involves much more than finding cases. It involves characterizing a legal problem and solutions to problems previously resolved in such a way as to enable one to find in the static expressions of those solutions a solution of the legal problem at hand.

100. *Cf.* Buchanan & Headrick, *supra* note 1, at 52.

101. Edward Levi has illustrated the notion sought to be expressed here as well as anyone. E. LEVI, *supra* note 65, at 3. His discussion of what he refers to as "reasoning by example" and the development of legal concepts captures the nature and source of the dynamic quality of law as a reflection of the constant change in society's ideas and policies. *Id.* at 4-19. Levi's comments that "[The rule] is windowdressing" and that it should not be forgotten that "the legal process does not work with the rule but on a much lower level," *id.* at 7, are most appropriate. Lon Fuller, an observer with a more conventional conception of a rule, nevertheless has opined that the emergence and development of rules in the midst of the resolution of a legal conflict—thereby subjecting the parties to rules formulated after the conduct which is the focus of the action—is one of the inherent difficulties of the legal process. Fuller, *The Forms and Limits of Adjudication,* in H. HART & A. SACKS, *supra* note 28, at 421-26. *See generally* the materials collected in note 99 *supra.*

Current ideas in the area of statutory interpretation and the process that lies behind the search for legislative intent generally involve the notion of policy. *See, e.g.,* H. HART & A. SACKS, *supra,* at 1144-1417. The basic similarities of the interpretation process to the common law have been stressed. *See, e.g.,* E. LEVI, *supra,* at 5. Interest analysis, a fluid, changing process which is difficult to define in terms of concrete rules, has been very much a part of recent approaches to the subject of conflict of laws. *E.g.,* Babcock v. Jackson, 12 N.Y.2d 473, 240 N.Y.S.2d 743 (1963); R. CRAMPTON & D. CURRIE, CONFLICT OF LAWS 208-334 (1968); *cf.* A. EHRENZWEIG, CONFLICTS IN A NUTSHELL 7, 106, 149, 165, 206, 229, 231 (1965). The search for reasoned distinctions between cases as discussed in H. HART & A. SACKS, *supra,* at 407-21, which involves the discovery of actual conflict, as in conflicts of law, and a reasoned resolution of the conflict is an example of the kind of analysis that seems to be especially apropos here.

102. Buchanan & Headrick, *supra* note 1, at 52-53.

103. *Id.* at 53 & n.18. Buchanan and Headrick use as an example a case in which a corporate officer with access to information that should have forewarned him of the fraud of a potential creditor of the corporation was held liable to his stockholders. From this they say that it could be argued by analogy that an airline officer who had access to information about impossible flying conditions but authorized a flight resulting in a fatal crash could also be held liable for negligence. The more general "rule" involved is a developing notion of fiduciary responsibility which arises because of the peculiar relationship of the parties. A somewhat similar example dealing with the development of rules governing the liability of carriers for damage or

knowledge that analogies are probably at the heart of the process of legal reasoning.[104] Unhappily, analogy is probably the least developed area of artificial intelligence research. There is a considerable hiatus between the capabilities required for drawing geometric analogies which have been machine implemented[105] and those capabilities seemingly required for the discovery, expression and application of legal analogies by machines.

As the foregoing discussion should suggest, involving machines in the processes of lawyering is an intriguing idea that will likely remain only that for some time to come. This does not mean that the area is so fraught with difficulty that it is not worth investigation. On the contrary, advances in artificial intelligence research have been rapid and impressive and the pace may be expected to quicken in the future. The effort must necessarily involve confrontation with the natural language barrier, and any progress here would have great implications throughout the fields of law and artificial intelligence. Were there no hope of success, there would still be ample justification for the efforts in the important by-product of such research, namely, an improved understanding of the lawyering process itself.[106] Rather than to discourage activity generally along the lines suggested by Buchanan and Headrick, these comments are intended to acknowledge their insights and assist further efforts by focusing on possible weaknesses in their analysis that could detract from those efforts. In particular, investigators should avoid too ready acceptance of the basic model of problem-solving behavior that has been offered, any suggestion that legal reasoning involves a search for rules as such, and more generally, the notion that advances in artificial intelligence research developed for solving problems in the physical sciences can, without considerable difficulty, be employed in legal problem solving.[107]

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loss of goods shipped and passenger baggage is discussed at length in H. Hart & A. Sacks, *supra* note 28, at 241-89.

104. *Compare* Buchanan & Headrick, *supra* note 1, at 53 & n.18, *with* E. Levi, *supra* note 65 at 2, 4-6. Analogizing comes into play both at the level of characterizing the problem to be solved and making best use of the solutions to problems already resolved and expressed in terms of case discussions. The importance of this observation in the context of machine legal problem solving behavior is made apparent in the discussions of the role of analogy outside the legal context. See E. Feigenbaum, Artificial Intelligence: Themes in the Second Decade 27-31 (Memo No. 67, Stanford Artificial Intelligence Project, Aug. 15, 1968).

105. Buchanan & Headrick, *supra* note 1, at 59. The authors here refer to Evans, *A Program of the Solution of Geometric-Analogy Intelligence Test Questions,* in Semantic Information Processing 271 (M. Minsky ed. 1968).

106. *Cf.* Computers and Thought, *supra* note 14, at 269-76; Buchanan & Headrick, *supra* note 1, at 46. These benefits need not be confined to law and legal reasoning. As Professor Scriven has asserted, "A good analysis of legal reasoning often shows us . . . some very important features of *all* reasoning . . . ." Scriven, *Methods of Reasoning and Justification in Social Science and Law,* 23 J. Legal Ed. 189, 193 (1970).

107. Efforts to apply artificial intelligence advances to specific problems arising

COMPUTERS, EMPIRICISM AND THE "REASON AND EXPERIENCE" SYNDROME

While simulation of lawyering by computers may be a worthy goal, it should not distract attention from the need and the efforts to improve the lawyering process itself. It has frequently been argued that lawyers and other legal decision makers could improve the process by reaching out and adopting the more scientific methodology of the social sciences.[108] Although it is acknowledged that "getting the facts" is critical to intelligent decision making,[109] many decisions are made on the basis of assumed facts or conclusions that are never verified empirically.[110]

Professor Rosenberg has offered in support of this criticism the Supreme Court's treatment of the question of whether a wife should be

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under INT. REV. CODE OF 1954, § 368 (corporate reorganization) are being made by L. Thorne McCarty, presently a Stanford Law and Computer Fellow.

108. The complaint is by no means of recent vintage. *E.g.*, Holmes, *supra* note 65; Pound, *Mechanical Jurisprudence*, 8 COLUM. L. REV. 605 (1908). The vigor with which the complaint has been lodged, however, and especially the response it has elicited seem to have followed a cyclical pattern. *See* LAW AND THE BEHAVIORAL SCIENCES 13-17 (L. FRIEDMAN & S. MACAULAY eds. 1969). Among the most persistent of the recent spokesmen has been Lee Loevinger who has urged the introduction of jurimetrics into the study and practice of law. Loevinger, *Jurimetrics: Science and Prediction in the Field of Law*, 46 MINN. L. REV. 255 (1961). For one of the more far-reaching and controversial proposals see F. BEUTEL, SOME POTENTIALITIES OF EXPERIMENTAL JURISPRUDENCE AS A NEW BALANCE OF SOCIAL SCIENCE (1957). *See generally* Symposium, *Social Research and the Law*, 23 J. LEGAL ED. 1 (1970). For a thorough discussion of the meaning of the scientific method as it has evolved and has been applied in varying fields of study, see J. COBB, THE APPLICATION OF SCIENTIFIC METHODS OF SOCIOLOGY (1934).

The express call for the adoption of the substantive developments in the social sciences is frequently made but is usually less enthusiastically received. *Cf., e.g.*, Auerbach, *Perspective: Division of Labor in Law Schools and Education of Law Teachers*, 23 J. LEGAL ED. 251 (1970). The lack of enthusiasm may result from an unarticulated acknowledgement that the substance of social science eventually works its way into law in any case, especially through the device of the Brandeis brief. *See, e.g.*, Brown v. Board of Educ., 347 U.S. 483, 494 & n.11 (1954). It has also been argued that the stuff of law is the stuff of social science. *See* H. HART & A. SACKS, *supra* note 28. On the other hand, the cool response may reflect a deep-seated skepticism about social science doctrine as such. *Cf.* LAW AND RESISTANCE 128-30 (L. Veysey ed. 1970).

109. Various methods are employed for obtaining facts to use in the legal process: lawyers use elaborate discovery devices to obtain facts; courts and juries seek facts through the presentation of evidence; and legislatures utilize hearings and investigations to get facts.

110. The distinction between the evidence made available to courts and the actual facts of a dispute has been emphasized by Lee Loevinger. Loevinger, *supra* note 108, at 268. It should not be assumed, however, that the employment of empirical methods guarantees the production of actual facts. Empirical methods deal in evidence or indicators of the phenomenon to be measured—attitudes, for example. *See, e.g.*, Blalock, *The Measurement Problem: A Gap between the Language of Theory and Research*, in METHODOLOGY IN SOCIAL RESEARCH 6 (H. Blalock & A. Blalock eds. 1968); Upshaw, *Attitude Measurement*, in *id.* at 60. This provides fuel for objections to the use of empirical methods. *See, e.g.*, F. KNIGHT, INTELLIGENCE AND DEMOCRATIC ACTION 11-12 (1960); Berns, *supra* note 70. The basic objection relates to validity and questions whether the sample used is truly representative of the whole. In any event, to justify its use, empiricism must demonstrate that its methods are more likely to expose the facts than the non-empirical approach.

permitted to testify against her husband.[111] Justice Black, addressing himself to the issue in *Hawkins v. United States,* concluded that to permit a wife to testify against her husband would undermine and impair domestic felicity, and in general be contrary to a policy of fostering family peace for the benefit of the family and the public.[112] He reached this conclusion in reliance upon "reason and experience," without the benefit of factual investigation. Yet, as Justice Stewart observed, factual support was eminently feasible and necessary if the question was to be disposed of on the grounds offered by Justice Black.[113] Professor Rosenberg himself concluded that the question presented ultimately rested upon a value judgment that it is simply "undignified, unworthy, and plain indecent for a wife to testify against her husband."[114]

As the example illustrates, the point is not that the facts can always be known or that decisions must not at times rest upon value judgments that are unverifiable in terms of the facts.[115] It is rather that intuition[116] has too often been substituted for sound inquiry where the facts can be known and assumptions and conclusions can be verified in terms of the facts. In short, legal decision making does not include a sufficiently complete empirical dimension. A remedy for this deficiency may lie in the employment in law, with the aid of computers, of empirical methods developed in the social sciences.[117] The appropriateness of this suggestion can best be illustrated by closely examining the use of these methods in fields other than law.

The two essential components of the empirical method are the sci-

111. Rosenberg, *Comments,* 23 J. LEGAL ED. 201-02 (1970).
112. 358 U.S. 74, 77 (1958).
113. *Id.* at 82-83.
114. Rosenberg, *supra* note 111, at 202.
115. It is customary for social scientists to make a distinction between values and empirically verifiable realities, and to disclaim any ability to subject value judgments to scientific analysis. This has been particularly so with respect to exponents of the scientific method in law. *See, e.g.,* Loevinger, *supra* note 108, at 269-70. Professor Rosenberg has offered the following as a "homely test" of whether an issue rests on value preferences: "Can you visualize evidence concerning the impact of your preferred version upon human behavior or conditions that would lead you to reject the choice for an alternative one? If not, the choice is animated by value considerations." Rosenberg, *supra* note 111, at 202.
116. The reference to intuition here is something of a problem since there is no reason to believe that intuition is not often a reliable means of inquiry. However, because intuition is largely an ineffable phenomenon and hence inherently non-objective, and because such evidence as there is indicates that intuition may frequently be unreliable, *see* Finkelstein, *The Application of Statistical Decision Theory to the Jury Discrimination Cases,* 80 HARV. L. REV. 338 (1966); Forrester, *Counterintuitive Behavior of Social Systems,* TECH. REV., Jan. 1971, at 53, references to the intuitive processes will be used by way of contrast to the empirical methods now under consideration.
117. It has long been recognized that there must be some differences as between the scientific method as developed and applied in the physical sciences and the method as employed in the social sciences, simply because of differences in subject matter. *See* J. COBB, *supra* note 108; materials cited in note 108 *supra.*

entific gathering and analysis of facts. Two basic methods may be employed in gathering data or facts: experimentation and survey. The choice between the two depends largely on the subject matter. In psychology, since control is possible, experimentation is common.[118] In sociology, on the other hand, because the subjects under study do not lend themselves to controlled experimentation, surveys are the primary tool.[119] Surveys will likely prove more adaptable to fact gathering in law since, as with sociology, many of the problems involved concern matters which for a variety of reasons restrict the use of experimentation.[120] For example, the trial of some criminal defendants without the assistance of counsel in order to discover the effects of the presence or absence of counsel would be prevented by the sixth amendment.[121] Nevertheless, interesting experiments have been conducted in law.[122]

Inevitably, whatever the tool employed, large amounts of data

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118. *See* G. FERGUSON, STATISTICAL ANALYSIS IN PSYCHOLOGY AND EDUCATION 270-80 (1966).

119. *See* Zeisel, *The Uses of Sociology in the Professions: The Law*, in THE USES OF SOCIOLOGY 81, 82-85 (P. Lazarsfeld, W. Sewall & H. Wilensky eds. 1967) (emphasizing that by and large the controlled experiment is not available). *See also* Blalock, *Theory Building and Causal Inferences*, in METHODOLOGY IN SOCIAL RESEARCH, *supra* note 110, at 155.

120. *See, e.g.*, D. CAPLOVITZ, DEBTORS IN DEFAULT (1970); Jacob & Sharma, *Justice After Trial: Prisoners' Need for Legal Services in the Criminal-Correctional Process*, 18 U. KAN. L. REV. 495 (1970); Nagel, *Testing the Effects of Excluding Illegally Seized Evidence*, 1965 WIS. L. REV. 283, 285-97 (including an appendix of survey materials); Schuchman, *Profit on Default: An Archival Study of Automobile Repossession and Resale*, 22 STAN. L. REV. 20 (1969); Note, *Empirical Study of Arkansas Usury Law: "With Friends Like That . . ."*, 1968 U. ILL. L.F. 544 (1968); Note, *Wage Garnishment in Washington—An Empirical Study*, 43 WASH. L. REV. 743 (1968); Note, *A Case Study of the Impact of Consumer Legislation: The Elimination of Negotiability and the Cooling Off Period*, 78 YALE L.J. 618 (1969). For a very helpful discussion of the techniques and methods involved in such research see Symposium, *Social Research and the Law*, 23 J. LEGAL ED. 1, 151-88 (1970). *See also* Lazerwitz, *Sampling Theory and Procedures*, in METHODOLOGY IN SOCIAL RESEARCH, *supra* note 110, at 278.

121. *See* Zeisel, *supra* note 119, at 82. It is interesting to note, however, that the federal system has often been supported on the ground that the states may serve as laboratories for the discovery of appropriate legal rules and that the Supreme Court has refused to define certain constitutional protections as pressed upon the Court because of the need for "experimentation" among the states. *See, e.g.*, Wolf v. Colorado, 338 U.S. 25, 28-32 (1949).

122. See Zeisel, *supra* note 119, at 81-96, discussing the kinds of experimentation possible in law and some of the projects that have involved experimentation. One such project was the Manhattan Bail Project. See Ares, Rankin & Sturz, *The Manhattan Bail Project: An Interim Report on the Use of Pre-Trial Parole*, 38 N.Y.U.L. REV. 67 (1963). *See generally* Blalock, *supra* note 119; Campbell, *Legal Reforms as Experiments*, 23 J. LEGAL ED. 217 (1970); Ross & Smith, *Orthodox Experimental Designs*, in METHODOLOGY IN SOCIAL RESEARCH, *supra* note 110, at 333. Possibilities for experimentation in law may be enhanced by the use of "simulated" legal conditions; that is, by simulating the circumstances in which a legal rule must operate and testing its effect under those circumstances. Professor Zeisel refers to this as the semi-natural experiment and cites as an example the insanity rule studies which used real jurors under simulated trial conditions. See Zeisel, *supra* at 88-91. The parallels with so-called man-computer simulations are clear. *See, e.g.*, G. EVANS, SIMULATIONS USING DIGITAL COMPUTERS (1967); Guetzkow, *Simulations in International Relations*, in SIMULATION IN THE STUDY OF POLITICS 9 (W. Coplin ed. 1968).

will be accumulated. Largely because of their amazing ability to store and process conveniently the huge amounts of data that may be accumulated in empirical studies, computers have become virtually indispensable to such studies.[123] It is possible to store, in multidimensional tabular form, large amounts of data that can be retrieved, cross-tabulated or otherwise processed, especially according to traditional statistical routines, with great speed and relative ease.[124] Such capabilities as random-access, which is the ability to go more or less directly to a particular datum without serially searching the entire storage area of the computer,[125] and their consolidation with advances in list-processing languages that accommodate the special dynamic character of empirical data gathering by minimizing the need to pre-allocate storage space,[126] have been particularly important in these regards.

With respect to scientific analysis of the facts gathered, particular methods vary somewhat depending upon whether the data were gathered by survey or experiment,[127] but the basic tool is statistical analysis founded upon probability theory.[128] Computers have not only greatly facilitated the use of traditional statistical techniques, but have contributed to an expansion of the number of techniques that may be employed.[129] Of special interest to lawyers, the use of computers in data analysis has become increasingly simple. Virtually every computer system has "library" routines. These are predesigned programs of frequently-employed statistical methods, such as those needed in computing means and standard deviations, that can be used independently or in conjunction with a more comprehensive program, thereby eliminating the necessity for each individual user to write such pro-

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123. *See generally* COMPUTER APPLICATIONS, *supra* note 14; COMPUTER METHODS, *supra* note 50; W. DAVISSON, *supra* note 15.

124. *See, e.g.*, Hornseth, *Semiautomatic Tabulations of Population Data Files such as the 1960 Census 1-1000 Sample*, in COMPUTER METHODS, *supra* note 50, at 11.

125. *See* W. DAVISSON, *supra* note 15, at 37.

126. *See* Kennedy, Newcombe, Okazaki & Smith, *supra* note 50; Sakoda, *A General Computer Language for the Social Sciences*, in COMPUTER METHODS, *supra* note 50, at 31.

127. *See* Blalock, *supra* note 119.

128. *See, e.g.*, G. FERGUSON, *supra* note 118, at 79-93. The relationship between probability theory and the statistical tools employed in analyzing data is especially marked with respect to inferential statistics; that is, statistics concerned with generalizing from observed sample data, as opposed to descriptive statistics that are concerned largely with summarizing data, usually in terms of central tendency, for example, mean and standard deviation. *Id.* at 79-80; J. SPENCE, B. UNDERWOOD, C. DUNCAN & J. COTTON, ELEMENTARY STATISTICS (1968) (ch. 5) [hereinafter cited as J. SPENCE *et al.*]. It has been suggested that legal decisions, as most decisions, are made in terms of probabilities, not certainties. See I. BROSS, DESIGN FOR DECISION (1953); Loevinger, *supra* note 108, at 266-67.

129. *See, e.g.*, Wrigley, *The University Computing Center*, in COMPUTER APPLICATIONS, *supra* note 14, at 140, 157-70, discussing the increase in the use of methods, such as multivariate statistical methods, that were only hypothesized prior to the advent of computers.

grams.[130] More dramatically, there are so-called "statistical packages" that will permit a user who knows virtually nothing about programming to employ many sophisticated statistical techniques in comprehensively analyzing his data. There are, of course, limitations on the capabilities of these canned programs and packages. There is also a certain danger inherent in their use. In addition to dispensing with the need for programming skills, these packages eliminate the requirement of understanding the analytical tools used and thus the user may not have the requisite knowledge to understand the analytical results they produce.[131]

Two characteristics of empirical methodology should be stressed. First, since statistics deals primarily with numbers, the statistical method is most appropriate for analyzing data that has been quantified,[132] and second, it is theoretically not possible to prove hypotheses, but only reject them.[133] Similarly, and of special importance, it is usually assumed that one cannot prove causation, but only correlation.[134] These

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130. *See, e.g.*, STANFORD COMPUTATION CENTER, USER'S MANUAL (3d ed. 1970) (ch. 6).

131. *See, e.g.*, N. NIE, D. BENT & C. HULL, STATISTICAL PACKAGE FOR THE SOCIAL SCIENCES 1 (1970). *See generally* W. DAVISSON, *supra* note 15, at 81-105.

132. It should be noted that there are statistical tools for dealing with ranks and frequencies which in some sense are not strictly quantitative, or at least are not simply measurement data, and may be more qualitative in what is represented and analyzed. One example is the frequency with which a judge or court votes a certain way on a given policy issue. These statistical tools are referred to as nonparametric tests and are not as constrained in terms of the assumptions which need be met in applying them, but are also somewhat less reliable in terms of the inferences to be drawn from the results of their use. *See, e.g.*, G. FERGUSON, *supra* note 118, at 354-71; J. SPENCE, *supra* note 128, at ch. 15. For a useful example of the application of these non-parametric tests, see Tanenhaus, *The Application of Social Science Methods to the Study of the Judicial Process*, in JUDICIAL BEHAVIOR: A READER IN THEORY AND RESEARCH 530 (G. Schubert ed. 1964) [hereinafter cited as JUDICIAL BEHAVIOR].

133. The basic technique in statistics is to set up a *null* hypothesis which is tested and then rejected if the results of the test disclose that the probability of the test data being observed, *were the null hypothesis correct*, is below some previously selected level of significance, commonly 5 in 100. *See, e.g.*, J. SPENCE, *supra* note 128, at 102-03. Despite the theoretical difficulties, in practice it is customary to adopt an alternatice hypothesis where a null hypothesis is rejected. G. FERGUSON, *supra* note 118, at 162-63. Two types of error may occur. In Type I the null hypothesis may be rejected when it is true, and in Type II not rejected when it is not true. The level of significance chosen for rejecting the null hypothesis will give the likelihood of making a Type I error. For example, at the 1 percent level the chances are 1 in 100 that the null hypothesis will have been incorrectly rejected. *Id.* at 163-64. *See* notes 145-50 and accompanying text *infra* for a discussion of the jury discrimination decisions and the statistical tests of significant discrepancies in numbers of Negroes observed and numbers expected if the null hypothesis (no systematic discrimination) were correct. *See generally* I. BROSS, *supra* note 128.

134. In general terms correlation is a measure of the extent to which variables are dependent upon each other; the extent to which *A* varies when *B* varies. Correlation may be zero (no correlation), plus one (perfect correlation), or minus one (negative correlation), or anywhere in between. *See* 2 W. HAYS & R. WINKLER, STATISTICS 1-20 (1970). In practice, however, decision makers are inclined to think in terms of causation rather than merely correlation. Important work involving reliance on partial correlation methods, which isolate and test a number of variables separately while other variables are held constant, has done much to expose the problems of "spurious" correlation—*A* varies with *B*, but only because of dependence on *C*—and more gen-

limitations inherent in empirical methodology impose certain constraints on the utility of empiricism in law. They preclude any suggestion that the methodology should replace existing decision-making processes, particularly where value judgments, which cannot be made scientifically, at least not directly,[135] are involved. The methods ought, however, to be introduced into law to the extent that legal decision making can be facilitated.

Efforts to employ empirical methods in the context of legal problems have already begun to reap some interesting and noteworthy benefits. For example, empirical methods have been employed to investigate whether pretrial hearings should be made optional or abandoned,[136] whether certain felons might be released without bail,[137] whether the *M'Naughten* or *Durham* instruction regarding the insanity defense is preferable, or indeed whether the latter is any instruction at all,[138] and what changes might be made to alleviate delays in the judicial administration of justice.[139] More recently, empirical techniques have been applied in the analysis of rule changes governing jury selection in capital punishment cases,[140] criteria for commitment of the mentally ill,[141] and the District of Columbia law of preventative detention.[142] Computers were used in a number of these empirical stud-

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erally to enhance the ability to discuss problems in causal terms. *See* Blalock, *supra* note 119. A less complete but somewhat more easily understood explanation of this work may be found in H. BLALOCK, SOCIAL STATISTICS 337-43 (1960). *See also* Lempert, *Strategies of Research Design in the Legal Impact Study: The Control of Plausible Rival Hypotheses,* 1 L. & SOC'Y REV. 111 (1966); Nagel, *Statistical Tests of Hypotheses,* in JUDICIAL BEHAVIOR, *supra* note 133, at 518 (includes a useful discussion of hypothesis testing in the legal context).

135. *See* Justice Black's opinion in Hawkins v. United States, 358 U.S. 74, 77 (1958). It should be noted that while empirical methods may not be of much direct assistance in the making of value judgments, it is reasonable to assume that empirical investigations may influence value judgements. Undoubtedly segregation has been inspired by value considerations, but studies which reveal that segregation is counterproductive economically may influence a decision in favor of integration, if only because the empirical evidence exposes the relevance of a higher value consideration that was not intuitively apparent.

136. *See* M. ROSENBERG, THE PRETRIAL CONFERENCE AND EFFECTIVE JUSTICE (1964).

137. *See* Ares, Rankin & Sturz, *supra* note 122.

138. *See* H. KALVEN & H. ZEISEL, THE AMERICAN JURY (1966); Broeder, *The University of Chicago Jury Project,* 38 NEB. L. REV. 744 (1959); *cf.* Durham v. United States, 214 F.2d 862 (D.C. Cir. 1954); M'Naghten's Case, 8 Eng. Rep. 718 (H.L. 1843); Project, *The Administration of Psychiatric Justice: Theory and Practice in Arizona,* 13 ARIZ. L. REV. 1, 147-59 (1971); "M'Naghten's Rule Revisited," 12 ARIZ. L. REV. 89, 149 (1970).

139. *See* H. ZEISEL, H. KALVEN & B. BUCHOLZ, DELAY IN COURT—AN ANALYSIS OF THE REMEDIES FOR DELAYED JUSTICE (1959). *See generally* Zeisel, *supra* note 119.

140. *See* Edison, *The Empirical Assault on Capital Punishment,* 23 J. LEGAL ED 2 (1970) (discussing in particular Witherspoon v. Illinois, 391 U.S. 510 (1968)); Kuh, *Comments on the Scrupled-Juror Problem,* 23 J. LEGAL ED. 16-24 (1970). *See also* H. ZEISEL, SOME DATA ON JUROR ATTITUDES TOWARD CAPITAL PUNISHMENT (1968).

141. Project, *The Administration of Psychiatric Justice: Theory and Practice in Arizona,* 13 ARIZ. L. REV. 1, 96-117 (1971).

142. *See Preventative Detention: An Empirical Analysis,* 6 HARV. CIV. RIGHTS-CIV. LIB. L. REV. 300 (1971) (including an appendix setting forth the methodology used).

ies.[143]

Empirical techniques have also been suggested for use in implementing decisions already made.[144] The Supreme Court decided relatively early that exclusion from juries by reason of race violated the equal protection guarantee of the fourteenth amendment.[145] Implementing this rule outside cases of complete exclusion, however, proved difficult. Where some or an occasional Negro appeared as a venireman or on a grand jury, intentional exclusion was not at all obvious. Intuitively the Court eventually decided that significant disparities between the numbers of Negroes in the general population from which jurors were drawn and the number of Negroes actually selected, if not adequately explained, would support a claim of racial exclusion.[146] Unfortunately, intuition could not provide a workable definition of "significant disparities" or criteria for deciding what explanations were "adequate."[147]

Empirical data and statistical analysis have been employed in an effort to solve these problems of implementation.[148] The basic approach was to determine whether the probabilities of the observed

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See also Dershowitz, *The Law of Dangerousness: Some Fictions about Predictions*, 23 J. LEGAL ED. 24 (1970); Foote, *Comments on Preventive Detention*, 23 J. LEGAL ED. 48-56 (1970).

143. Nagel, *supra* note 1, at 899 & n.34.

144. Finkelstein, *supra* note 116. *See* Finkelstein & Fairley, *A Bayesian Approach to Identification Evidence*, 83 HARV. L. REV. 489 (1970) (discussing the use of probability theory to bolster the identification of a criminal defendant in People v. Collins, 68 Cal. 2d 319, 438 P.2d 33, 66 Cal. Rptr. 497 (1968)); Ulmer, *Supreme Court Behavior in Racial Exclusion Cases: 1935-1960*, 56 AM. POL. SCI. REV. 325 (1962).

145. Neal v. Delaware, 103 U.S. 370 (1881); Strauder v. West Virginia, 100 U.S. 303 (1880); *cf.* Bush v. Kentucky, 107 U.S. 110 (1883).

146. Avery v. Georgia, 345 U.S. 559, 561-62 (1953); Norris v. Alabama, 294 U.S. 587, 596-98 (1935). Actually, it is the percentage of Negroes in the total population and not the absolute numbers that are important. See note 148 *infra*.

147. The definition of the problem, that is, the rule to be implemented and the difficulties confronting the Court, are accepted as stated in Finkelstein, *supra* note 116, at 338-53, without independent consideration.

148. *See* Finkelstein, *supra* note 116. In this treatment essentially two techniques were employed. The first was a basic probability analysis which was used to test whether the selection as veniremen of such a low number of Negroes as that observed was consistent with a situation involving no systematic exclusion of Negroes. The particular model used to make the test was a Bernoulli model which is especially appropriate for testing situations where only two outcomes are possible: in this case a Negro or non-Negro juror. Finkelstein, *supra*, at 353-65. The other technique used to examine the situation with respect to grand jury composition was a chi square (X^2) test. The test permits one to ask whether the distribution of Negroes on grand juries (the frequency of appearance on grand juries) was what one would expect if no systematic discrimination were operating. *Id.* at 365-73. Actually the chi square analysis was modified to take account of the problem of sample size and take advantage of a simplification made possible by the fact that in the situation considered the number of Negro jurors remained almost constant over the juries involved. The probabilities used in the model were based on population figures. Thus, if Negroes comprised 25 percent of the population from which jurors were drawn, the probability of selecting a Negro would be 0.25; the probability of selecting a non-Negro would be 0.75. *Id.* at 369-70. *See generally* G. FERGUSON, *supra* note 118; W. HAYS & R. WINKLER, *supra* note 135.

numbers of Negroes on juries were so small as to require rejection of the hypothesis that no discrimination was involved. With respect to the question of adequate explanation of numbers of Negroes so small as to call for a rejection of the non-discrimination hypothesis, one need only reverse the analysis; that is, discover what size population of Negroes eligible for jury selection would produce sufficiently high probabilities to preclude rejection of the non-discrimination hypothesis and then ask whether there were legitimate qualifying factors that could result in such a population.[149] The solution accords rather nicely with intuition.[150]

The example is suggestive of how computers can be used to carry out the complicated statistical analysis offered as a solution to the legal problems involved.[151] A related example is presented by proposals for relying on computers to redraw legislative districts in accordance with the mandates of the reapportionment decisions.[152] At least two such proposals have been made,[153] one of which is said to be both politically and economically feasible.[154] The special virtue of the computerized approach is that it can eliminate the gerrymandering quality characterizing most manually drawn reapportionments.[155] Other major advantages of the computer redistricting programs are that the impact on existing geographical units and incumbencies can be minimized if desired, and the programs can produce a much greater number of proposals much more rapidly than could be done manually, thus increasing the likelihood of producing a satisfactory plan.[156]

A further way in which empirical analysis may play a role in law

149. Finkelstein, *supra* note 116, at 360-65, 372. *See also* note 148 *supra*, indicating the relationship between "populations" and probabilities.

150. Finkelstein, *supra* note 116, at 352-53, 374-76. *See generally* I. BROSS, *supra* note 128, arguing that man is a decision maker who, by going beyond mysticism and pure reason and choosing to make decisions based on what he observes about him, has entered the realm of statistical decision theory, and that while that theory is "scientific" in nature, it is very much relevant and comparable to everyday decision making. *See also* Loevinger, *supra* note 108, at 266-67, discussing the role of probability theory in legal decision making.

151. In the jury racial discrimination study, Finkelstein, *supra* note 116, computers apparently were not used, but the need for their use was avoided only by the simplification of analysis made possible by the particular facts involved. *Id.* at 370. The analysis involved could probably have been accomplished on a computer using one of the standard routines discussed in note 148 *supra*.

152. *E.g.*, Reynolds v. Sims, 377 U.S. 533 (1964); Lucas v. Forty-Fourth General Assembly of the State of Colorado, 377 U.S. 713 (1964).

153. *See* Nagel, *supra* note 1 (including the complete program as well as a detailed explanation); Weaver & Hess, *A Procedure for Nonpartisan Districting: Development of Computer Techniques*, 73 YALE L.J. 288 (1963).

154. Nagel, *supra* note 1, at 893-98. Some of the differences in the programs are pointed out *id.* at 874 & n.12.

155. *Id.* at 881. It is interesting to note that contrary to what once might have been thought, the computer can be made to favor one party over another. *Id.* at 881 & n.17. *See also* T. O'ROURKE, REAPPORTIONMENT, LAW, POLITICS, COMPUTERS (1972) (ch. 3).

156. Nagel, *supra* note 1, at 893-95.

is in studying the subsequent effect of decisions made and implemented.[157] For example, one investigator studied the effects of the exclusionary rule[158] upon such variables as the adherence of police to the strictures of a legal search, efforts to raise the professional standards of police, the number of successful objections to the introduction of evidence alleged to have been illegally seized, and changes in crime rates.[159] Computers are most valuable, if not indispensable, to such studies.[160]

More controversially, empirical methods have been used increasingly in behavioral studies of legal decision makers themselves, including courts,[161] legislatures,[162] administrative agencies,[163] and even lawyers,[164] in an attempt to explain their decisions. Although these studies initially were of only theoretical interest, direct practical applications of the results of the studies increasingly have been sought.[165] Two of the studies have particular relevance here. The first is that of Professor Schubert who pioneered the employment of scientific methods in such studies.[166] By means of a complicated combination of relatively sophisticated quantitative techniques,[167] Schubert attempted to

157. *See, e.g.*, Shapiro, *The Impact of the Supreme Court*, 23 J. LEGAL ED. 77 (1970), suggesting studies ranging from the impact of decisions on particular governmental units that are the focus of a decision, such as schools and police, to the impact on American political life generally. Professor Shapiro suggests that these studies ought to focus in particular on whether the policy content of a decision has been implemented as opposed to whether there has been formal compliance. *Id.* at 81. Many so-called "impact studies" are cited *id.* at 80 & n.10. *See also* Barth, *Perception and Acceptance of Supreme Court Decisions at the State and Local Level*, 17 J. PUB. L. 308 (1968); Kessel, *Public Perceptions of the Supreme Court*, 10 MIDWEST J. POL. SCI. 167 (1966); Schuchman, *supra* note 120 (effect of legislative decisions in the consumer context). *See generally* materials cited in Shapiro, *supra*, at 83 & n.13.

158. *See* Mapp v. Ohio, 367 U.S. 643 (1961).

159. Nagel, *supra* note 120.

160. *Cf.* Nagel, *supra* note 1, at 898-99 (discussing the uses of computers in law).

161. *See, e.g.*, JUDICIAL BEHAVIOR, *supra* note 113. *Compare* G. SCHUBERT, QUANTITATIVE ANALYSIS OF JUDICIAL BEHAVIOR (1959) (scientific study), *with* F. RODELL, NINE MEN (1957) (nonscientific study).

162. Eulau & Hinckley, *Legislative Institutions and Processes*, in 1966 POLITICAL SCIENCE ANNUAL 85.

163. *Compare* L. MAYHEW, LAW AND EQUAL OPPORTUNITY (1968) (scientific study), *with* K. DAVIS, DISCRETIONARY JUSTICE (1969) (nonscientific study).

164. *See, e.g.*, Zald & Schliewen, *Ethno-Methodology and Simulation of Organizational Decision Making*, in SIMULATION IN THE STUDY OF POLITICS, *supra* note 122, at 227, 228.

165. Behavioral research need not have as its justification the ability to predict the behavior of lawmakers; it may be sufficient to explain that behavior. Yet prediction for its own sake has taken on a special importance. *See, e.g.*, Kort, *Simultaneous Equations and Boolean Algebra in the Analysis of Judicial Decisions*, 28 L. & CONTEMP. PROB. 143 (1963); Lawlor, *The Chancellor's Foot: A Modern View*, 6 HOUS. L. REV. 630 (1969); Schubert, *Judicial Attitudes and Voting Behavior: The 1961 Term of the United States Supreme Court*, 28 L. & CONTEMP. PROB. 100, 132-42 (1963).

166. *See, e.g.*, G. SCHUBERT, *supra* note 161; Schubert, *supra* note 165; Schubert, *Behavioral Jurisprudence*, 2 L. & SOC'Y REV. 407 (1968).

167. Two basic techniques were employed. The first was factor analysis which is a process used to break down the total variance observed (for example, in the tendency of certain judges to agree or disagree with each other or the majority of the court) into "factors" or dimensions that account for proportionately less and less of the variance

show that Supreme Court decisions were the results of the attitudes of the justices[168] toward the major policy issues presented in particular cases.[169] The basic idea was not unique,[170] but the effort was distinguishable from traditional studies of judicial attitudes in its employment of scientific methods and the attendant replicability of the results.[171] Efforts were made to predict results in actual cases primarily as a means of confirming the soundness of the analysis.[172]

In the other study, by Reed Lawlor, prediction assumed a dominant role.[173] The thrust of his work was that legal decisions were exclusively a function of the facts and that decisions could be expressed as either quantitative or logical results of particular combinations of facts.[174] Lawlor qualified this general conclusion by stating that the relationship between facts and decisions differed from judge to judge, but minimized the impact of that assertion by arguing that

observed. Schubert, *supra* note 165, at 114-19. *See generally* H. HARMAN, MODERN FACTOR ANALYSIS (1960). The second technique used was cumulative, or Guttman, scaling. This is a method for ranking subjects (here judges) according to their response (pro or con vote) to stimuli (cases) that are thought to vary in the degree of strength of the stimulus as measured in terms of an attitudinal component. *Id.* at 119-28. *See also* G. SCHUBERT, *supra* note 161, at 269-363; Upshaw, *supra* note 110, at 98-110.

168. On the meaning of "attitude" and the difficulties associated with its measurement and use, see Upshaw, *supra* note 110, at 98-110.

169. Schubert selected civil liberties and economic liberalism as the major policy issues that corresponded to the scales and the factors, respectively. Schubert, *supra* note 165, at 120, 123; see note 167 *supra*. Other issues of lesser importance were also considered. *Id.* at 128. Using a correlation test of the correspondence between the rankings of the justices as derived from the factor analysis and scaling techniques, Schubert concluded that differences in the attitudes of the justices toward the basic issues raised by the cases accounted for the differences in their voting behavior. *Id.* at 132-35.

170. *See, e.g.*, C. PRITCHETT, THE ROOSEVELT COURT: A STUDY IN JUDICIAL POLITICS AND VALUES 1937-47 (1948).

171. *See* Schubert, *supra* note 165, at 100-08; Ulmer, *Quantitative Analysis of Judicial Processes: Some Practical and Theoretical Applications,* 28 L. & CONTEMP. PROB. 164, 164-76 (1963).

172. Schubert, *supra* note 145, at 102-03. Postdiction, looking to see if the behavior one might expect according to the theory is confirmed by *past* decisions and votes, would serve just as well. *See, e.g.*, G. SCHUBERT, *supra* note 161, at 316-76, in which Professor Schubert compares his method to that of Fred Kort as set out in Kort, *Predicting Supreme Court Decisions Mathematically: A Quantitative Analysis of the "Right to Counsel" Cases,* 51 AM. POL. SCI. REV. 1 (1957).

173. *See* Lawlor, *supra* note 165; Lawlor, *Axiom of Fact Polarization and Fact Ranking—Their Role in Stare Decisis,* 14 VILL. L. REV. 703 (1969). *See also* Kort, *supra* note 172; Kort, *Content Analysis of Judicial Opinions and Rules of Law,* 4 INT'L YEARBOOK POL. BEHAV. RESEARCH 133 (1963); Ulmer, *supra* note 171.

174. Essentially two methods are involved, each premised on the controlling nature of the facts. The first is a quantitative method in which facts can be given numerical weights and case results predicted on the basis of whether the facts present in the case are above or below the weight required for a particular outcome. Facts are weighted primarily by giving them numerical values based on the votes of the justices in previous cases in which the facts were present. *See* Kort, *supra* note 165, at 144-50, where the method first set forth in Kort, *supra* note 172, is refined and elaborated upon. The second method is to define a rule of law in terms of its logical components; that is, if certain facts or sets of facts or their equivalents are present, certain results must follow. Kort, *supra* note 165, at 150-58. Lawlor uses a Boolean equation to provide a distinction between positive and negative results in the right-to-counsel cases. *Id.* at 152.

individual judges are consistent.[175] Consequently, he concluded that given the facts of a particular case presented for decision and the personal equation of each of the judges who will make the decision, the outcome in particular cases could be predicted with considerable certainty.[176] The difficulties in implementing any such decisional process are severe indeed. All of the objections of oversimplification raised in the discussion of the Allen proposal and the Buchanan and Headrick effort may again be made.[177] While the problem of fact recognition is acknowledged by Lawlor as being particularly troublesome,[178] he seems to exhibit an unrealistic degree of disdain for the impact of institutional constraints such as *stare decisis* on the behavior of individual judges.[179] Finally, as Lawlor and the others concede, despite the focus on prediction, as contrasted with postdictive validation, the approach is significantly restricted by the introduction of new facts or fact patterns which previously have not been considered.[180]

Nonetheless, the methods used in both kinds of studies might prove useful in essentially behavioralistic analyses of judges and courts, and perhaps even in the detection of inconsistencies within and actual departures from the line of development which seems to have emerged in a particular field of law. Such uses of the work done in these studies seem plausible because the especially thorny problem of anticipating new facts and new developments is minimized. Moreover, whatever the shortcomings, the investigators ought to be given credit for bringing to bear on a subject of considerable interest to lawyers, techniques largely alien to legal analysts that may ultimately prove to be quite helpful.

A significant aspect of Schubert's work involved "factor analysis," which is a complicated technique for breaking the sources of the observed variance into as few "factors" as possible.[181] It is a fair statement that the technique would not be used to the extent that it

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175. *See* Lawlor, *supra* note 165, at 631-39; Lawlor, *Personal Stare Decisis,* 41 S. CAL. L. REV. 73 (1968).
176. Lawlor, *supra* note 165, at 662-63.
177. The objections referred to are the problems with the assumption that decisions can be workably reduced to logical or quantitative statements. See text & notes 65-70, 84-107 *supra.*
178. *See* Lawlor, *supra* note 165, at 639-44; Lawlor, *Stare Decisis and Electronic Computers,* in JUDICIAL BEHAVIOR, *supra* note 133, at 492.
179. It seems unlikely that even the "ultra" legal realists would entirely disregard the role of such institutional restraints as stare decisis—the search for principles rather than cases "on all fours"—on judicial behavior. *See, e.g.,* Gilmore, *Legal Realism: Its Cause and Cure,* 70 YALE L.J. 1037, 1042 (1961).
180. *See, e.g.,* Kort, *supra* note 165, at 159-63. Lawlor has elaborated on the basic approach in his most recent work in an attempt to remedy this problem. *See also* H. DREYFUS, *supra* note 76, at 67-69.
181. See note 167 *supra.*

is, if at all, were it not for computers.[182] Computers likewise played a crucial role in research such as that engaged in by Reed Lawlor. A large number of simultaneous equations had to be solved in ascribing weights to the facts used in describing legal rules quantitatively.[183] This was made practicable only by computers. If the quantitative relationship is to be expressed in terms of factors rather than facts, computers are even more indispensable to ensure that each of the components of the relationship has only one possible weight, leading to a unique solution.[184] As to the attempt to utilize logical statements of the legal rules, a single Boolean algebraic expression quite likely could not be derived from all of the many possible combinations of facts, sets of facts and results without the assistance of computers.[185] Thus, while empirical methods certainly cannot replace the human decision makers or analysts of the decision makers, it seems apparent that they do much to aid the making and implementation of legal decisions and studies of the decision-making agents. It is also apparent that computers not only facilitate but have become virtually indispensable to the employment of such methods.

COMPUTERS, SIMULATORS, AND THE COUNTER-INTUITIVE COMPLEXITY OF SOCIO-LEGAL PROBLEMS

The subjects discussed so far have a common denominator, namely, getting machines to do what men do. Automated legal research, especially at the more sophisticated levels, involves machine replication or simulation of the human activities of storing, retrieving, and to some extent processing legal information. The Buchanan and Headrick effort was very much concerned with simulating lawyers' cognitive processes and, at another level, simulating the manner in which lawyers solve legal problems irrespective of the actual mental processes involved. Less obviously, the behavior of human empirical researchers is simulated to the extent that machines are employed in storing, processing, and analyzing empirical data. Finally, machines were used in some of the behavioral studies of legal decision makers to sim-

182. *See* Hornseth, *supra* note 124; Schubert, *A Psychometric Model of the Supreme Court,* AM. BEHAV. SCIENTIST, Nov. 1961, at 14. For a helpful discussion of "factoring" and the use of computers therein, see W. DAVISSON, *supra* note 15, at 159-70; Fruchter & Jennings, *Factor Analyses,* in COMPUTER APPLICATIONS, *supra* note 14, at 238-65.

183. *See* note 174 *supra.*

184. *See* Kort, *supra* note 165, at 147-48, 150.

185. *See* Kort, *supra* note 165, at 153-55. The unique suitability of computers for the true-false (on-off) decision behavior involved in Boolean algebraic analysis is discussed in COMPUTER APPLICATIONS, *supra* note 14, at 104-06. *See also* COMPUTERS AND THOUGHT, *supra* note 14, at 2.

ulate the behavior of judges and courts engaged in the decisional process, at least as they were theorized to behave.[186]

It is clear, however, that effective and complete simulation of other than essentially mechanistic tasks is not imminent. An important reason for this is that not enough is known or understood about the actual nature of the activities or behavior sought to be replicated. As was observed earlier, simulation efforts can often be justified solely in terms of their inevitable contribution to an understanding of the nature and behavior of the activities sought to be machine replicated.[187] This characteristic suggests that simulation may serve an important purpose distinguishable from the end of replicating human activities: enhancing man's ability to understand and deal with complex processes, and in particular understanding and resolving problems associated with socio-legal systems. Since the essence of the legal process is decision making, and since rational decision making presumes understanding,[188] this dimension of computer simulation ought to be of special interest to lawyers.

Employment of computer simulations to the end of rational decision making thus far has been pursued primarily outside the field of law.[189] Research in other fields has shown, however, that such simulations should be of considerable interest to lawyers and other legal decision makers.[190] Legal decision making, as with other decision making, involves both a need to understand the problem under considration and an ability to anticipate, with some reasonable degree of certainty, the consequences of particular decisions. Given the subject

186. Some of these attempts will be viewed with anxious anticipation. Relieving lawyers of the tedious, time-consuming, and therefore expensive task of researching a legal question would be a welcome accomplishment. Other attempts, to the extent that they suggest the replacement of lawyers and judges with machines, will be met with alarm.

187. See note 106 and accompanying text *supra.*

188. *See* Auerbach, *Legal Tasks for the Sociologist,* in LAW AND THE BEHAVIORAL SCIENCES, *supra* note 108, at 18, 22-25.

189. *See generally* C. CHERRYHOLMES & M. SHAPIRO, REPRESENTATIVES AND ROLL CALLS, A COMPUTER SIMULATION OF VOTING IN THE 88TH CONGRESS (1969); W. DAVISSON, *supra* note 15; DIGEST OF THE SECOND CONFERENCE ON APPLICATIONS OF SIMULATION (1968) [hereinafter cited as 2 APPLICATIONS OF SIMULATION]; DIGEST OF THE THIRD CONFERENCE ON APPLICATIONS OF SIMULATION (1969) [hereinafter cited as 3 APPLICATIONS OF SIMULATION]; G. EVANS, *supra* note 122; J. FORRESTER, URBAN DYNAMICS (1969); T. NAYLOR, J. BALINTFLY, D. BURDICK & K. CHU, COMPUTER SIMULATION TECHNIQUES (1966) [hereinafter cited as T. NAYLOR *et al.*]; J. RASER, SIMULATION AND SOCIETY (1969); SIMULATION IN THE STUDY OF POLITICS, *supra* note 122; Coplin, *Approaches to the Social Sciences Through Man- Computer Simulations,* 1 SIMULATION & GAMES 391 (1970).

190. Computer simulations may greatly enhance our ability to understand and deal with things ranging from the ways in which lawyers reason, to the ways in which judicial decisions are rendered, and ultimately to the virtually infinite range of concrete socio-legal problems continually confronting lawyers, judges and legislators. *See* C. CHERRYHOLMES & M. SHAPIRO, *supra* note 166, at 1-20.

matter of law, the understanding and degree of anticipation provided by traditional legal methodology are often deficient.[191]

Computer simulations can enhance understanding of legal problems and the context in which they arise and ultimately facilitate legal decision making for a number of reasons. Understanding ordinarily involves the formulation of a theory or model of the subject under consideration.[192] The hazy verbal models or theories that tend to typify much theorizing, especially outside the physical sciences, may mean many things to many people or nothing to anyone but the theorist. In contrast, a computerized theory—a simulation—must be very precise and explicit with respect to every element or component of the theory and every interrelationship among the components.[193] A possible ramification of this need for explicitness and precision is that the important assumptions underlying a model or theory, while they may still be empirically unverifiable[194] and may contine to defy simplistic logical or quantitative statements,[195] are exposed to scrutiny.[196]

Another significant feature of computer simulation that contributes to understanding and facilitating decision making is the ease with which the theory or model can be modified and manipulated.[197] A

191. It was stressed in the discussion of the use of empirical methodology in aid of legal decision making that legal decision makers often tend to be too intuitive. They make and accept without verification even those assumptions that could be verified. See text & notes 108-117 *supra*. Where the questions involve not only the facts, but also the things that interact to produce the observed state of facts, and how the situation will change in response to particular decisions, the inadequacies of traditional legal analysis become even more apparent. As to the latter questions, standard empirical techniques often break down as well, and computer simulation emerges as a means of providing the answers. See text & notes 211-232 *infra*.

192. It was earlier observed that all thought, and hence understanding, likely involves the formulation of a model or theory of the subject of analysis. See note 87 *supra*. The subject of analysis in the simulation context is the referent system. Coplin, *supra* note 189. The simulation need not, and in general cannot be an exact replica of the referent system. The representation is of necessity usually symbolic since physical replicas, even reduced in scale, are in general of limited utility. Consequently, means for simulating the referent system symbolically must be sought. W. DAVISSON, *supra* note 15, at 16-21; J. FORRESTER, PRINCIPLES OF SYSTEMS 3-1 to 3-12, W3-1 to W3-9 (1968). Exact symbolic representation would normally exceed the genius of most designers. Thus, not only is the simulation an abstraction, but it is complete only in the sense that it includes the segments of reality relevant to the purpose of the model. W. DAVISSON, *supra*, at 16-17. Those features of the referent system omitted from the simulation become the assumptions built into the simulation. *Id.*

193. The essence of simulation is identifying the components or elements. *See, e.g.*, G. EVANS, *supra* note 122, at ch. 1; T. NAYLOR *et al.*, *supra* note 189, at 1-20. *See also* COMPUTERS AND THOUGHT, *supra* note 14, at 271; J. FORRESTER, *supra* note 192, at 3-2.

194. *See, e.g.*, J. FORRESTER, *supra* note 192, at 3-4; J. FORRESTER, *supra* note 189, at 112; Blalock, *supra* note 110, at 6.

195. J. FORRESTER, *supra* note 189, at 112.

196. The exposure is certainly greater than is the case with regard to verbal models. J. FORRESTER, *supra* note 192, at 3-2. *See also* C. CHERRYHOLMES & M. SHAPIRO, *supra* note 189, at 1-17; W. DAVISSON, *supra* note 15, at 18.

197. *See, e.g.*, COMPUTERS AND THOUGHT, *supra* note 14, at 271. An illustration of this feature is given in the text accompanying note 156 *supra*. On the importance of flexibility as it is affected by the number of possible relationships that can exist, see G. EVANS, *supra* note 122, at 136.

computer can be programmed to make successive specified changes in the model or theory, or to perform in response to varying decisional inputs, all of which would be prohibited by the investment in time if they had to be accomplished manually. Some limitations are imposed by such things as the essential character of the computer system[198] and language capabilities,[199] but by and large these constraints are more than compensated for by the basic flexibility of computer simulation. This flexibility permits the simulator to begin modestly and to elaborate and refine his theory gradually until it more closely resembles and better explains the nature of the subject under study.[200] A recently developed simulation of the roll-call voting behavior of the House of Representatives,[201] considering the sheer numbers of components and interrelationships involved, illustrates rather well the attributes of flexibility and ease of modification and manipulation.[202] The Buchanan and Headrick effort, as do most projects inspired by artificial intelligence, exemplifies the attributes of explicitness, precision, and flexibility.

A related attribute of computer simulation is its potential for producing data from which to theorize. Theories and therefore the simulations that embody them may be classified as either empirically based or entirely theoretical.[203] Although the former are in general to be

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198. See text & note 25 *supra*. The special problems created for computer simulations are that methods must be devised for achieving sequentially what happens simultaneously in the referent system and, similarly, for representing by discrete operations phenomena that are actually continuous. *See, e.g.*, G. EVANS, *supra* note 122, at ch. 7; J. FORRESTER, *supra* note 192, at 6-3 to 6-12. Simultaneity in a sequentially operating system can be achieved through the "synchronizing" capabilities of the GPSS (General Purpose Simulation System). *See* IBM, INTRODUCTORY USER'S MANUAL (GPSS/360) 16-21, 42-47 (5th ed. 1969).

199. The problem of computer programming languages has been discussed in detail at text & notes 15-16 *supra*. It should be added that special computer languages and systems are being devised for the express purpose of aiding simulation. *See, e.g.*, G. EVANS, *supra* note 122, at 36, discussing the desirable features of simulation "packages" generally and the SIMCRIPT package in particular.

200. *See* C. CHERRYHOLMES & M. SHAPIRO, *supra* note 189. Perhaps a better illustration is the work of Dr. Kenneth Colby in developing a program which simulates paranoia and accepts natural language questions. *See* Colby & Enea, *supra* note 30; text & note 30 *supra*.

201. C. CHERRYHOLMES & M. SHAPIRO, *supra* note 189.

202. This simulation divides the factors affecting roll-call voting behavior into two categories: those which are essentially personal to each representative, such as his party affiliation or his constituency's regional interests and desires, and those which operate as a result of communication with other representatives. The factors in each category operate respectively at two different phases of the simulation, the predisposition phase and the communication phase, and each of the 435 representatives is given a final voting disposition as a result of the operation of the various factors during each phase. *Id.* at 13-15, 45-62.

203. Perhaps the best known illustration of the difference is to be found in statistics. There, experimental and theoretical sampling distributions are distinguished and the distinction is employed in "goodness of fit" tests, such as chi square. *See, e.g.*, G. FERGUSON, *supra* note 118, at 79-103, 191-213. A less orthodox but more appropriate example is suggested in the discussion of Professor Davis' approach to the problem of administrative discretion in Reiss, *Research on Administrative Discretion and Justice*, 23 J. LEGAL ED. 69 (1970).

preferred,[204] actual experimentation as a device for gathering data may not always be possible;[205] this is particularly true in law.[206] In other disciplines, especially the physical sciences, techniques have evolved for alleviating this problem, primarily by sampling from the simulation of distributions[207] that are thought to capture the essence of the phenomenon under consideration.[208] Perhaps a similar approach could be utilized in law. Although such an approach may sound like boot-strapping, a theory must begin somewhere, and the ultimate consideration is whether the theory devised satisfactorily explains the matter under consideration.[209] Where data are available, the empirical distribution from which the data must have been drawn can easily be simulated.[210]

A most important feature of computer simulations is their dynamic, time-varying quality,[211] which permits the behavior of a system to be considered as a function of time.[212] Dynamic models or theo-

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204. In the simulation context, the criticism of Professor Forrester's work and especially its essentially nonempirical foundations is a case in point. *See* Berger, Boulay & Zisk, *Simulation and the City*, 1 SIMULATION & GAMES 411, 424 (1970). On the other hand, Forrester argues that data is not so all-important because many of the relationships and interactions that must be included in the model will defy quantitative measurement, and that the important question is whether the simulation ultimately succeeds in capturing the essence of the referent system. J. FORRESTER, *supra* note 189, at 112; Forrester, *supra* note 116, at 55.

205. Among the primary inducements for the development of computer simulation, which originated in the physical sciences, were the needs to produce data where actual experimentation was not possible, and to permit at least approximate solutions to mathematical problems which were too complex for analytical treatment. *See* T. NAYLOR, *supra* note 189, at 1-20.

206. See text & notes 118-22 *supra*.

207. With respect to the types of "distribution", see note 203 *supra*.

208. Techniques have been devised for simulating most known distributions and presumably could be used to simulate any particular theoretical distribution that the researcher has in mind. *See* THE DESIGN OF COMPUTER SIMULATION EXPERIMENTS (T. Naylor ed. 1969); T. NAYLOR, *supra* note 189, at 4.

209. See text & note 204 *supra*.

210. *See, e.g.*, G. EVANS, *supra* note 122, at 182; IBM, *supra* note 198, at 32-33.

211. This is probably the single most important feature of the simulation technique insofar as the social sciences and law are concerned. *See, e.g.*, J. FORRESTER, *supra* note 192, at 54; Forrester, *supra* note 69, at 21.

212. The basic phenomenon is perhaps best illustrated by Professor Forrester's theory that the behavior of systems can be understood only in terms of "multiple-feedback loops" in which all interactions that cause changes in the system occur. The theory rejects simple *A* causes *B* linear causal analysis and proposes instead analysis in terms of interactive causation. Thus while *A* may affect *B*, *B* in turn affects *A*. In Forrester's theory, *A* is a level (a state or condition of a system) and *B* is a rate (or policy or decision). The condition or state of a system is a function of decisions or policies governing the condition and the policies or decisions made are a function of the condition or state of the system. A simple feedback loop is a man filling a glass of water. The level of water in the glass affects the rate at which the man allows the water to flow from the tap and the rate of flow in turn affects the level of the water. Complex social systems are composed of many such feedback loops, hence the phrase "multiple feedback loops." J. FORRESTER, *supra* note 192, at 2-1 to 2-39, W2-1 to W2-75. The theory has been applied in an attempt to simulate the "dynamics" of urban decay, J. FORRESTER, *supra* note 189, and most recently in an attempt to simulate the interaction of population, industrialization, depletion of natural resources, agriculture and pollution on a global scale. *See* Forrester, *supra* note 116, at 59-67. The relationship between time and the "state" or condition of the system has been carefully explained by reference to the two basic kinds of simulation packages:

ries may be designed using more or less standard analytical techniques, but the methods tend to be very complicated and the models difficult to manage.[213] The more complex the system under study, the more complicated the analytical solution becomes, until at some point the systems and problems become so complex that they defy analytical solution completely.[214] Many of the problems of concern to lawyers fall into this category.[215]

That computer simulations can alleviate these difficulties associated with analytical methods is neither easily explained nor readily appreciated. If computer simulations are viewed exclusively as computerized mathematical models, they may simply compound the difficulties of constructing such models. Although most simulation to date has involved high-level mathematical models,[216] this may be a result of the origins of the technique[217] and the nature of the sources of financial support available.[218] Simulations need not be so oriented, however. Especially outside the physical sciences, they increasingly tend to be combinations of mathematical and logical models[219] or to involve no mathematics whatsoever.[220] Professor Forrester of the Massachusetts Institute of Technology has urged that understanding inherently complex social systems does not necessitate equally complicated mathematical simulations.[221] By narrowing the focus in the analysis to two basic components, rates and levels (policy and condition), and insisting that the essential process of dynamic interaction in social systems is based on integration rather than differentiation,[222] the former

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"fixed-time step," where all events are considered to have taken place at the end of the time interval in which they actually occur or would occur in the referent system, and "next event," where events are considered to happen sequentially at the time they actually occur. *See* G. EVANS, *supra* note 122, at ch. 7.

213. *See, e.g.*, Coleman, *The Mathematical Study of Change*, in METHODOLOGY IN SOCIAL RESEARCH, *supra* note 110, at 428.

214. J. FORRESTER, *supra* note 192, at 3-9 to 3-11; T. NAYLOR *et al.*, *supra* note 189 at 1-20.

215. Professor Forrester's more recent work has reflected the judgment that social systems are neither easily nor accurately understood when reliance is placed on either intuition or standard analytical methods. *See, e.g.*, Forrester, *supra* note 116. Others have made a similar judgment but responded somewhat differently by suggesting revised mathematical techniques. *See* Beshers, *Substantive Issues in Models of Large-Scale Social Systems*, in COMPUTER METHODS, *supra* note 50, at 121.

216. *See generally* 2 APPLICATIONS OF SIMULATION, *supra* note 189.

217. See note 205 *supra*.

218. Most applications to date have been sponsored by the Department of Defense or business, and have been done by physical scientists or economists who tend quite naturally to have a heavy mathematical orientation. *See, e.g.*, G. EVANS, *supra* note 122; T. NAYLOR, *et al.*, *supra* note 189. *See generally* 2 APPLICATIONS OF SIMULATION, *supra* note 189.

219. *See, e.g.*, C. CHERRYHOLMES & M. SHAPIRO, *supra* note 189.

220. *See, e.g.*, the simulations referred to in text & notes 264 & 267 *infra;* J. FORRESTER, *supra* note 189 at 53-55. *See also* Forrester, *supra* note 116.

221. Forrester, *supra* note 116, at 22-23.

222. *Id. See also* J. FORRESTER, *supra* note 192, at 6-11 to 6-12; note 212 *supra*.

being less difficult to handle both intuitively and mathematically,[223] Forrester has been able to simulate corporate,[224] urban,[225] and even world dynamics[226] by using relatively simple equations.

Finally, it is possible that computer simulations may increase the degree of validity associated with most model building or theorizing efforts, thereby partially alleviating the troublesome problem of how closely the model or theory corresponds to the referent system.[227] At one level the problem of validity may be irresolvable, but in general it reduces itself to the question of whether there is a consensus that the model corresponds to the referent system. This may be the only understanding of validity which has any importance. Whether computer simulations are used or not, explanations will be sought and given, but will be accepted, and more importantly, acted upon only to the extent that there is consensus.[228]

Computer simulations would seem to be especially adapted to achieving this kind of validity. In the first place, the explicitness and precision required of such models may enhance their comprehension and therefore their acceptance. The fact that assumptions may thus be more fully exposed may also enhance acceptance,[229] but such a contention arguably is less important to consensus validity than the adequacy of the simulation results with reference to the purposes of the simulation.[230] In this regard computer simulations permit extensive experimentation under a range of conditions so as to produce ample

223. Forrester's method utilizes a much simplified form of integral calculus designed to improve and simplify simulation of complex systems. *See, e.g.*, J. FORRESTER, *supra* note 189; Forrester, *supra* note 116. For this reason his method could conceivably revolutionize the entire field. Compare Forrester's work, for example, with Coleman, *supra* note 213. For a comprehensive and easily understood statement of Forrester's methods see J. FORRESTER, *supra* note 192.

224. *See* J. FORRESTER, INDUSTRIAL DYNAMICS (1961).

225. *See* J. FORRESTER, *supra* note 189.

226. *See* Forrester, *supra* note 116.

227. *See* Coplin, *supra* note 189. Validity should be distinguished from "reliability" which refers to the extent of variation among succeeding executions of the computer simulation program. *Id.* at 395. Both validity and reliability are important considerations throughout the empirical sciences. *See* text & notes 115-117 *supra.*

228. There is of course ample reason to be skeptical of this "consensus" reality, particularly if the consensus is essentially temporary and not transcendental. *See, e.g.*, H. MARCUSE, ONE-DIMENSIONAL MAN (1964), and especially the criticisms of the "operationalist" doctrine. But the challenge is to science in law not simply computer simulation in law. *See* text & notes 110, 115-117 *supra.*

229. *See* note 192 *supra.*

230. In other words, putting aside the question of assumptions, is the simulation "valid" for the purposes for which it was intended? Does it produce results that could not have been produced unless the simulation was "valid"? *See, e.g.*, G. EVANS, *supra* note 122, at 11-13; Waltz, *Realities, Assumptions and Simulations*, in SIMULATION IN THE STUDY OF POLITICS, *supra* note 122, at 105. In generalizing from the simulation to systems other than that which was simulated even incompletely, a different problem arises, one which does not have to do with the technique of simulation but rather with the representativeness of the system simulated. *See, e.g.*, Brunner, *Some Comments on Simulating Theories of Political Development*, in SIMULATION IN THE STUDY OF POLITICS, *supra*, at 329.

results for forming the basis of a judgment concerning validity.[231] The "Turing" test of validity, which makes the validity of a simulation dependent on the inability of men to distinguish the performance of certain tasks by the simulating computer program from the performance of these same tasks by men, captures quite well the essence of this discussion of validity.[232]

There are, of course, obstacles to the realization of the promise offered by computer simulations. The mechanics of simulation, particularly outside the physical sciences, have yet to be delineated.[233] Certain general steps, however, have been set down.[234] The major requirement is that the system to be simulated must be understood sufficiently to permit the simulation effort to begin and ultimately to produce a simulation which is adequate to the purposes in mind. This requirement can abort the entire venture. Obviously, one should not embark on a computer simulation of some complex subject without developing basic expertise in the area. On the other hand, the flexibility inherent in the method does mean that the referent system need not be understood in every detail. Exactly how much understanding is required as a minimum prerequisite to simulation is a variable dependent upon the complexity of the system to be simulated.

In contrast, it is imperative that the simulator has clearly in mind at the outset his purpose or purposes in using the technique.[235] Without a clarification of objectives, such important questions as the degree of detail needed and the amenability of the simulation to manipulation and experimentation cannot be answered.[236] In this regard any inherent strain between the two interrelated uses of simulation—theory building and manipulation or experimentation in aid of decision making[237]—may be eased by an early clarification of purpose. A particular

231. *See* text & note 197 *supra*.

232. *See* Turing, *Computing Machinery and Intelligence*, in COMPUTERS AND THOUGHT, *supra* note 14, at 11. *See also* note 85 *supra*.

233. Cost, although it is reducing, is nevertheless an important consideration in deciding the amount of manipulation and the number of program executions which it is possible to design into a simulation. See, *e.g.*, G. EVANS, *supra* note 122, at 136-41; Gilman, *A Brief Survey of Stopping Rules in Monte Carlo Simulations*, in 2 APPLICATIONS OF SIMULATION, *supra* note 189, at 16; Kobek, *Stopping Rules for Queuing Simulations: Non-Independent Tours*, in 2 APPLICATIONS OF SIMULATION, *supra* note 189.

234. *See* G. EVANS, *supra* note 122, at 15-36; T. NAYLOR, *et al.*, *supra* note 189, at 23-42. Professor Forrester's book, URBAN DYNAMICS, sets forth in infinite detail the application of his methodology in simulating the dynamics of the process of urban growth and decay. J. FORRESTER, *supra* note 189. *See also* J. FORRESTER, *supra* note 192, at 3-1 to 3-12, W3-1 to W3-9. Interestingly, computer simulations have been used to simulate data processing systems, with a view toward improving those systems. *See* IBM, INTRODUCTORY USER'S MANUAL (GPSS/360) 4 (1968).

235. *See* G. EVANS, *supra* note 122, at 15; T. NAYLOR, *et al.*, *supra* note 189, at 24.

236. *See* G. EVANS, *supra* note 122, at 15; T. NAYLOR, *et al.*, *supra* note 189, at 24.

237. *See* C. CHERRYHOLMES & M. SHAPIRO, *supra* note 189, at 11-12.

strategy which may be useful in this regard, the "modular" approach, breaks a system or problem down into as many parts or "modules" as possible, deals with the modules separately until they are satisfactorily developed, and then combines them into the complete simulation.[238]

Since the theory may involve concepts and conceptual relationships that defy or seem to defy explicit statement, a more troublesome problem is translating the theory being developed into a computer program. This is a disadvantage of the demand for explicitness and precision. The difficulty is not merely that some concepts and relationships cannot readily be reduced to simple, or even complicated quantitative, logical, or even qualitative relationships.[239] Frequently, the problem of translation will stem from the fact that the concepts, relationships, or processes studied have not as yet been adequately explained.[240] Where the processes involved are continuous or there is a need to reproduce the effects of simultaneity of occurrence, obstacles arising from the facts that computers operate sequentially and are discrete-state machines must be overcome. These are tasks that are not always easily or satisfactorily accomplished.[241] Other difficulties are created by the emphasis on mathematics as the means of achieving the explicitness and precision that the computer seems to crave. The hope here seems to be in the creation of a modified mathematical approach such as that being developed by Forrester or essentially nonmathematical approaches that achieve the necessary results.[242]

The problem of translating the theory into a computer simulation is also in part that of stating the theory itself in language which the computer is able to use.[243] Again the natural language deficiency asserts itself. General purpose languages are inadequate for simulation.[244] Accordingly, increasing attention has been given to the development of languages especially suited to computer simulations.[245]

238. *E.g.*, Coombs, Fried & Robinovitz, *An Approach to Election Simulation through Modular Systems*, in SIMULATION IN THE STUDY OF POLITICS, *supra* note 122, at 286. The Buchanan and Headrick effort is a possible example of this approach.

239. *See* text & notes 90-92 *supra*.

240. *See, e.g.*, note 88 *supra*.

241. *See* notes 14, 198 *supra*.

242. *See* text & notes 216-23 *supra*.

243. *See* the discussion of the general problem in text & notes 15-17 *supra*.

244. "General purpose" is something of a misnomer here because the languages are for the most part designed for use, or at least had their origins, in mathematics and the physical sciences. Some less widely known and more recently developed languages are much more deserving of the denotation "general purpose." One such language is SNOBOL, which is useful for many purposes including simulation and is very easy to employ. Because of its many capabilities, however, it is relatively slow and inefficient. *See* R. GRISWOLD, J. POAGE & I. POLONSKY, THE SNOBOL4 PROGRAMMING LANGUAGE (1968).

245. It is more accurate to refer to the development of simulation "systems" which will include a number of special facilities, such as a "clock" for timing the various events in the simulation, as well as a language aimed at easing the task of constructing

Although mathematical orientation may be unnecessarily biasing and restricting their development,[246] there is a correspondence between the interest in such languages, and the widening application of the simulation technique, and progress is being made.[247] It is not unreasonable to suggest that the future of the simulation technique as a generally available theory-building and decision-making device may rest with the development of such languages.

Several features of Forrester's work warrant comment here. As has already been pointed out, it is intended to expedite implementation especially through the simplification of the mathematics involved in other simulation efforts. Second, the simulations resulting from his method are what were previously referred to as theoretically, as opposed to empirically, based.[248] This in effect means that the model was constructed without scientific gathering of data and that the assumptions built into the simulation, more so than with other efforts, were not "scientifically" grounded.[249] Furthermore, such things as the initial parameters[250] used were given diminished importance. Thus, in Forrester's theory systems tend to be moving either toward or away from some goal and will establish equilibrium with respect to the goal depending on decisions that are made (changes that have taken place) at various points in the system. It is the equilibrium values of the various rates (policies) and levels (conditions)[251] that are important, and these equilibrium values are much more dependent upon the repre-

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the simulation. *See* G. EVANS, *supra* note 122, at 36-38 (referring especially to the SIMSCRIPT system or package). Professor Forrester's work has been done using the DYNAMO compiler system developed at Massachusetts Institute of Technology. *See* J. FORRESTER, *supra* note 192. The special features of that system are referred to in explanations of his method. *Id. See also* note 234 *supra.*

246. *See, e.g.,* Felder, *The GPSS/360 Random Number Generator,* in 2 APPLICATIONS OF SIMULATION, *supra* note 189, at 21; Green, *Modeling a Weather Environment,* in 2 APPLICATIONS OF SIMULATION, *supra,* at 337 (which involves a simulation employing GPSS).

247. *See, e.g.,* the discussion of SIMULA67, a powerful "general purpose" language designed with special reference to simulation, in Felder, *supra* note 246, at 29. *See also* Goldberg & Mittman. *SPURT-A Simulation Package for University Research and Teaching,* in 2 APPLICATIONS OF SIMULATION, *supra* note 189, at 40 (discussing a language that was spawned for scientific applications but designed for use by persons without programming expertise); Weamer, *QUIKSIM—A Block Structured Simulation Language Written in SIMSCRIPT,* in 3 APPLICATIONS OF SIMULATION, *supra* note 189, at 2 (discussing a system that attempts to combine the best features of SIMSCRIPT—basically an algebraic language with relative flexibility—and GPSS, a block-structured language which is relatively inflexible but more efficient and quicker to run).

248. *See* J. FORRESTER, *supra* note 189, at 112-13; Forrester, *supra* note 116.

249. *See* J. FORRESTER, *supra* note 189, at 112-13.

250. "Parameters" are the numerical values that indicate the relative importance of particular variables used in equations expressing the relationships making up the simulation. *See* T. NAYLOR *et al., supra* note 189, at 5-9. It may be useful to think of statistical regression analysis and its methods of estimating parameters. *See, e.g.,* 2 W. HAYS & R. WINKLER, *supra* note 135, at 26-31; T. NAYLOR *et al., supra* note 189, at 32-34.

251. *See* text & note 222 *supra.*

sentation of the significant interrelationships making up the system than they are on the initial values of the parameters.[252] The method can be and has been criticized because of these features.[253] As has been suggested, however, the acid test of a simulation may be its validity in terms of its ability to command a consensus that is sufficiently resembles that which it purports to simulate to justify reliance for decision-making purposes.[254] Moreover, as Professor Forrester has stressed, it is very important to keep in mind the kind of human decision-making against which simulation is being tested.[255]

It also appears that the Forrester method is best suited to simulating systems on a macro-scale, where the decision to be made requires an understanding only of the major components and interrelationships defining the behavior of the system.[256] While decisions pertaining to the dynamics of urban growth and decay may be enhanced by macroanalysis, such a method may be inadequate for decisions affecting the behavior of individuals. The difference is perhaps typified by the distinction sometimes drawn between strict decision theory analysis, which tends to focus on individual decision makers and the ways in which they interact, and systems analysis, which tends to focus on the universe of decision makers, especially in terms of communication as a system within a system and information feedback as a control mechanism.[257] According to this distinction one might differentiate the roll-call voting behavior simulation, especially its predisposition phase,[258] from the simulations based on Forrester's method, placing the former in the category of simulations best adapted to replicating individual behavior.[259]

It might be possible to combine micro- and macroanalytical simulation and thereby minimize the deficiencies of each used separately.[260] It is further possible, however, that microanalytical studies can be conducted only by using man-computer simulations, methods which have already had widespread attention in the social sciences.[261] On

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252. *See* J. FORRESTER, *supra* note 189, at 36, 110-11, 112-13. *See also* J. FORRESTER, *supra* note 192, at 4-1 to 4-17.
253. *See* note 116 *supra.*
254. *See* text & notes 192, 227-32 *supra.*
255. J. FORRESTER, *supra* note 192, at 3-3 to 3-5, 3-5 to 3-10; *see* note 262 *infra.*
256. *See, e.g.,* T. NAYLOR *et al., supra* note 189, at 16-23.
257. *See* J. RAZER, *supra* note 189, at 51-69.
258. *See* text & notes 201-02 *supra.*
259. Professor Forrester probably would object to such a distinction as he tends to suggest that social phenomena may be understood exclusively from a systems approach, more specifically from his systems approach. *See* Forrester, *supra* note 69.
260. C. CHERRYHOLMES & M. SHAPIRO, *supra* note 189, at 13.
261. *See, e.g.,* Boguslaw & Davis, *Social Process Modeling: A Comparison of a Live and Computerized Simulation,* 14 BEHAV. SCI. 197 (1969); Coplin, *supra* note 189. Consider the use of such simulations, for example, in connection with the study of

the other hand, the macro or systems approach alone may be completely adequate as to most decisions regarding social systems, including most legal decisions, since such decisions do not call for other than an aggregated view of individual behavior. In any event, the purpose here is certainly not to offer Forrester's method as *the* method, but only as one which seems to have considerable potential.[262]

Although computer simulation as an aid to understanding and decision making has yet to be meaningfully employed in the field of law, efforts have been made that are suggestive of its potential. Given the ever increasing concern about court congestion and the administration of justice,[263] one of the most important and so far more promising uses of the technique is represented by attempts to simulate the administration of cases in a court system[264] and to investigate delays in such a system, especially through the device of queuing statistics.[265] Of a similar nature have been attempts to simulate the disposition of police resources, such as patrol cars, in response to calls for assistance.[266]

On another level efforts have been made by a Wisconsin legal aid group to simulate the process of interviewing clients in domestic relations cases, especially at the initial stages. The problem is to decide what questions to ask in order to elicit the basic facts and circumstances of the client's case. In its simplest form it might be sufficient for the program to ask carefully devised questions in a predetermined sequence and record the answers. A truly successful simulation, how-

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jury instructions. See note 112 *supra*. For an entirely different approach, see Robinson & Foster, *The Simulation of Human Systems*, in 2 APPLICATIONS OF SIMULATION, *supra* note 189, at 166.

262. Despite the appeal of Forrester's approach and its potential significance for the study of social systems if it proves to be conceptually sound, it should be stressed that the utilization of the simulation technique is not dependent upon the fate of that approach. Simulations, as the computers themselves, are not restricted to mathematical operations. It is symbols that are manipulated, not just numbers. *See* text & note 24 *supra*. Logical operations—operations based on the fundamental logical conditions of truth or falsity, rather than merely the ability to handle relationships stated in Boolean algebraic form—appear to epitomize the nature and potentiality of the computer. *See* text & notes 185, 219 *supra*. The importance of these fundamental features of the computer, especially to the simulation technique, cannot be overemphasized. *See* COMPUTERS AND THOUGHT, *supra* note 14, at 1-2.

263. *See, e.g.*, Burger, *The State of the Federal Judiciary—1971*, 57 A.B.A.J. 855 (1971).

264. *See* Navarro & Taylor, *Data Analyses and Simulation of a Court System for the Processing of Criminal Cases*, 9 JURIMETRICS J. 101 (1968). *See also* Halloran, *Judicial Data Centers*, 2 L. & COMPUTER TECH., Apr. 1968, at 9.

265. *See, e.g.*, Kobek, *supra* note 233, at 13. *See generally* 2 APPLICATIONS OF SIMULATION, *supra* note 189; 3 APPLICATIONS OF SIMULATION, *supra* note 189. The designers of the more familiar simulation "packages" seem to have had such systems particularly in mind. *See, e.g.*, IBM, *supra* note 234.

266. *See* Surkis, *A Simulation Model of the New York City Police Department Response System*, in 2 APPLICATIONS OF SIMULATION, *supra* note 189, at 218. *See also The Simulation of Ambulance Dispatching In and Out of a Battle Zone*, in G. EVANS, *supra* note 122, at ch. 3 & Appendix A.

ever, would be dynamic over the course of an interview, with the order of questions and the depth of probing as to particular facts and circumstances being dependent on the responses given to the questions. Although the latter type of simulation would be much more difficult because of the natural language barrier, work done outside of the legal context[267] is suggestive as to how the effort might proceed. Whether or not an effective simulation could actually be designed, the understanding of the dynamics of legal interviewing would certainly be enhanced.[268]

The efforts of Jay Forrester, which focus so sharply on understanding the behavior of social systems, must certainly be examples of great interest to law. Those efforts have been directed at providing a means not only to gain the insight and information needed to afford the basis of sound decision making, things not available through unbridled and often incomplete or misleading intuitions or even more "scientific" approaches,[269] but also to test the consequences of particular decisions. The attempts at explaining such things as the workings of corporations, the essentials of the process of urban decay, and even the fundamental nature of the worldwide environmental crises may have already measurably enriched legal theory. From his simulation of the process of urban decay, for example, Forrester concludes that contrary to what intuition may suggest, building more housing units is not the answer to and may well aggravate urban problems.[270] Although judgment must be reserved on the efforts themselves, especially anything as all-encompassing as a simulation of world environmental dynamics, the work seems to illustrate well the potential of the computer simulation technique. The simplified mathematical mode of expression ought to make the approach especially appealing to legal theorists.

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267. *See* Colby & Enea, *supra* note 30, and the question-answering programs discussed in text & notes 81-82 *supra*.

268. An effort has also been made to simulate the method of teaching thought to be characteristic of today's law professors. The cleverly designed and outwardly impressive simulation constructed by Mark Fischer, a Stanford Law and Computer fellow, for a variety of reasons presently falls short of duplication which could have practical utility. Once again the natural language barrier presents a basic difficulty. The program asks questions and accepts answers in natural language, in an attempt to analyze the classic case of Pierson v. Post, 3 Cai. R. 175 (N.Y. Sup. Ct. 1805). This is accomplished using the key-words-in-combination device. There is no understanding as such, and the program can proceed only if the answers are "responsive," both as to substance and vocabulary, within anticipated limits provided for by the programmer. For this reason the importance of the simulation probably lies in the lessons that were learned in designing it, and its shortcomings, rather than any practical purpose to which it can actually be put. *See also* Silberman & Caulson, *Automated Teaching*, in COMPUTER APPLICATIONS, *supra* note 14, at ch. 14.

269. *See* Forrester, *supra* note 116. *See generally* J. FORRESTER, *supra* note 192.

270. *See* J. FORRESTER, *supra* note 189, at 51-106; Forrester, *supra* note 116, at 55-59.

CONCLUSION

Computers and law is a subject of legitimate concern to the law. While in need of some rethinking if they are to live up to their potential, computerized basic law searching systems are operational today. Actively engaging machines in legal problem-solving tasks is at present only a provocative and challenging idea. Much more must be known about legal problem-solving processes, and capabilities for implementing the processes on machines have yet to be developed. Even if effective replication is never achieved, the promise of advancements as to either or both of these prerequisites is sufficient to justify the effort. Computers presently can provide valuable assistance to human legal decision makers. The employment of empirical methodology can and has improved legal decision making. Computers are a necessary part of such an endeavor. Computer simulations of the complex socio-legal systems out of which many legal problems arise appear to have an even greater contribution to make. While the technique originated and has been developing outside the field of law, substantial wherewithal exists and it remains only for the legal decision makers to take advantage of it. Because the argument favoring greater reliance on the scientific method appears to have prevailed,[271] philosophical objections[272] to a scientific model-building approach to legal decision making ought not to be an obstacle.

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271. *See, e.g.,* THE REPORT OF THE AALS CURRICULUM STUDY PROJECT, TRAINING FOR THE PUBLIC PROFESSION OF THE LAW (1971). *See generally* LAW AND THE BEHAVIORAL SCIENCES, *supra* note 108.

272. *See* R. BOGUSLAW, *supra* note 5, in which the author argues that there is a danger that system designers may not only repeat the errors of the classical utopians, but in having lost the humanitarian orientation that motivated classical utopians, proceed from a philosophical base from which the traditional values of Western societies have been excluded.