# A SOFTWARE AND DATA LIBRARY FOR EXPERIMENTS, SIMULATIONS, AND ARCHIVING: NARRATIVE

## A WEB-LAB LIBRARY

We propose to build, maintain and evaluate a new kind of digital library. To build the library, leading experi-mentalists in economics and sociology organized in Collaboratories will be associated in a research partnership crossing the U.S. Taken together they cover the major specializations of experimental work in economics and sociology. The central task of this research partnership is to develop software for experimental research and place it on the Web producing a "Web-Lab Library." The Web-Lab Library is not an adjunct to existing or proposed laboratory facilities; it is itself the Laboratory. Its software will support multiple experimental designs such that experimenters at any location with access to the Internet can use the Web-Lab Library to run experiments.

The proposed library will fundamentally change social science investigation. For the first time since the develop-ment of electronic laboratories, researchers will be able to break out from the limits of the campus to run experiments using subjects from large and diverse populations distributed at many locations. Experiments will cross many boundaries, bringing new population samples into the laboratory. For example, bargaining studies can pit Dutch against Japanese and Turks against Canadians in multilingual cross-national experiments; information on each subject's screen will be in that subject's language.

While firmly grounded in methods and procedures of contemporary electronic laboratories, the Web-Lab Library is a revolutionary advance. Unlike current practice, the software we develop will be shareware which is quite general and flexible and not restricted to a single project. Once designs are available on the web, research need no longer be delayed by software development. For local laboratories, the Web-Lab Library can eliminate costs of software development while substantially reducing hardware costs. A local laboratory will need no more than a few computers with access to the web. By speeding and democratizing experimental research, we expect an explosion of new knowledge.

The Web-Lab Library's educational initiative integrates research and instruction. Because its experimental designs are real, not virtual, students in computer classrooms can conduct real experiments while learning the most advanced methods in current use. When experiments are run, results will be displayed — even experimental outcomes involving the students themselves moments before. As a result, the Web-Lab Library promises to provide students with laboratory experiences in SBE sciences at least the equal of that found in other laboratory sciences. Because the Web-Lab Library will also house a library of simulation programs, activities can be driven by individual students. At the core of this educational initiative is outreach to minorities, focusing on African-Americans.

### Electronic Laboratories and Infrastructure Problems

Today economics, sociology, and other social sciences face a dilemma. Electronic laboratories have advanced experimental research by offering levels of control not previously possible. Yet the laboratory infrastructure of these sciences is very weak. Infrastructure is weak because, while solving problems of control, the current practice of electronic laboratories has caused others. These problems include:

1. a threat to reduce the size of the community of active experimentalists below the number needed to assure the integrity of scientific knowledge,
2. a slowing of the research process and thus the creation and transmission of knowledge, and
3. a blocking of research which is crucial to the generality of social science knowledge: cross national experiments and replications.

There is no doubt that electronic laboratories advance experimental research in the social sciences. Consider ExNet II, a Windows-based electronic laboratory system which investigates exchange networks. Exchange networks are imperfectly competitive markets, which are studied by sociologists to gain insights into how social structure affects behavior. ExNet II, developed by the P.I. at South Carolina, is currently state-of-the-art. Subjects seated at PCs in separate rooms send offers and make exchanges using mouse control only. The design of ExNet II follows the rule, "Show don't tell." The network being investigated is an active display on each subject's screen; subjects click icons to make offers and complete exchanges. With experimental conditions actively displayed, many uncontrolled effects of language on subjects are avoided. Compared to previous instruments, ExNet II is more intuitive; subject training time is much shorter and subject errors are substantially reduced. But now consider the problems which electronic laboratories like ExNet II produce.

Though an advance, electronic laboratories are expensive. Their expense threatens to reduce the size of the community of experimenters below the critical mass needed to assure the integrity of social science knowledge. There are only three other electronic sociology laboratories which study exchange networks in the U.S.; the University of Iowa (Lovaglia et al. 1995), UCLA (Bienenstock and Bonacich 1992; 1993; Bonacich and Bienenstock 1995), and the University of Washington (Cook et al. 1983 now inactive).[1] Only four advanced electronic laboratories study other theories in sociology.[2] In sociology there are 70 - 80 active experimenters, but, at most, 12 can access an electronic laboratory at their home schools.

Whereas sociology has less than ten "dedicated laboratories," there are two to three times that number in economics.[3] By dedicated laboratories, we mean laboratories with instruments and space used only for research. Because of the diversity of experimental economics, in spite of the larger number of laboratories, the problem of a critical mass of experimenters is just as great as in sociology. For example, Kagel and Roth (1995) count seven major areas of experimental economics but that number does not include rent seeking, smart markets, voting studies or a number of further important areas of study. In fact specializations in experimental economics are proliferating much more rapidly than the numbers of dedicated laboratories.[4]

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[1] There only two international electronic laboratories in sociology; they are at Groningen, The Netherlands and Krakow, Poland.

[2] Beyond network exchange theory, two other theories in sociology have been intensively experimentally investigated; status characteristics theory and legitimacy theory. Only four electronic laboratories investigate status characteristics theory; Foschi's lab at Vancouver developed the first software and Troyer at Iowa the second (Troyer and Younts 1997). Ridgeway at Stanford (Ridgeway et al. 1998), and Ilardi at Rochester use these systems. Only Stanford uses an electronic laboratory to investigate legitimacy theory.

[3] Major laboratories in economics that are dedicated to experimental research (and education) can be found at the University of Pittsburgh, Georgia State University and the University of Arizona. The first two are Associated Collaboratories of this proposal. Cooperative relations have been established with the University of Arizona. Major publications from the University of Pittsburgh's laboratory include Kagel, Harstad, and Levin [1987], Kagel and Levin [1985], Kagel and Levin [1986], and Kagel and Levin [1993]. The experimental activities at Georgia State University have a shorter history, but a strong impact on resource and environmental economics. See, for example, Bjornstad, Cummings, and Osborne [1997] and Bjornstad, Brewer, Cummings, and McKee [1997]. The University of Arizona also has a long history of experimental research. See, for example, Smith [1965], Coursey, Isaac, and Smith [1984], Cox, Smith, and Walker [1985], and McCabe, Rassenti, and Smith [1990].

[4] Because of the small number of dedicated laboratories, experimental economists frequently have no option but to use facilities such as statistical labs and computer classrooms for experimental research. For example, at the University of South Carolina. economics experimenters have an extensive history of experimental research (cf. Harrison [1990], Harrison, Hoffman, Rutström, and Spitzer [1987], and Rutström [1998]), but no dedicated

Scientific knowledge can be objective and self-correcting only through the critical cooperation of a community of active researchers. Today, the size of the community of experimenters is generally too small to assure the ongoing integrity of social science knowledge. Furthermore, entry into the community of active experimenters is more and more closed to new researchers by increased laboratory costs. Years ago, when a lab could be an egg timer and a box of poker chips, entry into the scientific community was open. Because the cost of entry is now over $80,000 for even a modest laboratory,[5] the vast majority do not have access to a dedicated electronic laboratory. Poker chips and egg timers are no longer good enough. Reviewers recognize that electronic laboratories are more precise so experimental reports based on less sophisticated technology are strongly disadvantaged.

With research concentrated in a few laboratories, the majority of experimenters are disenfranchised. High start-up costs imply that the future is equally bleak. Young investigators without electronic laboratories cannot build up the research reputation needed to justify funding the lab they lack. The result is a dangerous privatization of social science knowledge. Lacking laboratory facilities, there is a very real possibility that the next generation of scholars will be forced into less rigorous areas of inquiry.

Second, though electronic laboratories should speed the accumulation of knowledge, very frequently they have slowed the research process. Within the structure of funding opportunities, each researcher has had to develop her own software. It is not unusual for a three year research project to expend two years on software development.[6] With time and money pressures, the software which is developed is much more specialized and far less flexible than is optimal. The designs of researchers collaborating on this proposal, even ones who cross specializations, have remained specialized (e.g. Cummings, Harrison, and Rutström [1995], Cummings, Elliott, Harrison, and Murphy [1997], and Harrison and McCabe [1996]). The scope of theory should set the boundaries of software use, but current practice is much narrower, typically limiting use to the project for which the software was developed. As a result, the researcher's next project will be similarly slowed by software development. Because overly specialized software development is wasteful, it is costly and works to restrict the number of social science laboratories, already small in number, further threatening the integrity of social science knowledge.

Third, in sharp contrast to other sciences, in the social sciences, large-scale replications of previous experiments are almost unknown. Whatever the cause of this fault in the past, as the quality of research increases, the opportunities to publicly check results by replication have decreased. Seeking greater experimental control, scattered laboratories have developed specialized software for local use. The unanticipated consequence of this advance is that it is increasingly difficult to run replications because, for practical reasons such as incompatible hardware or lack of overlapping programming knowledge, access to that specialized software is very limited. The lack of replication may once have been the result of the relatively under-developed level of social science experimentation. As experimentation has matured, however, specialized software increasingly blocks replication of results from the most advanced laboratories. Replication should be a typical exercise for graduate students but currently it is not.

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facility. While multi-use facilities are not ideal, they would be far more effective with the Web-Lab Library in place.

[5] For a small laboratory, ten PCs at $3,000 each as subject stations, one server at $5,000 and a Hub at $10,000 gives hardware costs of $45,000. To produce a windows - based system will require three years for a computer science graduate student at minimally $12,000/year for a total of $81,000. In addition to these costs, the individual researcher should expect at least a two year delay for software completion and minimally six months for debugging. A thirty PC laboratory will cost over $100,000 for computer hardware alone.

[6] For example, SBR-9423231 to the P.I. of this proposal is a three year project with one year planned for software development and two for research. In fact, software development required almost two years before research could begin and programming is still being completed now late in the third year.

Furthermore, cross-cultural and cross-national experiments which test theory for universality have also become increasingly restricted. Like all scientific theory, social science theory must claim universality -- must claim not to be conditioned by specifics of time and place (Lakatos 1970, Walker and Cohen 1985). Since theory is asserted to hold regardless of special conditions of cultures and nations, cross-cultural and cross-national experiments are an essential part of the production of social science knowledge (Foschi 1980; Faucheux 1976; Willer and Szmatka 1993). Before electronic laboratories became the norm, cross-cultural/cross-national experimental study was straightforward.[7] Because laboratories of networked desktop PCs are not portable instruments, however, cross-cultural and cross-national studies replicating electronic laboratory results are, with few exceptions, no longer feasible.[8]

The lack of portability of electronic laboratories also narrows the population from which experimental subjects can be drawn. In the past, most experimental work in the social sciences used undergraduates as subjects: they work cheaply and are easily available. But there have been important exceptions (Milgram 1974). The maturing of experimental research should have been accompanied by an increasing diversity of populations from which subjects are drawn. But increased maturity has been associated with reduced diversity. With the development of electronic laboratories with fixed locations, experimenters are increasingly locked into the very special conditions of the undergraduate population.[9]

These problems are particularly egregious in light of the special contributions of experimental work to SBE knowledge development. Much non-experimental research in sociology is descriptive and, when its results bear only on particulars of time and place, the stock of general knowledge grows little. In economics, when theory is tested with field data, often information on critical control variables is not available making precise testing difficult, sometimes impossible. By contrast, experiments and theory development are closely linked and their joint result is precise, tested theory which cumulates as general knowledge and which can be applied without regard to special conditions. Experimentalists in SBE sciences are small in numbers, but their contributions to general knowledge are disproportionally large. And increasing their numbers -- as the Web-Lab Library is designed to do -- will have a disproportional effect on the growth of general knowledge in both sociology and economics.

**Web-Lab Library Solutions to Knowledge Development Problems**

By placing software on the web as shareware, the Web-Lab Library:

- solves the three problems just discussed.
- facilitates research which is now infeasible or impossible while integrating across SBE fields.
- integrates research with education and business training applications.

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[7] For U.S. results replicated cross-nationally in communist Poland, subjects in both settings negotiated over stacks of poker chips. Plywood boards as barriers between selected subjects set network structures while an egg timer timed interactions. This kind of technology is easily moved or cheaply acquired. The only substantial problem faced by experimenters was standardizing payments of U.S. vs. Polish subjects (Willer and Szmatka 1993). Cross-national economics experiments have also been conducted without computers (cf. Roth, Prasnikar, Okuno-Fujiwara, and Zamir [1991]).

[8] Cross-national or cross -cultural study is still possible in the occasional case where laboratories at other locations have similar electronic capabilities. Alternatively, there are some few proprietary net-based systems which can reach across cultural and national boundaries. As explained above, access to this net-based software for outsiders is frequently not feasible. For yet another alternative, a recently developed portable electronic laboratory, see note 9.

[9] Our Collaboratory at Georgia State has recently built a 15-station portable laboratory which is based on Laptop computers. Their portable lab, when using the proposed Web-Lab Library, will test the limits of portability.

The proposed Web-Lab Library solves the problem of critical mass needed for objective social scientific knowledge. The problem is solved because the Web-Lab Library will democratize experimental research. Instead of becoming increasingly expensive, experimental research will become one of the least expensive modes of enquiry. Local laboratories will have virtually no software costs. With user-friendly flexible shareware in place at the Web-Lab Library, local laboratories can use existing designs or build new ones from available modules. Furthermore, hardware requirements of local laboratories are drastically cut. Because the Web-Lab Library connects subject PCs, local labs do not need hubs: they will require no more than a few computers. In many cases, no dedicated hardware or space will be needed. Existing computer classrooms can serve as settings for experiments. In fact, many dedicated economics laboratories are very like computer classrooms but with the addition of dividers between subjects. Alternatively, accessability of the Web-Lab Library allows subjects to participate in experiments using computers at home or at public library facilities.
Reduced costs should result in a rapid growth in the number of experimenters, but the quality of experimental work will not decline. The Web-Lab Library will be associated with an increase in the quality of experimental work and with a strengthening of the community of experimenters. As detailed below, the Web-Lab Library's experimental designs will be developed by leading scholars. With their state-of-the-art designs on the web, the quality of experimental research should increase. When linked electronically though the Web-Lab Library, subjects at separate locations can be run simultaneously. Because experiments can be run on widely distributed subjects, the Web-Lab Library will encourage the formation of networks of cooperation among experimentalists distributed across states and nations. The result links local labs in an extensive knowledge network allowing them to run experiments with large numbers of subjects. Local labs will become Super-Labs. Precisely because experimenters are widely distributed, these cooperative knowledge networks will build a strong community.

Second, the Web-Lab Library will speed the growth of social science knowledge in a number of ways. When needed software is available as shareware on the Web, software development will not delay research as it does today. When software has multiple users, not the single project, but the scope of theory will determine the kinds of designs to be developed. The result will be better and more flexible software which will satisfy the needs of an array of users. Even when a needed design is not immediately available at the Web-Lab, time will be saved relative to current practice. Today, programming at even the most advanced laboratories is slow because it is carried out by computer science graduate students with no previous experience in the social sciences -- and frequently no previous experience in building complex user-friendly systems of any kind. The Web-Lab Library will employ professional programmers who will become specialists in software for the social sciences. Because software is shareware, costs per user and per use are sharply reduced, a reduction which justifies the larger investments needed to support professional programmers. Further savings will be realized as modular programming is introduced such that new experimental designs can be built by users out of existing parts.[10]

The increased number of experimenters and increased speed of their work will strongly impact the growth of general social science knowledge, but that knowledge will become increasingly coherent and integrated because the Web-Lab Library will archive current and past research. The Web-Lab Library will automatically archive current research, recording data in standard format Innovative methods of data retrieval and display will be developed. For example, when network exchange experiments are conducted, the PC screen displays all subjects' activities on the network including offers, counteroffers and exchanges. Playback capability, designed as part of the software,

[10] High quality designs at the Web-Lab Library require 1) a permanent staff of professional programmers who have developed substantial knowledge of social science research and 2) social scientists committed to interfacing with the programmers. To achieve that commitment across distributed Collaboratories, this research links software development to the ongoing research programs of collaborating sociologists and economists. In addition, to achieve optimal diversity of designs, experimentalists not associated with a Collaboratory can request or order new designs.

will allow these interactions to be displayed again so that secondary analyses can find patterns not previously evident.[11]

User-friendly formats developed for current research will be used to archive results from significant past research. Fortunately, electronic laboratories have been routinely recording data electronically for some time. Therefore, Web-Lab Library archiving efforts can concentrate on developing user-friendly standardized archiving formats and translating previously recorded data into those formats prior to housing them on the web.[12] With few exceptions, experimental data is less subject to error than is data from other kinds of SBE research.[13] Focusing archiving efforts on experimental work will result in new data bases of much higher quality than is normal for the social sciences.

Third, the Web-Lab Library directly solves problems of replication, cross cultural and cross national research created by the development of the electronic laboratory. Replication will be easier than ever before. Where once there was little or no replication, with software for experiments in place at the Library, replication of research carried out there will be a typical exercise for graduate students. With replications becoming routine, it should become a norm that software for replications must be made publicly available. As that norm develops, it will be the responsibility of the Web-Lab Library to assist in making the software available. Said somewhat differently, the norm of replication will make available to the proposed Library the expertise of experimenters across all of the social sciences.

The Web-Lab Library solves the problems of cross-cultural research because, unlike current practice, experiments using the Library need not be carried out on a college campus. Subject populations can be widely distributed. So theory testing need no longer be limited to a population of college students. More diverse groups can be included; subjects can be in any set of locations with web access. With software on the web and virtual reality headsets, for the first time social science laboratories will become fully portable, optimizing geographical reach and maximizing the diversity of populations included.

The Web-Lab Library promises to revolutionize cross-national experiments. Because the world-wide-web extends across national boundaries, it will be easy to include subjects from many countries in one experiment. For example, bargaining studies can pit Swedes against Japanese and Colombians against Egyptians with information on each subjects' screen being in that subject's language. Since the theoretical upper limit for an experiment is the number of computers with web access, market theories which demand very large numbers of subjects can easily be

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[11] Publicly archiving experimental results raises important ethical issues of fair use. Here the rights of the individual researcher and the need for scientific knowledge to be public can conflict. These issues are made more difficult by the very long publication delays typical of leading social science journals. We intend to restrict access to data to the researcher who has produced it for a period keyed to typical review times of leading journals and to grant researchers reasonable extensions when publications are delayed.

[12] The possibility of making data from classic studies such as the Ash (1951, 1956) and Siegel and Fouraker (1960) experiments publicly available is a very exciting prospect. Because these data were never recorded electronically, this proposal includes funding for keying a limited number of classic studies. Decades of status characteristics and legitimacy research at Stanford generated very large banks of data also never recorded electronically. This Web-Lab Library is dedicated to archiving those data. We will seek support separately for that and other large projects where data must be keyed from hard copy.

[13] The higher quality of experimental data is due in part to the controlled conditions under which it is collected. In addition, when electronic laboratories record subject activities automatically in real time, most of the measurement error which routinely occurs in nonexperimental research is eliminated.

tested. In fact, the Collaboratories of this research already have well established cooperative relations with a number of laboratories outside the U.S.

**Science Education and Knowledge Transfer**

Science education will be one of the greatest strengths of the Web-Lab Library. We intend to integrate research and instruction. Today most social science instruction has no laboratory component whatsoever. This is a serious problem, especially in contrast to the recent development of virtual laboratories for physical science instruction. Experimental designs of the Library are, however, real, not virtual. Students will be immersed in designs which are at the cutting edge. The Web-Lab Library promises to provide students with laboratory experiences in SBE sciences at least the equal of that found in other laboratory sciences. As soon as the inventory of software at the Library is large enough, courses can be developed in which students conduct real experiments while learning the most advanced methods in current use.[14]

As a second important resource for science education, the Web-Lab Library will house two kinds of simulation programs. First, simulations will be constructed by adding simulated actors (programmed strategies) to experimental designs housed at the Web-Lab. For example, since software for Prisoner's Dilemma experiments will be housed, the classic Axelrod study will be built, with Tit-for-Tat and an array of other strategies which were submitted. With these resources in hand, user-friendly Library software will allow students to play against selected strategies or run their own tournaments replicating Axelrod. Advanced students can submit new strategy programs to be included in the Library.

Parallel projects are possible for game theory and network exchange experiments. Bonacich, who leads our network exchange Collaboratory, has developed contrasting simulated actors for exchange networks. User-friendly software, already developed for network exchange experiments, will allow students to build networks with varying configurations and parameters into which one or more kinds of simulated actors can be placed. Students can choose to play against simulated actors from a selected network position or run the network when peopled only by simulants. Both running of tournaments and incorporation of new simulated actor programs are also possible here.

Second, already existing stand-alone simulation programs in economics and sociology can be reprogrammed for the Library in user friendly form. We already have in hand two simulation programs widely used in sociology. Power's "Crowd" studies dynamic actor spacial movements as governed by parameters under the control of the student. Markovsky's "Xnet" studies exchange networks. These programs are research tools. For example, Xnet investigations discovered "weak power" (Markovsky 1995). Sociology has scores of simulations, but economics has hundreds, though not all have pedagogical value. Those with greatest instructional value will be selected for the Library.

Because multimedia computer classrooms are already becoming the norm in colleges and universities across the nation, the Web-Lab Library can make SBE laboratory research inexpensively and widely available. Any classroom connected to the net and equipped with personal computers can run Web-Lab Library programs. When activities engaging a number of students are desired, classrooms can run the same programs actually employed by experiments using the Web-Lab. When experiments are run results will be displayed — even experimental outcomes involving the students themselves moments before. Alternatively, activities can be driven by individual

[14] In those locations fortunate to already have a laboratory facility, the impact on teaching has already been shown to be highly successful. A good example is the teaching effort at the University of Iowa where the Iowa Political Stock Market began as a class project and since has become a powerful teaching tool for economics and political science. Further examples are found at Caltech, University of Arizona, Indiana University, University of Virginia, and nearly all business schools where students participate in experiments.

students. Given user-friendly interfaces, the student can select from the library of simulation programs to investigate one of an array of SBE issues.

**Collaboratories for Building the Web-Lab Library**

This section details the activities of this proposed multi-disciplinary, multi-institutional project. There is a Hub at the University of South Carolina (USC) connected to two Collaborating Laboratories, or "Collaboratories," which are connected to each other.

Senior Investigators consist of the P.I. and coP.I. at the Hub and Leaders of each of the two Collaboratories. The Hub evaluates the performance of the Library. The Hub also builds and maintains the Web-Lab Library's website. Each Collaboratory is a research team experienced in electronic laboratories. Because social scientists are geographically dispersed, only some, not all Collaboratories are concentrated at a single location; but each location has a Senior Investigator. Collaboratories perform parallel activities which differ in substance. Each will develop Web-Lab Library software and, with the cooperation of the Hub, place it on the Web. Each Collaboratory will test its software in pilot studies.

**The Hub**: The P.I. and coP.I. at Hub, located at the University of South Carolina (USC), will administer the overall effort as well as the evaluation plan. In consultation with the Collaboratories, they will select the simulation programs to be included at the Web-Lab. The P.I. and coP.I. will lead in developing laboratory components for courses in sociology and economics. The Web-Lab server will be located at the Hub. Reporting to the P.I. and coP.I. are the hardware staff responsible for the server's functioning, the system administrator who will have major responsibility for archiving previous research and the administrative assistant.

Also located at the Hub will be programmers who will report to the P.I. and coP.I. They will be assigned the tasks of developing modular architecture for the Web-Lab Library, solving problems of compatibility between this architecture and underlying programming languages, and developing systematic data storage and retrieval. They will also have responsibility for reprogramming the simulation programs and installing them in the Library. An important responsibility of the programmers at the Hub is their work with the graduate assistant programmers. The programmers at the Hub will supervise and assist graduate assistant programmers in their programming work for the Collaboratories.

**Sociology Collaboratory for Network Exchange**: Michael Lovaglia, Iowa. In cooperation with Willer at the Hub, this Collaboratory places network exchange software on the Web. The first task is to reprogram Willer's ExNet II into JAVA and place it on the Web. This professionally developed software system is the first in which experimental subjects use only mouse control to negotiate, can act collectively against power structures and where resources can move throughout the network. The Web-based system, ExNet III will continue and extend current design characteristics. Subjects will continue to use only mouse control to send offers, counteroffers and make exchanges. Since displays have proven to be quite intuitive for subjects, the new version will display the network of exchange relations similarly.

Reprogramming for the Web offers the opportunity to incorporate important advances on current capabilities. Currently, the size of networks to be investigated is limited by the number of relations and nodes which can be displayed on each subject's screen. The Web-based ExNet III will eliminate that limitation, allowing subjects to move the screen view right/left/up/down to scan across much larger networks. ExNet II experiments have shown that subjects can form coalitions which are effective at countervailing power. The coalition designs now in place are far too restrictive, however. Currently, subjects choosing to join a coalition 1) must share the resources gained in exchange and 2) may coerce subjects who prefer free riding to joining the coalition. For ExNet III, experiment-

ers will be able to select either sharing or coercing (or both). Adding new conditions, like side payments, adds further flexibility.

More fundamental changes are planned. ExNet II resources are always private goods, but ExNet III will also allow collective goods to be transmitted and received. For example, as Stokman and Willer (1996) have shown, an exchange network contains a collective good "x" if the transmission of x from A to B necessarily transmits x also to C and similarly for A's transmission to C. That collective good produces the following problem: since both receive the good if either does, B and C both prefer the other to pay for it. This is a well known collective action problem and we hope to gain new insights into its solution by investigating it in a network exchange context.[15]

In all, four electronic laboratory systems have been used to investigate exchange networks and all will be placed on the Web. The other three are: The University of Washington's developed by Yamagishi, Iowa's developed by Markovsky, and UCLA's developed by Bonacich. These three systems will be easier and quicker to place on the Web than ExNet II. All three restrict information to the subject's own exchange relations so the network is not displayed on subjects' screens. Subjects use keystrokes to enter offers and complete exchanges. To optimize comparisons among systems, in ExNet III experimentalists will be able to restrict information available to subjects to correspond to each of other three systems. Once all are on the Web, exactly the same subject populations can be investigated under contrasting system conditions aiding the evaluation of theories of exchange.

**Economics Collaboratory at Georgia State University:** Ronald G. Cummings, GSU Collaboratory Leader; Laura Osborne (GSU); Michael McKee (University of New Mexico). This Collaboratory will focus on institutional experiments relating to environmental damage assessment. GSU research is intended to overcome limitations of previous work based on the Contingent Valuation Method (CVM). For CVM, respondents give their valuation of changes in environmental goods, such as reduced air pollution and oil spills; these valuations are purely hypothetical. Since no goods are delivered and no payment is collected, the incentive compatibility nature of CVMs is open to considerable question.

GSU will investigate the many institutional dimensions of measuring instruments like CVM. For example, the framing of the hypothetical payment vehicle could be either as a tax or as a lump sum payment. The provision vehicle for delivery of the environmental good could be unidentified or specified in detail. The valuation question itself can also have many different forms, such as a pre-specified dollar amount with a take-it-or-leave-it option or a more open-ended format of the kind: "How much would you be willing to pay?". An additional important dimension is whether the question concerns the avoidance of future damage to the environment, or a compensation for damage that has already occurred.[16]

The testing of these institutional dimensions and the effect institutional choices have on responses have previously been performed in the dedicated electronic laboratory at GSU. In many instances these tests have been performed under conditions where the good being evaluated has actually been delivered to the subjects conditional on their evaluation, implying an important incentive element. Responses given under conditions where the goods are delivered can then be compared to responses given under conditions where no good is being delivered, i.e. where the

[15] None of these changes will reduce or eliminate flexibility now a part of this software. For example, as now configured, the value of each exchange relation can be set individually. Since predicting exchange ratios for networks with varying exchange values is a new area of theory competition (Bonacich and Friedkin forthcoming), this capability will carry over.

[16] Ronald G. Cummings and collaborators are already well published in this field. See, for example, Bjornstad, Brewer, Cummings, and McKee [1997], Bjornstad, Cummings, and Osborne [1997], Cummings, Harrison, and Rutström [1995], and Cummings, Elliott, Harrison, and Murphy [1997].

delivery is only hypothetical. In other instances comparisons have been made across situations where delivery condition is the same, namely hypothetical, but the framing of the question varies.

Moving these electronic survey instruments to the Web-Lab Library could be done very easily. The decomposition of players into a modular architecture will be straightforward, involving instructional and message modules only. A major benefit of putting this type of experimental research on the web is the expansion of the subject pool. Currently the pool is primarily GSU students, but placing software on the Web will allow expansion to include students at other universities in the US and abroad. Links with other universities have already been developed in Mexico, Russia, South Africa, and China. Finally, researchers not currently linked to the GSU collaboratory will benefit from the availability of this software at the Library.

**Socio-Economics Collaboratory at the University of South Carolina:** Elisabet Rutström, USC Collaboratory Leader; Björn Jawerth, Terrance Huntsberger, Glenn W. Harrison, Shane Thye and David Willer. The USC Collaboratory will focus on the theory of rationality and self-interest in exchange and market situations. The four major divisions of this research are: bounded rationality; equity, justice and fairness; framing; and valuation/influence. Because research interests of the collaboratory members at USC overlap research interests of the Georgia State Collaboratory (Cummings, Harrison, and Rutström 1995, Rutström 1998, and Harrison 1990) and the Collaboratory for Network Exchange, the USC Collaboratory will participate in cooperative software development and pilot studies.

The common theme for the research at the USC Collaboratory stems from questions of bounded rationality, the departure from assumptions of perfect rationality common to economic and rational choice theory. Decision making situations which are very complex require the adoption of heuristics to speed information processing and guide decisions. Web-based auction institutions will, for example, allow the investigation of Harrison's (1989) hypothesis that the use of biased heuristics by bidders in auction experiments gives the appearance of irrational behavior when subjects face decisions with low reward levels. McDaniel and Rutström (1998) focus directly on the properties of cognitive processes and how these relate subject reactions to changes in reward levels. The software-based institution they use is not interactive and can very easily be added to the Library.

Rutström and collaborators[17] have also investigated preferences for fairness in interactive environments, such as bargaining and income sharing. Many experiments find that subjects do not appear to behave in a self-interested manner. Minor deviations in institutional design and in framing, including the terminology used, lead to significant variations in behavioral response. The Web-Lab Library will allow the large samples and important cultural and national variations needed for these investigations.

Willer's program of research in network exchange (cf. Willer and Markovsky 1993; Willer and Skvoretz 1997a&b) will continue as the driving force in the development of the ExNet II & III systems as described under the Collaboratory for Network Exchange. In addition, Thye and Willer will cooperate to develop software to investigate the effects of influence and valuation on exchange ratios as suggested by links they have drawn between elementary theory and status characteristics theory (Thye forthcoming; Willer et al. 1997).

**Goals**

With the development of the Web-Lab Library, we intend nothing less than a fundamental change in the way knowledge is acquired in the social sciences. As the experimental designs in the Library are built up, we expect the experiment, too long at the periphery, to become the central method of the SBE sciences. The immediate result will be a substantial increase in the precision and scope of social science theory and a corresponding increase in its

[17] See, for example, Rutström and Williams [1998] and McDaniel, Rutström and Williams [1994].

utility in application to the economy and society. Changes of the same order are intended for social science education. Because these are substantial goals, we are requesting three years of support. The steps toward these goals by year are:

**Year 1**: For the first year each Collaboratory will choose one experimental design and install it in the Web-Lab Library. For example, The Network Exchange Collaboratory will install ExNet II and the Status Organizing Collaboratory will install the "Standardized Experimental Setting." These projects, which will not use a common approach or programming language, will be the testing ground for the programmers and Collaboratory - Hub organization. To test for bottlenecks along Internet links, each Collaboratory will serve as a remote site for experiments controlled by a second Collaboratory. Collaboratories and the Hub will develop standardized formats for archiving. Work begins placing simulations in the Library and extends through the five years planned for the Project.

**Year 2**: In year 2 we will develop a common, flexible approach for posting experimental design modules such that modules assembled from an array of experimental designs can easily be combined into new designs. Web-Lab Library archiving of data from current and past experiments will begin. Courses at the Collaboratories in experimental sociology and economics will begin using Library designs. Using the same designs, graduate students, supported by this project, will replicate previous research.

**Year 3**: Programming will now use the common modular architecture. The Collaboratory at Georgia State will provide modules for designing general preference elicitation experiments. The USC Collaboratory will provide individual choice modules, as well as modules for normal form games and two-person bargaining games -- and similarly for the focal concerns of each other the Collaboratories. Automatic archiving will be on-line.

**Evaluation Plan**: The evaluative procedures proposed here focus on the Web-Lab Library's central quantity goals, to foster substantially more experimental research, extend the use of experimental research data-bases, and substantially expand the laboratory component of social science education.[18]

1. Annually the members of the Economic Science Association will be electronically surveyed using the membership directory at its website. The Association includes effectively all experimental economists.[19] We will seek quantitative and qualitative information on their overall experimental research activity of the year -- how many experiments each has run on what issues with how many experimental subjects -- and what part of this activity used Web-Lab Library resources.
2. Annually members of "Group Process" will be similarly electronically surveyed. "Group Process" is an informal association which meets annually in conjunction with the American Sociological Association and includes effectively all experimental sociologists. For the survey we will use the E-mail listing we have in hand to be posted at the Web-Lab. Information given by scholars logging into the Web-Lab Library will allow us to routinely update listings of sociologists and others to be surveyed.
3. Annually the number and value of the grants for experimental research in economics and sociology by the National Science Foundation will be found. Information from our two surveys should allow us to determine the contribution of the Web-Lab Library to grant activity.
4. A count of publications by Collaboratory researchers is a further indicator of Web-Lab Library activity. Unlike physical sciences, in sociology and economics it is not unusual for a paper appear many years after

[18] Yearly performance goals are given in Section 5.

[19] Economists who experiment only infrequently will not identify themselves as experimental economists and may not be members of the association.

it was first submitted to a leading journal. To gain a more up-to-date count of the products of Web-Lab Library research, working papers will be posted and numbers of paper down-loads will be counted.

5. The Web-Lab Library itself will count and track the evolution of the number of its users. Counters for each part of the Library, together with information given by users when logging in, will allow us to differentiate kinds of uses including data-base investigations, experimental research, experiment education, and running simulations.
6. As the number of education users builds up, annual electronic surveys will seek information on course development and plans of study, some of which will be posted in the Library. Activity counts will aid evaluation of the Library's impact on social science education.

**Survivability of the Web-Lab Library**: The University of South Carolina is committed to maintaining the Web-Lab Library's website for its useful life. Therefore the Library will survive beyond the proposed funding period. We are committed to seeking continuing funding, however, so that the Web-Lab Library can continue to grow as a vital center for knowledge development in the SBE sciences.

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