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The Allure of Wireless: Preliminary Report on a Trial of PCS Telephony

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EXECUTIVE SUMMARY

A field trial of an advanced form of cellular technology (PCS) provided the context for behavioral research on wireless, portable telephony. We describe here a study at Carnegie Mellon University of how 100 participants in the trial learned, used, and felt about wireless communication, and we provide some preliminary information about future demand for this technology and its potential social implications. Our data from surveys, interviews, and diaries of communications permit comparisons of face-to-face, telephone, email, and facsimile communication in offices, buildings, outdoor and public places, cars, and homes. Three departments participated in the research to allow for an estimate of group effects and of how wireless might be used when many people have access to the technology.

Should wireless technology be taken to a broader consumer market? Our data suggest very strongly the answer is "yes." Participants in this trial were not only enthusiastic about trying the PCS phones, but they quickly came to rely on them (5-12 calls a day). They depended on them especially for family and personal emergencies, and for keeping in touch in crisis situations at work or in the family. They became attached to them as personal possessions, "like a wallet" or even "a part of my anatomy." Participants used their PCS phones for work and social purposes in as many locations as we could think to ask them about—on the grounds of the university, in restaurants, friends' homes, stores, airplanes, parks, and construction sites. The patterns differed within each group, suggesting that the technology is a flexible one that adapts to many styles. The patterns also suggest, however, that to be successful in addressing the general consumer market, wireless communications must have broad coverage, and adequate capacity. The original business model for cellular, which envisioned it as a high cost service used by only a few (predominately wealthy businessmen), may have been appropriate in the past. Our study suggests there is a large part of the public who would use wireless if the industry and the FCC commit to making the spectrum and the infrastructure available, and the service evolves, as wired telephones did, towards access for many people at a low price. More research is needed on the use and usability of wireless to insure that these investments are directed in ways that will maximize user satisfaction and insure the success of these investments.

Few of the participants in this research were previous cellular users; they were more typical of the U.S. consumer than actual cellular consumers of today. Our participants expected their PCS phones to be as easy to use and to learn as their wired telephone service at home. They encountered problems. A simple example: the "send button" is red, which in this

culture indicates "stop." Sales representatives predicted it would take novices 13 minutes to learn voice mail, but novices in advanced degree programs actually required 33 minutes to learn it. (We conclude experts cannot "disremember" their expertise and imagine the difficulties and uncertainty faced by novices.) Participants did not use functions or services they thought would be useful but found hard to use. Since usage of the phones generally was found to correlate with usability, investment into usability design, research, and testing is indicated if wireless communication is to be brought to the general consumer market.

Preliminary analyses of participants' attitudes and communication behavior suggest that wireless communication could lead to changes in work and personal life. The advent of more communication access for more people is an advantage, but only when people feel they have some control over who they are connected with. Our participants are particularly concerned with the intrusion aspect of privacy. They may want to call "anyone, anywhere, at any time" but they do not want wireless calls from "anyone, anywhere, at any time." Technological applications may improve the buffer between people and others, but thus far they work imperfectly. (In our study, only 2% of the participants used the call screening services offered.) There is also a need for a better understanding of how technology, organizational policies, or etiquette can help people deal with the explosion of communication access in our society.

Wireless communication seems likely to increase people's mobility and flexibility, and possibly to further blur the distinction between workplaces and social places. Our data show that participants, after the introduction of PCS phones, had more work communications at home and in other social places and that they had more social communications in offices and other workplaces. These changes have implications for how organizations manage employees and for how individuals manage their own lives. As with other secondary (side effects) of technology, such changes are hard to predict but can be leveraged for greater organizational effectiveness and quality of life.

INTRODUCTION

This report describes a study of how 100 people are using an advanced form of wireless (cellular) portable telephony, sometimes called "personal communications service" or PCS.[1] The purposes of this study were, first, to examine preferences for portable telephony based on trial participants' experiences; and second, to gain a preliminary understanding of the social implications of wireless communication technology, especially how this technology might change people's mobility and their communications in work, management, and social relationships.

The context of this study was a technical and marketing trial of PCS-type technology conducted by Bell Atlantic Mobile Systems, Inc. (BAMS), with cooperation from Motorola, Inc., in Pittsburgh, Pennsylvania during 1993 and 1994. As part of the trial, Carnegie-Mellon University (CMU) and BAMS formed a joint venture to carry out behavioral research with a subgroup of participants—staff, faculty, and students at CMU. The joint venture focused on aspects of PCS technology that are particularly suited to university research, such as the privacy implications of PCS, the usability issues, and how the technology affects people's social relationships and work.

This study took place in a time of technological, organizational, and marketing innovation in wireless communications. No one knows what wireless communication products and services will be offered in the future, who will sell them, how much they will cost, and how they will be interconnected with other communication technologies. This PCS trial was limited to person-to-person communications using analog technology and did not include, for instance, wireless digital data communications, broadcast, or information services. Because the demand for technology and its place in the social fabric depends on the nature of what is being supplied, this study provides only a preliminary analysis of the potential demand for wireless technology and of its role in work and social life .

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[1] The term used to describe this trial technology was "personal line service." PCS is a more general term referring to cellular service employing many more receiving and transmitting stations than now exist for cellular. The increase allows for lower-power transmissions and smaller handsets. PCS also sometimes refers to the idea of one easily-toted phone that will work everywhere, allowing people to have one number for work and personal use.

To our knowledge this has been the first behavioral study of wireless communication that compared people's use of wireless technology with all their other ways of communicating. Comparative studies have a great advantage over studies of one or a few technologies because they allow us to look at how using one technology affects the use of other technologies. For instance, one question we asked was whether access to portable wireless communication might increase mobility, and as a side effect, increase face-to-face communication outdoors, in cars, or in public settings. Increased mobility could have important business and social implications that we detect only in a comparative study.

This study also gives us a picture of how users themselves might affect innovation and development in wireless technology. What do users like and dislike about this trial technology? A lesson from the history of communication technologies—telephones, computer-based email, facsimile, and so forth—is that people's response to technologies affect developments of the technology. The business historian JoAnne Yates describes how, in the 1890s, Prudential Life Insurance company rejected Herman Hollerith's punch card tabulating equipment (a precursor of the computer) because its sorting function was too slow. Prudential's actuary, named John Gore, decided to develop his own sorter. Hollerith responded by developing a superior sorter to work with the Hollerith tabulating equipment, and eventually his company won over users and became the successful core of what is now IBM (Yates, 1993). Claude Fisher's (1994) research on the history of telephone also tells a story of users' influence on the technology. Early in this century, telephone companies sold phones as a business tool. To prevent overloading exchanges, vendors tried to discourage women from calling friends and family "unnecessarily." Consumers' unrelenting desire for personal connections caused telephones to be developed and regulated as a universal consumer good. Similarly, portable wireless telephony already seems to be following a pattern of co-evolution of technology and user behavior.

This report has 4 sections. In the first section we describe the trial and our research methods. In the second section we describe participants' initial experiences with PCS phones—how they learned to use them, their early decisions to stay in the trial or not, and how they solved or alleviated problems using the technology. We also discuss differences among work groups and people at different levels of management. In the third section, we present participants' attitudes about PCS technology, including their self-reports of usage and their feelings about the advantages and disadvantages of the technology. Participants in this study completed diaries, or logs, of all their communications during a 24-hour period before they received PCS phones and again after they had used them for about 2 months. In

the fourth section we examine pre-PCS and post-PCS changes in social behavior, including where participants were located when they communicated with others, and how they used different technologies to communicate in their work and personal lives.

THE PCS TRIAL

Discussions about a trial of PCS technology began within BAMS in 1992, and became feasible when the FCC approved the use of spectrum for a Pittsburgh trial as of August, 1992. At the time, BAMS envisioned the trial as a sales or marketing trial to demonstrate the viability of PCS as an advanced form of cellular service. The spectrum and infrastructure available for cellular communication in 1992 was limited; cellular vendors allocated supply by offering cellular at a high price. In Pittsburgh, Motorola's MicoTAC listed for $669.00. Subscriptions for service, not including charges for calls themselves, were approximately $30.00 per month, but average monthly bills for cellular service and calls approached $80-100. At the start of this trial, cellular telephony was mainly confined to entrepreneurs and highly-placed managers or professionals (such as physicians) whose company paid the bills or who could count cellular bills for tax purposes as a business expense. More than 80% of cellular calls were for business. Articles on wireless in the press generally emphasized upper-income consumers and business uses, and envisioned somewhat low usage, about 100 minutes a month (see for instance, USAir Magazine, 1992). BAMS managers and especially its sales and marketing staff envisioned PCS as an extension of cellular for existing cellular business customers. A 1993 BAMS color brochure to advertise the trial pictured a surgeon, realtor, construction engineers in suits and ties, an attorney, and an insurance adjuster—also wearing a tie. Healthy demand might convince the FCC to allocate more spectrum to individual use, but at the time there was little discussion of wireless communication as a universal consumer good.[2] In our study, however, we did not make assumptions about market segmentation.

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[2]The history of cellular helps to explain the current situation (Marvin Sirbu, personal communication). Cellular was originally conceived some 20 years ago as a way to better support car telephones. Because of regulatory delay, the service did not get off the ground until 1983. When it did, the car phone was a 1970s model that assumed phones would be large and heavy, and that they would mostly be used in cars which had the battery power and could carry the weight. The technology traded high capacity for the ability to work well when the caller was driving at 60 mph. Semiconductor advances made "personal phones"

The PCS trial was introduced in Pittsburgh in January, 1993. At a special subscription price of $25.00, consumers could join the trial. A complete set of equipment to the customer included: Motorola Micro TAC Lite handset with internal lock, small (1 hour) and large (8 hours) battery, plastic belt carrying case, fast charger and adapter, overnight charger and adapter, base station with antenna and adapter to be attached by a phone cord to the home (and/or office) telephone, for automatically forwarding incoming and outgoing calls through

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possible. About 1987, the industry began to see that small, lightweight "personal" phones would be technically feasible by the 1990s. It also saw explosive growth in the use of cordless telephones and so-called "transportables" (bag phones). These changes convinced many in the industry that there would be a market for personal, as opposed to purely automobile-oriented, wireless phone service. To attack that market, however, the companies needed to make many changes to both the technology and the business model. For example, under the car model, you could assume a relatively high power phone with a heavy battery and cell diameters measured in miles. A personal phone would have to be smaller, with a smaller battery, which means cell sizes should be less than a mile because the phone doesn't have enough power to transmit as far. Other changes to the technology meant seeking more spectrum from the FCC, developing digital cellular that could handle more calls in existing frequency allocations, and figuring out how to reduce the cost of cell sites so you could afford to build thousands in a city rather than dozens. Some in the industry believed that so many changes meant you needed to start over in a new band of spectrum to design a new service optimized for individuals that could be offered at low cost. This meant waiting for the FCC to allocate spectrum. Others thought there might be a way to migrate existing cellular systems—for example, by building dual function phones that used both older analog and newer digital technology—which the first group argued would be too expensive. In 1994, both groups may get a chance to prove their theories. The FCC is preparing to auction off more spectrum (about twice as much as is already allocated to cellular), but since the cellular companies are excluded from bidding on most of it, they are trying to evolve their own technology to handle personal phones. In the event, expansion to a broad market will require further investment in the technology, including the infrastructure required to carry calls from many people and address public concerns about access, privacy, and intrusion. The industry's infrastructure challenges are very diverse, much like those of early telephone vendors. (And it is unlike that of other "public" technologies, most notably, the automobile industry, which did not have to build roads and highways, pay traffic cops, or teach students in schools how to drive to reach the average consumer with affordable cars!).

the home phone when the customer was at home, and a number of parts needed for a car installation that would permit charging in the car and hands-free talk (see Figure 1). Network "intelligent" services would be included such as automatic forwarding to a base station (whereupon the handset is used as a cordless phone), memory dialing, and for an extra fee of $16/month. voice mail, 3-way calling, "one number" service, and real-time call forwarding and call waiting. Another $6/month would buy selective blocking, the use of a PIN number for locking and unlocking the phone, and pre-determined call screening. (Because of the Pennsylvania regulations in effect at the time, caller-id was not available.) The aforementioned prices did not include installation of the car unit, per-call charges, charges for roaming, and long distance charges.

At a few organizations, BAMS arranged for multi-person participation in the trial, and the company installed Motorola "micro-cells" to register calls and reduce the load on its existing macro-cells.[3] Functionally, the PCS trial differed from existing portable cellular service primarily in its automatic forwarding and hand off of calls from cellular to microcells and to base stations at work or home, where the handset would automatically become simply a cordless telephone on the customer's wired telephone service. This would make possible using the same handset everywhere, payment of reduced fees (since hand-off was always to the least expensive service), and "one telephone number" whereby all calls might be forwarded to the PCS line (or its voice mail).

Managers from BAMS approached CMU in the summer of 1992 about participation in the trial. At the time only a few persons at CMU had cellular telephones, mainly high-level

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[3]"Cellular" refers to the macro-cells or broadcasting units that transmit calls 1 to 10 miles through the radio frequency. Cells relay calls to other cells or to a mobile switching office or to the local phone company. Microcells are like other cells but they are smaller, have reduced power, and are less expensive. When an area is covered with multiple microcells rather than one large macrocell, there is more reuse of spectrum in nonadjacent microcells. Spectrum reuse provides additional capacity at the same power, which supports more usage in heavily used sites. Cellular handsets also automatically use less power when they are used in closer proximity to cells. Since there are more microcells per unit of area than macrocells, people are more likely to be calling close by to a microcell than to a macrocell; hence they use less power in making calls, which lets them use their batteries longer before having to recharge them.

administrators (e.g., the head of computer science and the business affairs director). Installing micro-cells at CMU would afford BAMS technical experience and access to faculty and staff who were interested in research on wireless communications. CMU proposed a subsidized trial for university participants that would ask: If PCS were available at little cost except being a subject in a research trial, who would want to use it and for what purpose? What problems and advantages would people encounter? BAMS agreed to install micro-cells on campus and to subsidize participation in the PCS trial for 100 CMU staff, faculty, and students. BAMS incurred the direct costs of all equipment and installation and the costs of cellular service; CMU provided staff from Computing and Communications Services and Physical Plant, space on campus for microcells, and faculty and graduate student researchers. Participants donated their time by filling out surveys, keeping diaries of their communications, and submitting to interviews.

Research Design and Method

The main site of the research trial was Carnegie Mellon University, located in the east end of Pittsburgh, Pennsylvania (pop. 380,000). The university has approximately 680 full-time faculty, 2,277 full-time staff, 478 part-time faculty and staff, and 7,000 undergraduate and graduate students. The campus is approximately 100 acres and contains 54 buildings.

Participants. To simulate an environment of the future, in which many people would have access to wireless, we did not select individuals randomly or ask for volunteers. Instead we sought the participation of departments with a high need for internal coordination. By enrolling departments, we could observe how entire work groups responded to the technology. We approached three departments at the university about participation in the trial and all readily agreed to participate.[4]

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[4]The PCS technology for this trial, unlike technologies such as desktop video or the video phone, has the great advantage of two-way interconnection with the existing wired telephone network. Anyone using a wired phone can call a PCS phone, and the PCS caller can reach anyone on another PCS phone, another cellular phone, or a wired phone. Therefore for purposes of the trial, we had no need to build a "critical mass" of users for PCS to be useful in connections people wanted to make.

University Relations: This department handles public relations, relationships with the press, special events, and publications and printing for the university. Employees must coordinate their work for many internal and public releases of information, especially when publications and events involve several university departments and colleges. The background of most of these employees is in journalism and publishing or liberal arts. Public relations staff "live with" the people they write about, so at the time the trial began they were scattered in offices in 12 different buildings on campus. All 23 members of the management, public relations, and special events staff of university relations were invited to participate in the study. Another 42 staff in the university publications and printing division were not part of the study initially. However some of these staff are highly mobile and coordinate their work with other members of University Relations. Therefore, when 4 PR staff dropped out after the "cancer scare" news on cellular phones, we replaced them with participants from the publications and printing division. The final sample includes staff at five levels of organizational authority, from those with no supervisory responsibility to a senior vice-president.

Computing and Communication Services ("Telecom"): This department, with 80 employees, develops and operates the computer network and telephone systems in the university. A majority of the people in this department have technical electronics training or are computer hardware or software professionals. At the time the trial began, the Telecommunications division (11 staff not including 3 telephone operators) was installing a new telephone network on the campus. Because Telecommunications staff were working in buildings all over the campus and highly mobile, that group seemed an excellent prospect for the study. The Data Communications division (10 persons) and Network Development group (4 persons) had to coordinate changes in the telephone network, so they were invited to participate also. A total of 25 staff plus 3 administrators participated in the study. The final sample includes staff at five levels of organizational authority, from field staff with no supervisory responsibility to a senior vice-president.

Drama: The members of the academic department of drama include its 25 faculty and 13 staff who coordinate and instruct students in theater and television productions and have titles such as "shops supervisor" and "costumer." The department presents as many as 15 productions a year that are open to the public and university community. Preparing for a drama production entails considerable mobility on and off campus and real-time coordination against immovable deadlines. When we first talked with Drama staff, the staff and students in charge of dramatic productions already used beepers and, in a few cases, car phones, to

coordinate their work. We invited the department to participate in the trial, allocating "permanent" trial PCS phones to the associate department head and 10 faculty and staff involved with productions. Another 15 PCS phones were allocated to the graduate students in charge of productions at the beginning of the development of the production, and then rotated to new production managers when productions had finished their runs. The sample includes staff at four levels of organizational authority.

Researchers: Once most of the PCS equipment was allocated to the groups described above, the remaining equipment was made available to faculty and students in a policy analysis course and courses on networking and wireless technology, and to faculty and graduate students doing research in the trial. Sixteen researchers used the PCS technology for sufficient time to complete the survey on their use and attitudes, but researchers did not participate in the diary studies.

Data Collection

To examine changes in behavior and attitudes, we employed a pre-post research design. Data were collected before and after the trial from surveys, interviews, and diaries of communications. Additional data were gathered in a separate experiment on usability and from messages posted to the computer bulletin board set up for trial participants. The order of data collection was as follows.

	Month 0	Month 1	Month 3	Month 4	Month 5	Month 6
Short survey, diary & interview	x			x		
PCS distribution		x				
Survey			x			x

We used surveys, interviews, and diaries of behavior because they each have different advantages. Surveys are efficient, but people tend not to introduce information that isn't asked on the survey. A source of bias in any retrospective survey is that people tend to give "good stories" to explain their behavior. For instance, those who abandon a new technology will tend to report experiencing more defects and problems than those who continue to use it, even though both groups may have had the same experiences. (Retrospective bias is an even

more serious bias in focus groups, because people self-select questions as well as answers.) We used diaries of behavior and interviews held the day after the diaries to estimate retrospective bias in the surveys. We also used interviews to check on errors in the diaries and to gather sensitive information that is generally difficult to gather in diaries.

Diaries are done at the time (or shortly after) people's experiences, so they are less influenced by retrospective bias. However, diaries require attention and work, especially when they are supposed to log events throughout the day. People are likely to make mistakes, to get tired, and to lose motivation to be comprehensive and accurate. Because of the effort required, we asked participants to log all their communications for only two 24-hour periods, once before and once during the trial. Because participants might have felt apprehensive about revealing so much of their lives, we told them to write only "personal" whenever they had a sensitive conversation.

Pre-PCS Data. Researchers held face-to-face meetings to explain the trial with participating departments in late January, 1993. At those meetings, trial participants completed a survey of their current uses of communications technology and signed informed consent statements. On the day after their meeting, participants kept a diary or "log" of all of their communications for the next 24 hours, including conversations outside of work, at home, in the car, and in all other locations. They were to log everyone with whom they communicated whether colleagues, friends, family, or strangers. Everyone in the same department was to keep a diary on the same day, so that data from both senders and receivers of the departments' communications would be available for analysis. Participants keeping the diary indicated the time of each communication; whether the conversation was in person or what technology they used; whether they were the "sender" (or initiator) or "receiver" of the conversation, call, or message; whether the communication was a reply to a previous communication; the name of the person(s), whether in the same department or not, whether more than 2 people were included (e.g., a meeting or group email), and where they were located at the time. Participants also indicated whether the communication included good or bad news, and they made notes on the log sheet about the content of their communications so they would be able to recall the topic when interviewed.[5]

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[5]Researchers may obtain copies of the diary instruments from the authors at CMU.

The day after participants kept their communication diaries, a researcher interviewed them privately 20 minutes to one hour. The interviewer asked the participant if the diary reflected a "typical" day and to discuss each logged conversation or message. The interviewer asked the participant to rate the importance of each communication listed in the log using a 10-point scale (where "10" was "very important and "1" was "not important at all"). Then the participant indicated the urgency of each communication (0 = not urgent, 1 = urgent) and whether he or she would have liked more privacy (0 = no, 1 = yes). The rest of the interview concerned participants' attitudes about their telephones.

Distribution of PCS. When pre-PCS data had been collected from every participant in the department, another group meeting was held. BAMS marketing and sales staff attended this meeting to distribute PCS equipment, instruct participants on its use, answer questions, and collect information from participants (such as address and home telephone number) to register them in the trial. Figure 1 (shown in the next section) shows the box and equipment given to each participant. At the meeting, trial participants also received written instruction booklets for use of the handset, for voice mail, and for roaming; a special cellular phone number to call for service and the PCS telephone number of the marketing manager, and the name of a computer bulletin board at CMU where they could post comments about the trial.

Post-PCS Data. Approximately 8 weeks after participants had been using their PCS phones, they were given a long survey (more than 100 items) to assess their attitudes and self-reports of their communication behavior and their work and social use of communications technology. Some items on this survey were included at the request of the students in the policy analysis course to be used in their report. The timing of this survey was determined by the need to collect data for the students to use in the spring semester.

Approximately 10 weeks after participants had begun using their PCS phones, they kept another diary of all their communications for 24 hours. The logging task was identical to the pre-PCS logging task, except that participants recorded PCS calls as well. The day following the diary, a researcher interviewed participants. The interview was the same as the pre-PCS interview, except for added questions about attitudes about the PCS phone and social communications.

Response Rates and Reliability of Data

Table 1 shows the distribution of participants in the trial and the response rates for the main sources of data. The response rate for the survey (percentage of those who were asked to

complete the survey who actually did so) is 98%. The response rate for the logs and interviews is 85%, including people who were out of town, ill, or attended funerals. To estimate the extent to which the groups that completed both pre-PCS and post-PCS diaries of their communications are comparable to the total group of participants, we compared the survey responses of that group with those who completed the survey but only one or no diaries. (The latter group includes all of the researchers.) We found no statistically significant differences, which suggests that participants who completed diaries are like all trial participants.

We repeated several questions about telephone habits in a pre-trial survey and on the Post-PCS survey in order to estimate survey measurement reliability. We obtained a correlation of r = .88 for number of times per day the respondent accesses email (the mean was greater than 7 times a day!). Other repeated items were whether another person (secretary or receptionist) screens phone calls (r = .84); whether other person screens email (r = .86), whether participant has unlisted home number (r = .84), whether the participant has call waiting (r = .81), uses *69 to find out who called (r = .50), and uses 3-way calling (r = .50).[6] Too few people (3%) used call blocking or call forwarding telephone services to calculate reliability coefficients. The introduction of a voice mail system at CMU caused some participants to switch to voice mail from a desk answering machine. Hence there were lower correlations on these items from pre-trial to post-PCS surveys: number of times per day person accesses voice mail (pre-PCS = 2.85, post-PCS = 3.05, r = .49), uses answering machine to screen calls (pre-PCS = 43%, post-PCS = 49%, r = .48).

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[6]The correlation is reduced because *69 and 3-way calling is done infrequently.

Table 1. Participant and sample sizes.

	Number persons offered PCS	Number persons in the trial	Left CMU during 1st 6 months[a]	Returned PCS during first 6 months	Completed survey[f] (response rate)	Completed pre- and post-PCS diaries and interviews[f]
University Relations	27	26	0	5[c]	30 (30/31)	23 (23/31)
Computing & Commun. (Telecom)	29	28	2	3[d]	25 (25/26)	25 (25/26)
Drama						
Faculty/ staff	12	11	1	1[e]	11 (11/11)	10 (10/11)
Students	15[b]	15	n.a.	0	8 (8/8)	
Researchers	17	20	n.a	n.a.	16	n.a.
Total		100	3	9	90	58

[a]Participants who left the university were asked to return their PCS equipment. When possible, employees who replaced them were given the same PCS equipment.

[b]PCS equipment for students was rotated to those students who were directors and production managers of developing productions. None of the Drama graduate students participated in the trial long enough to complete both diaries.

[c]Of the 5 returns in University Relations, 4 were for "health" concerns raised by news reports of a suit of a cellular user against Motorola after he acquired brain cancer. One person returned the PCS phone because she did not use it.

[d]Of the 3 returns in Telecom, 1 person decided to buy his own cellular equipment, 1 person traveled to Europe and could not use his PCS phone, and 1 person was removed from the study for violating conditions of the trial.

[e]One participant in Drama returned the PCS phone because she did not use it.

[f]The survey total is greater than the number of participants because some of those who returned the PCS equipment (and were replaced with new participants) also completed the survey.

We compared certain survey self-report questions about participants' habits with the behavior evidenced in their diaries. On their surveys, participants were asked where they spend their time at work (for instance, what percentage of the time they work in their own office). We compared these answers to the distribution of locations noted by participants when they logged their communications. Although the two measures are not entirely comparable (a person could work at a location without communicating), the data show considerable consistency. Of logged communications during work hours (8 am to 5 PM, not including lunch hour), 75% recorded on the post-PCS diary were in office and work areas; the 58 participants who participated in both diaries reported on the survey that they spent 66% of their working hours in those areas. These aggregate percentages are not statistically different.

Communication estimates. The analyses above suggest our data are reliable (i.e., consistent across time and instruments), but there is evidence of incompleteness in the diaries, caused by participants failing to log all of their communications. If the diaries were comprehensive, every logged communication between two participants in the trial from the same department would have been recorded at least twice, once by the "sender" of the communication and once by the "receiver" of the same communication. For instance, when a faculty member in the Drama department recorded on his log sheet that he had a conversation with a colleague at 10 am., his colleague should have recorded that conversation. Not counting email or telephone messages that might have been sent or received on a day before or after the diaries were made, this matching was not obtained for nearly half of all communications.

We carried out a statistical analysis to evaluate whether these errors of omission occurred to the same degree before and during the trial and across modes of communication and other variables. By comparing "matched" communications (i.e., sender and receiver reported the communication) with "matchable" communications (i.e., in our judgment, sender and receiver should have reported the communication), we can estimate whether there was simply an overall incompleteness in the diaries or whether there were any systematic biases in people's logging of their communications. The results of this analysis show some biases, in particular, that participants underreported communications on their diaries more after the trial started than before it (see section 4 for more discussion of this difference). We believe also that some participants reported their PCS calls as "telephone" calls. (Calls at home through the base station or calls forwarded to the desk phone would have been experienced as wired phone calls.) We conclude the diary data underestimate usage of PCS and present

corrected estimates (in section 3) based on our analysis of matched communications and on self-reports in the surveys.

LEARNING AND USABILITY

The participants in this trial, for the most part, received their PCS handsets and PCS equipment at department meetings. Researchers and BAMS sales staff attended these meetings, and the Pittsburgh marketing director instructed participants on the use of their new phones. The meetings generally lasted 45 minutes to one hour.

Notes taken at these meetings show that participants laughed in surprise at the numerous pieces of equipment associated with PCS (12, not including the car unit) and the size and heftiness of the carton they would take with them (approximately 10 lbs). They had expected a "pocket phone" and instead lugged home a carton. (See figure 1). Participants learned at the meeting that even a "pocket" or "portable" phone requires a somewhat bulky battery (for all day use), rechargers for home and work, adapters, base stations, and special equipment for automobile hookups.

Participants used their knowledge of wired telephones to form expectations about PCS. They had not used a cellular phone and expected it to work as a wired phone does. They expected to push the "on" button and hear a dial tone; they did not expect to have to wait for the cellular connection and they did not look for a blinking light, which indicated when a connection was made. Hence participants came to PCS with an incorrect cognitive model, that is, of a "pocket" phone that nonetheless would work like a wired desk phone. As a result their first experience often was to fail to place a call. They would turn the phone off and on wondering what was wrong. Often, they would attempt to send a call before the "ready" indicator light was illuminated and would hear a loud indecipherable signal. They would look at the manual on operating the phone, but the manual did not mention the absence of a dial tone, waiting for the cellular connection, or what the error signal meant. Eventually, all participants learned to turn on their phones in the cellular mode and to place and answer a call. In each department, knowledgeable staff helped co-workers learn to use the PCS phones.

Learning

The post-PCS survey provides data on what features and functions of the PCS phones participants actually learned to use after (on average) 8 weeks. Participants completed a form asking them whether or not they had learned to use each of 11 features or services, and for those features or services learned, how they had gotten help. Figure 2 shows the percentage of each group that learned each of the 11 items. There are statistically

significant differences among the items ($F [10, 800] = 49.07$, $p < .001$), group differences in the number of functions learned ($F [3, 80] = 6.0$, $p < .001$), and an interaction effect showing that different groups were more likely to learn different features or services ($F [30, 800] = 2.79$, $p < .001$). Group differences, which reflect differences in the technical background and work of participants, were much larger than differences among levels of management, which did not differ statistically. The most notable aspect of this figure is that only about two-thirds of the participants learned the functions we thought essential to successful enjoyment of the technology (e.g., using voice mail), and fewer than half learned 4 of the 11 items (locking the phone, memory dialing, forwarding calls, and call blocking). Another notable aspect is the significant difference in learning of the technically-oriented Telecom department as compared with the other groups.

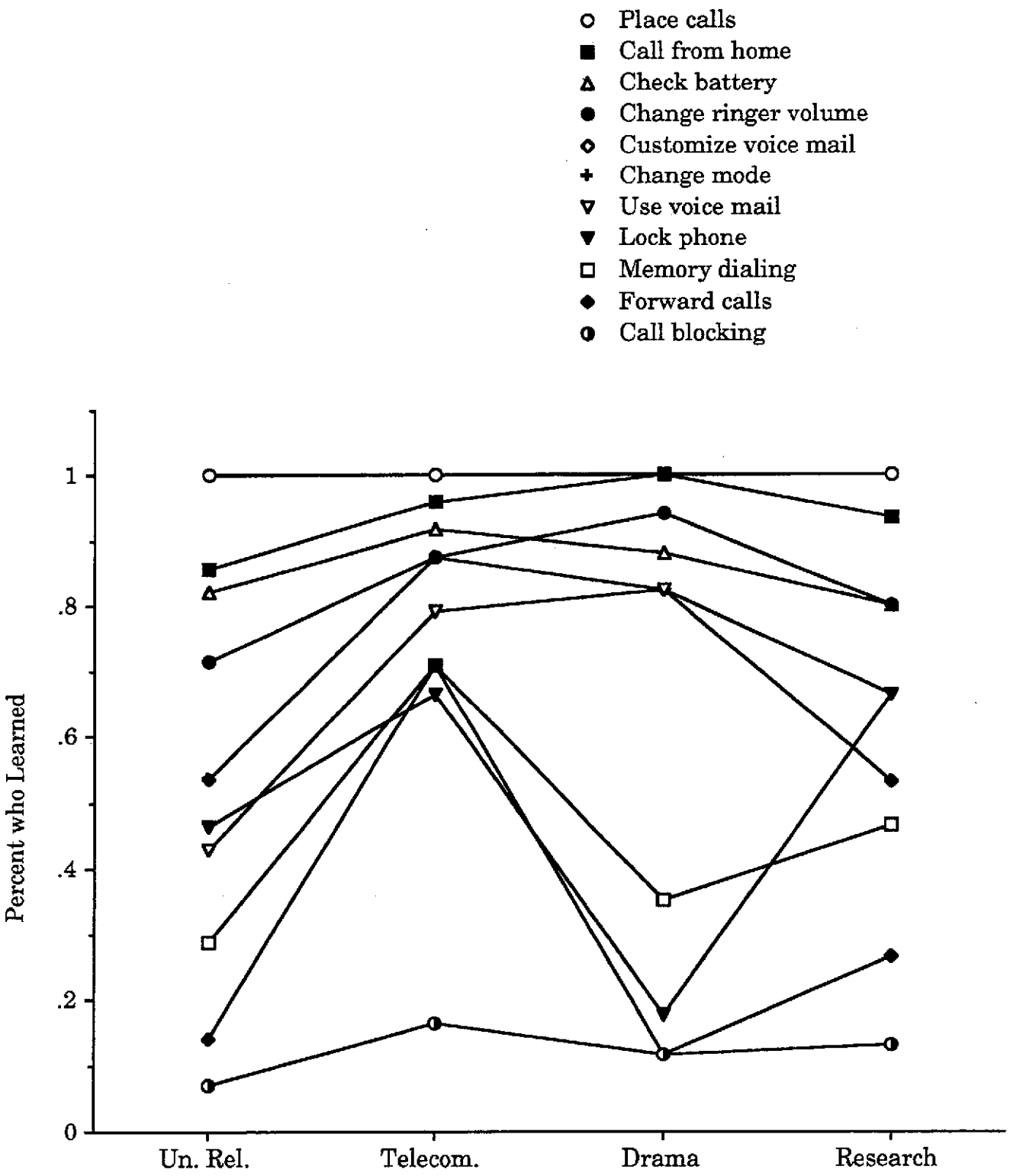


Figure 2. Percentage of participants in four departments who learned various PCS features and services. (Line graphs are used to show patterns.)

Their group membership and other attributes of individuals, the training and help they receive, and the usability of the specific features of the technology are interrelated forces that contribute to people's utilization of features, as shown in the "usability triangle" of Figure 3. In this study, people who were already skilled in the use of the technology, or were highly motivated to use particular features, tended to use those features regardless of the training or help available or the usability of the feature. If, on the other hand, a feature was easy to use, people tended to use it whether or not they were skilled and motivated, or whether they had help or training. If people were provided help or training, their use of features increased, and their skill or motivation and the usability of features influenced their use less. The PCS technology was designed for a select group of motivated business customers who had used cellular previously, but our trial included a much wider variety of people. Our broader sample therefore made a number of training and usability issues important that might not have meant as much for a narrower, more skilled and motivated, market segment.

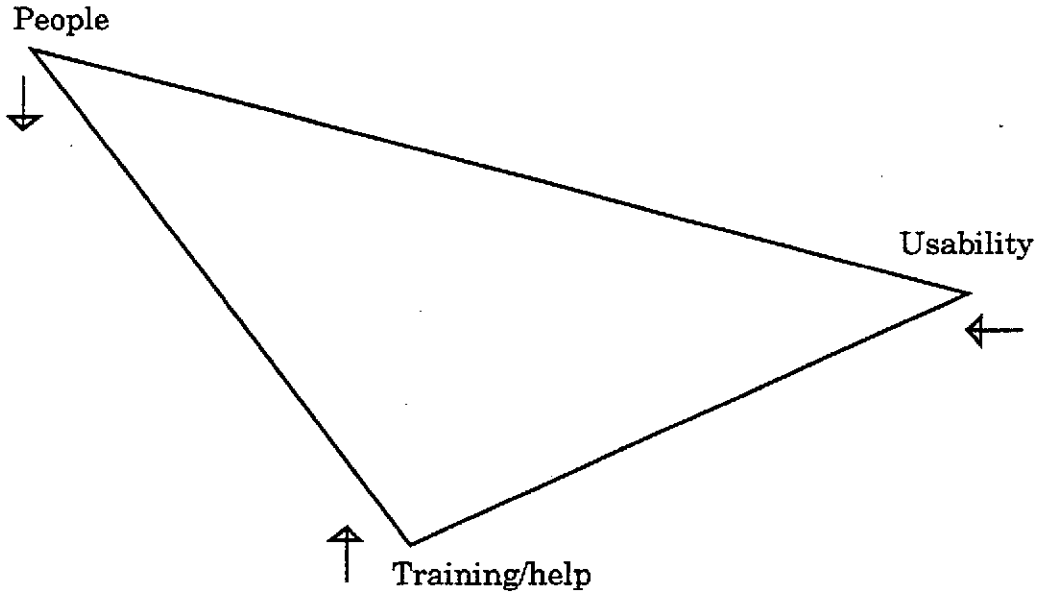


Figure 3. The "usability triangle" shows how the importance of usability depends upon the competence and motivation of people who are using the technology and the training and help available to them. Each point on the triangle represents a set of factors that influence whether or not people use a technology or a feature of a technology. As the strength of each set of factors increases, the need for the other sets of factors decreases. When all factors are weak, then all three sets of factors need to be considered and if possible, strengthened, to ensure the technology (or feature) is used.

Individual differences. Participants' perceived usefulness of a feature or service affected whether they were motivated to learn to use it. Few participants thought locking the phone or call blocking would be useful, for instance, so they did not bother to try learning how to lock and unlock the phone or to implement call blocking. Usefulness of features and services is discussed in Section 3.

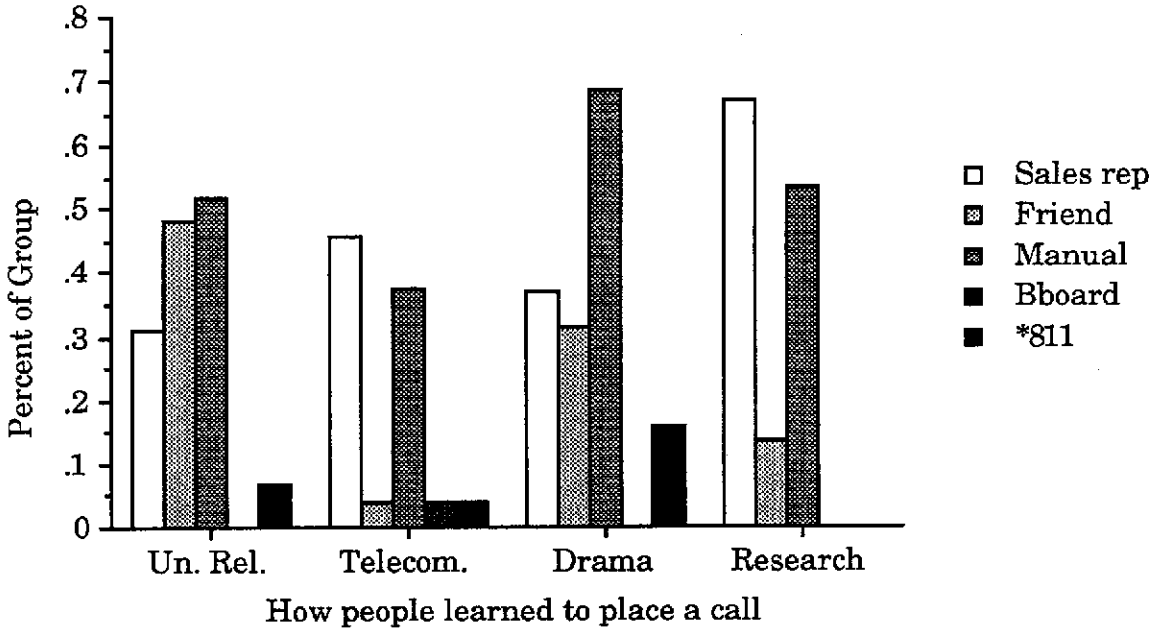
Another individual difference that affected learning was whether people thought learning would be a chore or would create more frustration than they wanted to handle. (This is not the same as how long people thought it would take them to learn, a factor unrelated to motivation to learn.) Two functions many people thought would be beneficial, but not fun to learn and perhaps too disruptive or frustrating to learn, were voice mail and memory dialing. Each of these (like customization of a computer, another activity few people do) requires the person to commit time to learning initially in exchange for later benefits. One participant exclaimed, when asked if he wanted his group to have instruction, "Please. No more 'sessions'! I've had it with sessions." His comment reflects a context in which the PCS technology was only one of many new technologies that participants were learning to use—a new central phone system and voice mail, new email software, "multimedia" computers, videoconferencing, and color copiers, not to speak of numerous upgrades of existing word processing, statistical, graphics, and spreadsheet software. Caught up in this continuous progression of marginal technological improvements, some people came to a point of exasperation and decided to stick with whatever they could use as is.

Training and help. An important influence on what participants learned was whether or not they had help, and the nature of the help they received. Figure 4 shows how people got help when they learned to use various features of the PCS phones. The data in the first chart show that trial participants used a variety of sources even for learning to use the phone initially. Most of them first learned how to use the PCS phones from the sales representative who introduced them to the technology, from friends, and from the manual. For this and other elementary functions, such as using the PCS phone at home (as a cordless, that is), the sales representative's help was significant. That is, the sales representative's help predicted at a statistically significant level whether or not the person actually used that function (see Table 2). This finding suggests that the technology is not readily usable for "off the shelf" sales to the general public.

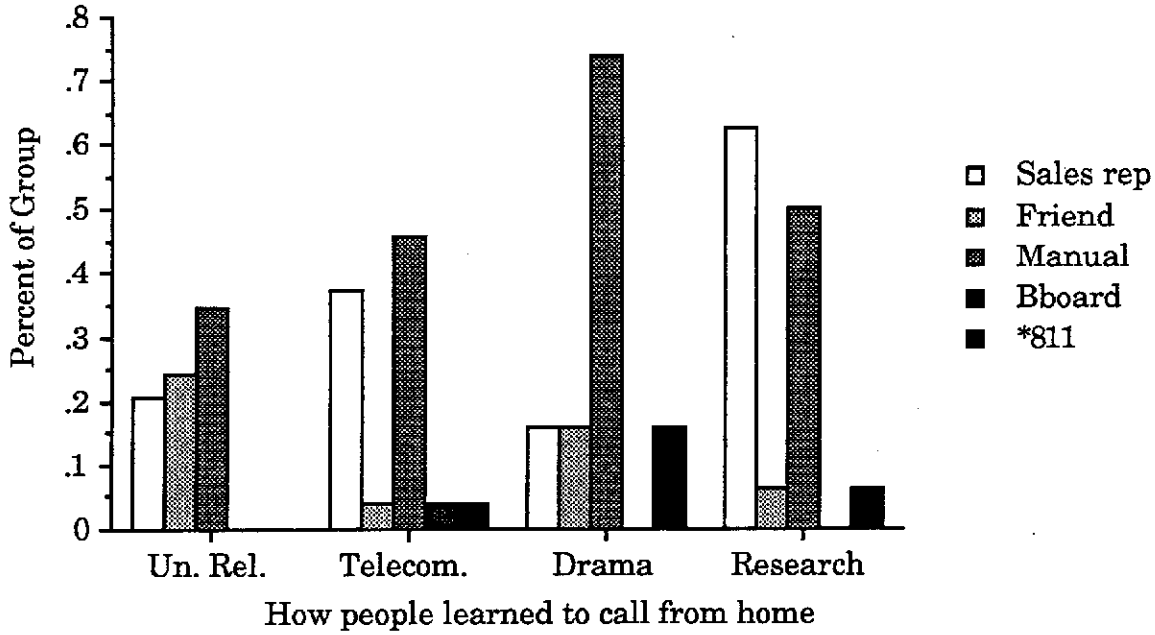
Figure 4 also shows how different groups learned to use the PCS phone. For instance, the University Relations group relied more heavily than other groups on friends and colleagues for initial help in learning to use the PCS phones, which reflects their more general preference for direct personal communication. (This preference also showed up in their communication diaries.) Sales representatives gave more help to the researchers and the Telecom department to get the trial started.

The charts in Figure 4 also illustrate where people got help in learning to use more "advanced" features and services of the PCS technology. For learning functions such as using and customizing voice mail, memory dialing, and forwarding calls, help from a sales representative was less influential than help from colleagues or friends. (The direct help of colleagues or friends on use of new technology is already well known in the usability literature.) When friends weren't around, many participants called the special *811 telephone help line at Bell Atlantic Mobile to get help in learning how to use some of the PCS features.

Contrary to the maxim that "people don't read manuals," participants in this trial relied very heavily on manuals and written instructions. Using the manual was in most cases very significantly related to whether or not people learned to use (and did use) a feature or service. This reliance on the manual may reflect the fact that participants work at a university, which is generally a literate environment. From Figure 4, we see that the groups that got most help from manuals tended to be the technical or mechanically-skilled groups, that is, the Telecom and the Drama production departments. Table 2 summarizes the statistical analyses that compare the influence of sales representative, friend, and manual on whether or not participants learned to use different functions. Taken together, the data indicate the importance of written instructions and suggest that more attention should be put to the readability of manuals for nontechnical people.



How people learned to place a call



How people learned to call from home

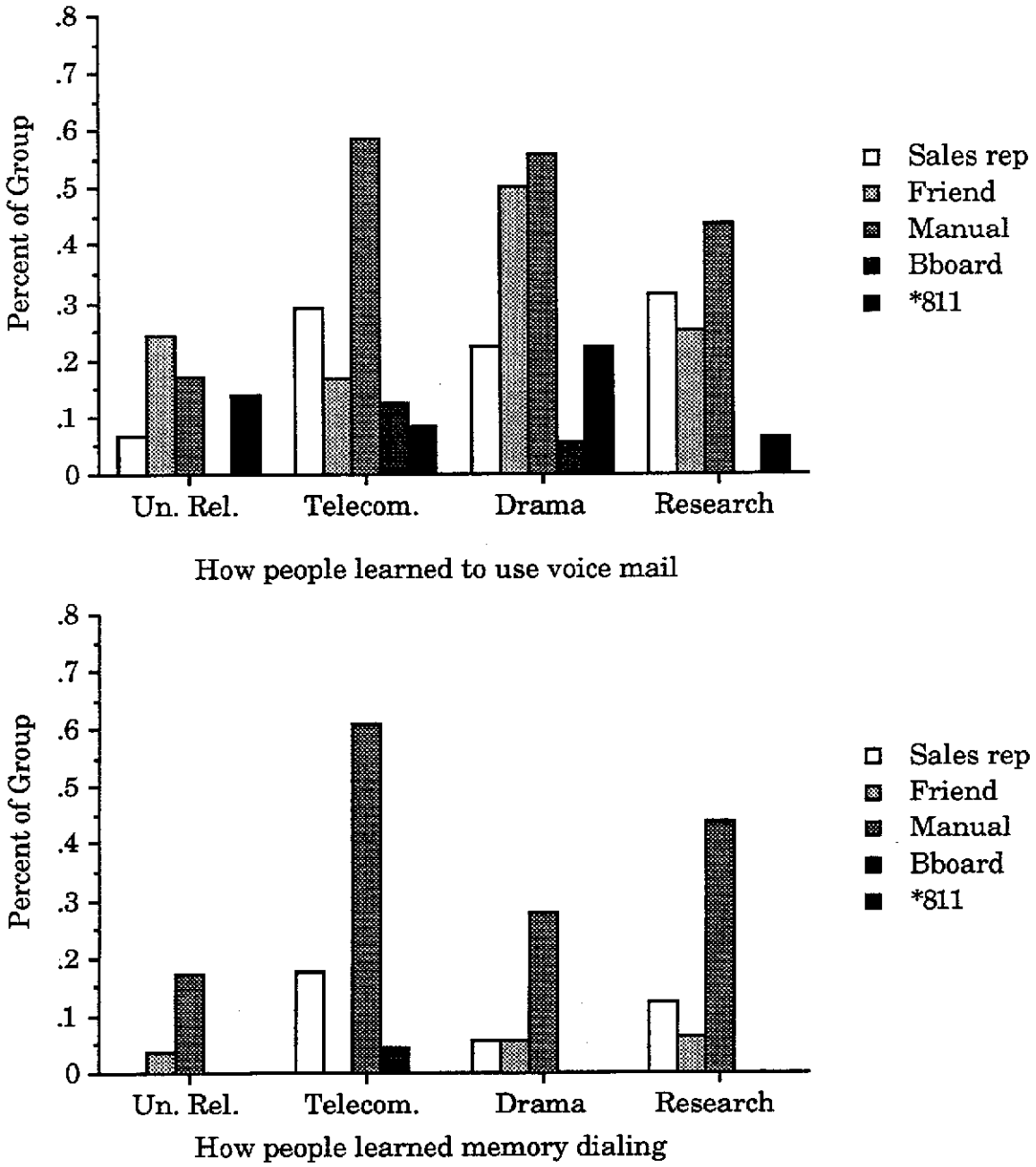


Figure 4. Sources of help to learn functions of PCS.

Table 2. Influence of help on learning.

Learned to make calls from home? (n = 88, R^2 = .12, Model F = 3.9, p < .05)

Sources of help	Beta	t-test	p value
Intercept	.82 (.04)	19.4	
Sales rep	.12 (.06)	2.1	<.05
Friend	.07 (.07)	.97	n.s.
Manual	.14 (.05)	2.7	<.01

Learned to use voice mail? (n = 87, R^2 = .50, Model F = 27.25, p < .01)

Sources of help	Beta	t-test	p value
Intercept	.31 (.05)	5.8	
Sales rep	.15 (.09)	1.6	.10
Friend	.34 (.08)	4.0	<.01
Manual	.54 (.08)	7.0	<.01

Learned speed (memory) dialing? (n = 86, R^2 = .76, Model F = 87.62, p < .01)

Sources of help	Beta	t-test	p value
Intercept	.10 (.03)	3.1	
Sales rep	.05 (.10)	.5	n.s.
Friend	.59 (.15)	4.0	<.01
Manual	.87 (.06)	15.2	<.01

Learned to forward calls? (n = 88, R^2 = .44, Model F = 21.7, p < .01)

Sources of help	Beta	t-test	p value
Intercept	.17 (.04)	3.9	
Sales rep	.59 (.26)	2.2	<.05
Friend	.50 (.14)	3.5	<.01
Manual	.79 (.12)	6.6	<.01

Usability

Usability is especially an issue in learning to use PCS technology because people expect portable phones to be as easy to use as the familiar wired telephone. This was not the case, although in only one instance did a participant turn in his PCS phone explicitly because it lacked usability. More often, participants avoided using features or services that were not easy to use at the outset. Also, they used "work arounds" such as manually turning off the phone before a regular meeting instead of arranging for call blocking to turn off the phone automatically. (See also Kam-cheong Tsoi, 1993.)

Table 3 enumerates the principle problems people reported on their survey using their PCS technology. Table 4 summarizes the kinds of complaints they posted to the trial electronic bulletin board as they experienced problems. (Most bboard posts are from the Telecom group, that is, from relatively technical participants.) Clearly, some of the main problems (such as reception and dropping calls) are associated with the fact that this was a trial; the infrastructure, for example, the distribution of microcells, was not fully developed.[7] However, other problems such as not hearing the phone ring or pushing the wrong key were associated with the design of the handset and interface; this was true for both features and services. This report does not address the full range of usability issues; we were unable to mount a detailed usability research study. Our data suggest a significant need for usability tests and research from the perspective of customers and service providers. We illustrate two usability problems below.

Memory dialing was a feature of the handset that people found hard to use. The main difficulty is that procedures for storing and changing stored numbers differ among telephones and lack logical or memorable structure. Since people store new numbers infrequently, they do not have their own phone's procedure in mind. Without a mnemonic or logic to prompt whether one first enters a phone number and then its code, or whether one

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[7]The "intelligent" network services that were highly touted at the start of the trial also were not very usable. One trial participant reported that he tried to use the call screening capability to limit calls coming in during class hours, but to had to call five separate times to make a change in the screening schedule.

pushes the "store" button before or after the "enter" button, the user has a choice of trial and error or finding the manual and following the procedure given. This difficulty was vividly brought home to us when a sales representative, presumably an expert on his own technology, pulled an instruction sheet out of his pocket when he attempted to enter a number in memory.

The PCS voice mail feature exemplifies a service attached to the PCS phone that many people had a hard time learning to use. The most difficult aspects of voice mail are initial customization of the password and message. In Figure 5, we have reproduced one participant's written notes on his voice mail instructions. He wrote these comments as the interviewer explained how to use voice mail. Note that the formal menu structure of these instructions is already "deep" (i.e., 4 levels) for voice mail, violating typical interface design standards. The actual menu structure is even deeper at 6 levels: enter temporary password; press 4; enter "administrative options;" press 2; set password; press 1; enter name & greeting; press 3; enter personal greeting; press 1. Through this somewhat circuitous path, various mishaps might prevent completion. One might press the incorrect button, which can happen because of the close proximity of the soft keys. One might forget where one is in the menu. One might be interrupted. Many participants tried several times to use their voice mail feature, failed at some step in the process (even after reaching the automated "walk through") and then gave up. The pamphlet on voice mail, which assured users how easy it was, and labeled the diagrammed instructions as "Mobile Messenger at a glance," caused some participants to blame themselves for their usability problems and to resist using it even when we offered to teach them personally.

Figure 5. Notes of a participant on his voice mail instructions.

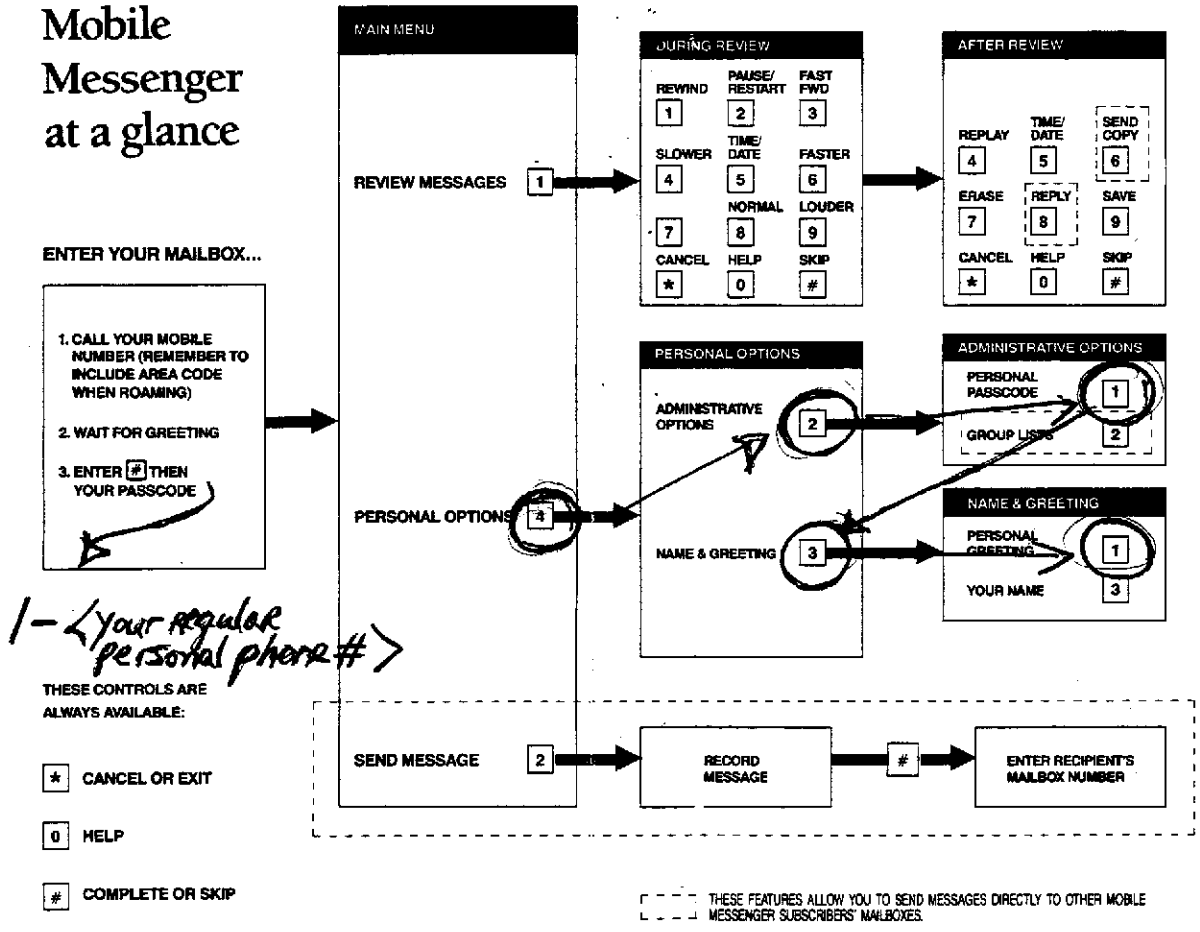

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Table 3. Major problems people reported on the survey. (1-5 scale, where 5 = worse problem)

Problem	Mean	Std. Dev.
Small battery ran out (e.g., sudden loss of power, no warning)	4.273	3.341
Dropped call	3.318	4.028
Reception on campus	3.182	3.096
Reception elsewhere	2.864	2.817
Missed a call (grabbing the phone in purse, battery moved in pocket, etc.)	2.727	3.508
Large battery lost power (unexpected loss of power, contact with phone moved, etc.)	2.682	2.835
Cordless reception	2.591	3.157
No ring or didn't hear ring	2.045	3.047
Couldn't forward call or call didn't forward	.636	2.194
Defective handset (something broke, etc.)	.591	1.790
Couldn't block call or call blocking didn't work	.455	2.132
Lost voice mail msg. (e.g., pushed delete #)	.091	.294

Table 4. Problems posted in email.

Problem	Number of Messages
Reception	10
Reception on campus	9
Dropped call	8
Roam comes on locally	7
Noise in microcell	7
Phone shuts itself off	7
Couldn't forward call or call didn't forward	6
Small battery ran out (e.g., sudden loss of power, no warning)	6
No ring or didn't hear ring	4
Ear gets hot	3
Large battery lost power (unexpected loss of power, contact with phone moved, etc.)	2
Missed a call (grabbing the phone in purse, battery moved in pocket, etc.)	2

Why Is Usability Hard? An Experiment[8]

Some features or services connected with the PCS phones, such as an indicator to tell the user if a voice mail message is waiting, or a battery that does not store charge, would have made the technology for this trial more usable, and probably better used. Some of these items are well known, but are expensive or hard to implement, or the technology requires further development. (In the next section we enumerate some of the most desirable features and services that were or are not yet available.) However, other aspects of the PCS design would have been easy to improve. A simple example is the red color of the "send" button on the handset, which if colored green, would have been more consistent with the meaning of color in our society (green = go, red = stop) and also more readable against the dark gray color of the handset.

Engineers and marketers do not purposely build technologies that are hard to use. But technologies ranging from VCRs to picture-in-picture televisions to portable phones are hard to use. Why? One reason is that we generally underestimate the difficulty of tasks and how long it will take to complete them. Expertise about a technology itself might be a barrier to designing for usability. Experts have a more abstract picture of technology than novices do, which may interfere with their ability to calibrate what novices need to learn. Research has shown that people tend to overestimate how similar others are to themselves. Experts might believe novices know more than they actually do. Experts also might fall victim to "the curse of knowledge" (Camerer, Loewenstein, and Weber, 1989), which is the inability to remember one's previous state of ignorance. The more expertise a person has, and the more time that has passed since the expert was a novice, the harder it will be for the expert to remember (and sympathize with) the experience of having been a novice. Yet it is these very experts who design the technologies that novices must learn and decide whether or not the technologies are usable.

The experiment to be described was conducted using three groups: sales representatives from a local cellular telephone company who were experts in using the PCS technology (n = 22), participants in the trial (n = 61), and non-engineering graduate students at the university who had never used cellular or PCS phones and did not have voice mail (n = 51).

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[8]This study was conducted by Pamela Hinds and will be published in more detail in a separate paper.

The sales reps and participants in the trial completed a survey of how much they themselves knew about cellular telephony and voice mail. Then they estimated how long it would take a novice to learn to use the cellular handset (1) to store a greeting on voice mail, (2) to leave a message on voice mail, (3) to listen to the messages in their voice mail box, erase the first one, and save the message they recorded in step (2).

There were three experimental conditions. In one condition, respondents were told only that the novices were "graduate students at Carnegie Mellon University from the Heinz School of Public Policy and Management, the School of Humanities of Social Sciences, and the Graduate School of Industrial Administration." They were shown the manual and written instructions these novices would use to learn the tasks. In a second condition, the respondents were asked to use their own experience and write down a list of problems that might occur in learning to use the voice mail associated with the PCS technology. They were to come up with a scenario of what it might take for novices to learn the tasks. Presumably, having to imagine the scenario should remind an expert of how long it would take a novice to learn to use voice mail. In the third condition, respondents were provided with a list of difficulties or problems that novices actually experience in learning to use voice mail on a cellular phone. The list of problems, developed from observations of novices, were as follows:

turning the phone on and waiting for it to work;

figuring out the correct password to get into voice mail;

interpreting the voice prompts;

figuring out how to get to a previous menu after making an error;

clearing the display when making a dialing error;

hanging up (ending the call).

Each novice, after looking at the manual and instructions, estimated how long it would take him or her to learn the tasks. Then novices performed the tasks, following the manual and written instructions and the automated menu in the voice mail system. The experimenter measured how long it took the novices to complete the tasks and what kinds of mistakes slowed them up.

The main results of this experiment are shown in Table 5. Experts underestimated how long it would take novices to learn by nearly 20 minutes, or 60%. They were as inaccurate as novices themselves, who had never tried the tasks. By contrast, trial participants, who were

somewhat new users of the technology, were significantly more accurate than either novices or experts in predicting how long it would take novices to learn.

Table 5. Estimates of how long it will take to learn to use voice mail.

Expertise of Respondents	Mean Estimate (minutes)	Std. Dev.
Experts (sales representatives)	13.0	5.3
Medium expertise (trial participants)	23.3	13.4
Low expertise (trial participants)	20.4	10.3
Novices (graduate students)	16.5	8.5
Actual median time for novices to learn	33.0	

The data from this study also speak to whether reminders of the difficulties of novices increase the accuracy of estimates. That is, do experts simply lack information about novices? Providing a list of difficulties did improve the accuracy of people's estimates though they still underestimated learning time significantly. However, the list of difficulties improved the accuracy of experts less than other groups. Experts provided with the list of difficulties still estimated that novices would take only about 13 minutes to learn voice mail. This finding suggests that experts are somewhat impervious to exhortations or information about the difficulties novices face. Also, it supports the "curse of knowledge" theory. That is, experts do not simply lack information about novices; they have a sophisticated and abstract view of the technology that they cannot erase to imagine the state of novices.

Summary

After their initial surprise that the technology differed from that of wired phones, participants did not find the PCS phones difficult to use for placing and receiving calls. Nonetheless, they used many fewer features and services than they could have used. Although partly this response is due to their not believing these features or services were useful, an important barrier was the initial inconvenience of learning or using the feature or service. The data also indicate the importance of written instructions and suggest that more attention should be put to the readability of manuals for nontechnical people.

In studying how people learned, we gradually realized that most participants learned to use, and thought about, their PCS technology simply as a portable telephone. As we see more

clearly in the next section, this led to a gap between telephone vendors' view of the technology and participants' view. One marketing person within BAMS described the trial as a "joint trial of the first cellular-based person communications service designed to provide users with a single personal telephone number." But most of our participants did not learn to forward calls or otherwise use the technology as a one-number telephone even though they could have done so at no charge. Hence we have one answer to our initial question, whether people want PCS technology even at low cost. The answer is that people want portable telephony but they are not eager to develop "PCS skills." In the next section we address how trial participants used and felt about their PCS phones.

ATTITUDES

To determine how participants were using their PCS phones and how they felt about PCS technology, we administered a survey to all trial participants (including researchers) two to three months following the introduction of the technology. Subsequently, we interviewed all participants to detect their attachment to PCS, since we thought those data would be better gained face-to-face. Six months later, we collected more survey data on new features of PCS technology that participants thought would be valuable.

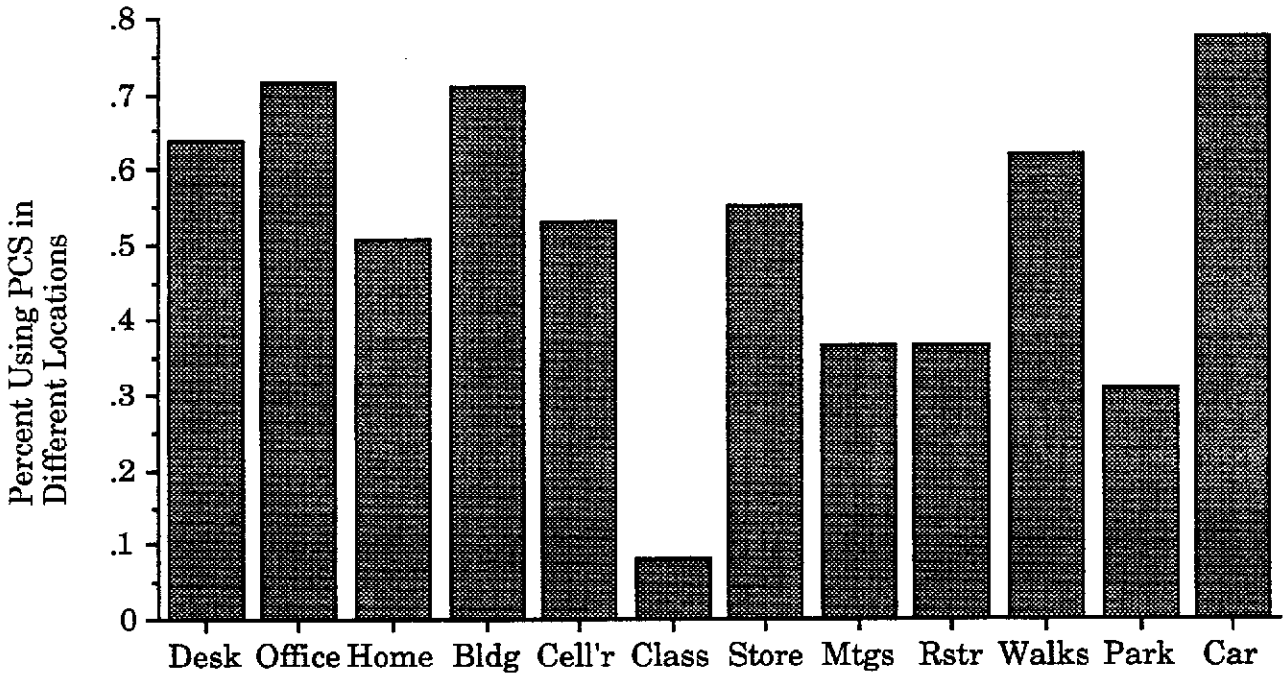
Usage

Few of the people in this trial had tried cellular phones and only half were using cordless phones before the trial. Hence wireless was a new technology for them. Nonetheless, after having PCS for 2-3 months, participants reported using the PCS phones an average of 12.5 times per day, placing 6.9 calls and receiving 5.5 calls. (This difference reflects a general preference for sending over receiving calls, which tends to be repeated with other communication technologies, and is related to attitudes about privacy and intrusion.) The high number of reported PCS calls (more than the communications logged in the post-PCS diaries) may reflect, in part, an exaggeration by respondents due to the newness of the technology. Based on our estimates that the diary data underreport communications by 50%, and that calls through base stations at home or work were logged as telephone rather than PCS calls, we believe a more correct estimate of usage to be 5-10 calls per day, which is still considerable considering that our trial participants worked in close proximity to many people and also had easy access to telephone, fax, paper, copy machines, secretarial services, and ubiquitous email communication.

There is a small positive correlation, $r = .14$, between the number of weeks people had the PCS phone and the extent to which they used it, which suggests that people did not require much time to reach a high level of usage. Learning how to use various functions, as might be expected, was associated with usage also. In particular, learning to use voice mail and speed or memory dialing was significantly associated with usage.

Participants used their PCS phones nearly every place they went. Figure 6 shows the locations we evaluated: the participant's own desk, his or her office, his or her home, a building on campus, cellular mode near home, in class, at the store, in meetings, in restaurants, on walks outside, in the park, and in the car. Figure 6a shows the data for all groups; PCS is used in many locations, which supports our suspicion that portable telephony

might blur the boundaries between workplaces and social places, a possibility we discuss in section 4. Figure 6b shows that in any given place, participants placed more calls using PCS than they received, except for calls made at the desk, where they had wired phones, and in meetings and classes, where they were constrained by social pressure from placing calls (figure 6b). There was a significant statistical interaction of location with group ($F [33, 924] = 1.7$, $p < .01$; see figure 6c). Telecom and Drama participants were more likely than other groups to use the PCS phones in their offices, on walks, in the car, and in meetings. We also found a statistical interaction of location with level of management ($F [22,935 = 1.7$, $p < .05$; see figure 6d). Each group and level of management showed a distinctive pattern, which suggests PCS technology is a flexible one that adapts to the mobility preferences of different groups and levels of management. The data also suggest that broad cellular coverage will be required to support all groups and types of people.



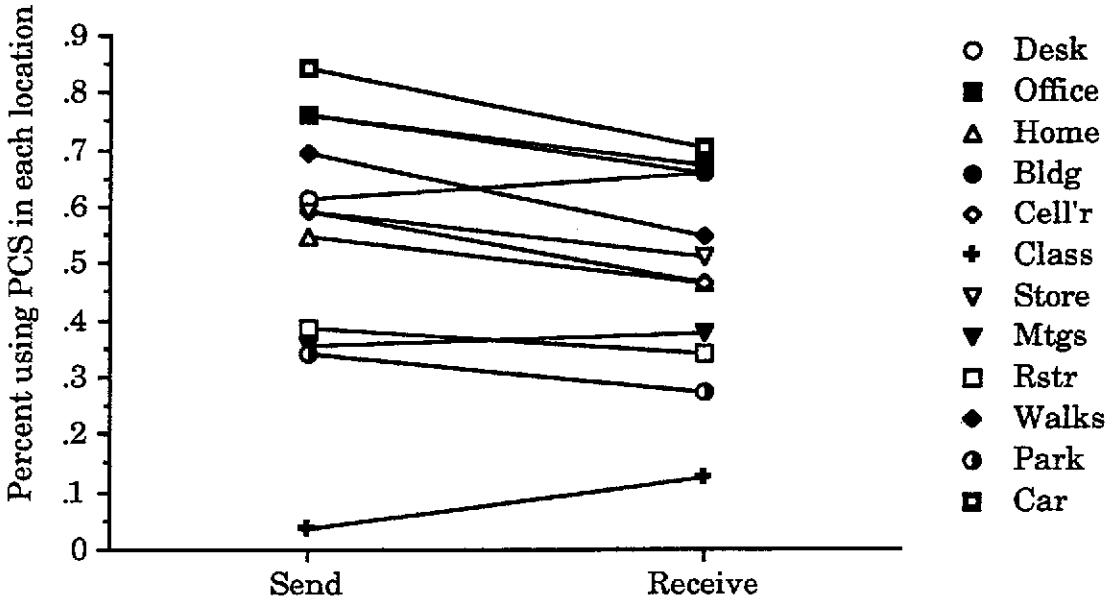


Figure 6a (top panel). Where people used PCS phones.[9] Figure 6b (bottom panel). PCS phones to send and receive calls.

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[9]In Figure 6, "Bldg" is any building on campus; "Cell'r" refers to calls switched to cellular in range of base station, e.g., around the home; "Rstr" is restaurants.

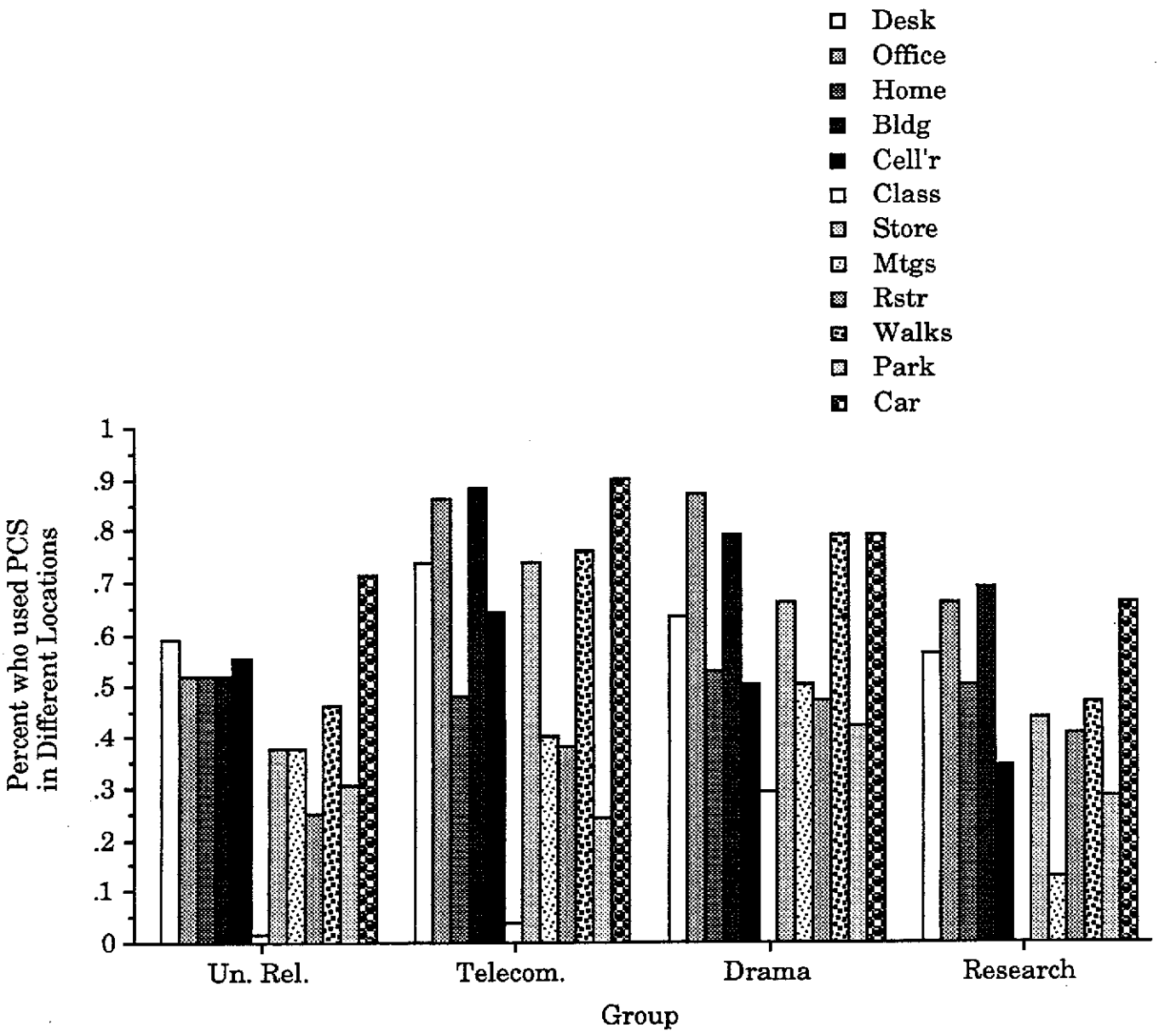

Figure 6c. Groups used PCS in different locations.

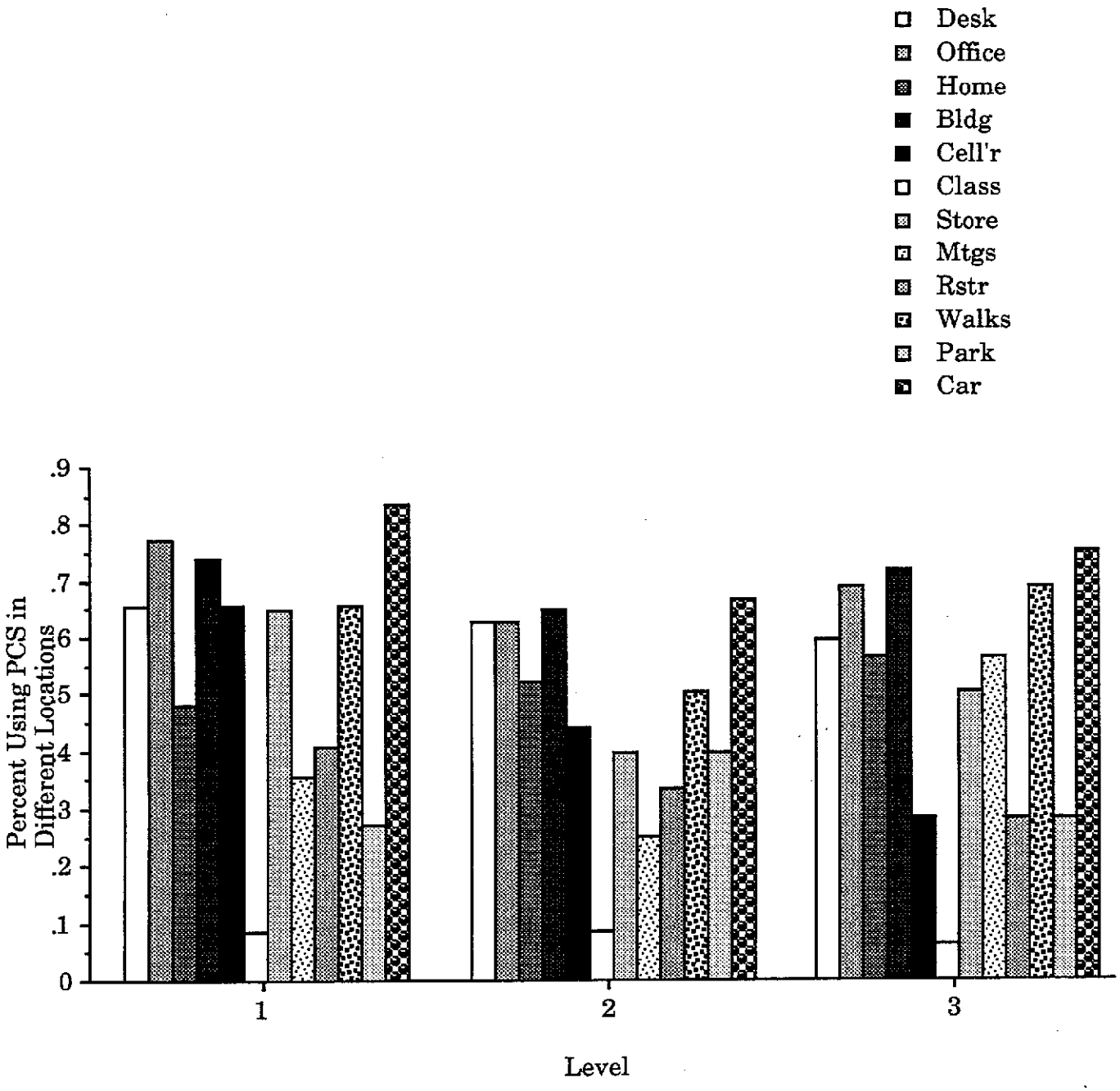

Figure 6d. Employees at different levels of management used PCS in different locations. (Nonsupervisory = 1, First level and middle management = 2, Upper level management = 3.)

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Attitudes about PCS

Participants were critical of features or functions that didn't work well (and somewhat intolerant of glitches in trial service), but their enthusiasms for their PCS telephones outweighed their criticisms of it. We asked participants to review a list of 19 features and services attached to their phones and to tell us whether they thought these features or services were useful. Only 4 items in the list failed to be endorsed by fewer than half of the participants. There were, however, statistically significant differences among the usefulness ratings of different items ($F [18,576] = 10.9$, $p < .001$). We examined whether ratings of useful features predicted usage; they did, once we deleted relatively less useful features from the list. A model of usage including ratings of the pouch (carrying case), cordless mode, automatic registration, call forwarding, speed dialing, battery check, small battery, car kit, and voice mail predicts usage significantly (model $F [9, 28] = 2.4$, $p = .04$). The features that best predicted more usage were positive ratings of the pouch (which may be correlated with being a mobile field technician; $t = 1.8$, $p = .08$), negative ratings of automatic registration, which also may be associated with a technical job ($t = 2.3$, $p = .03$), positive ratings of the battery check ($t = 2.1$, $p = .05$), and positive ratings of the car kit ($t = 1.9$, $p = .07$). This model may be unreliable because ratings of useful features are correlated with one another; dropping and adding features changes the model considerably. Also, of course, the data are correlational. High usage probably affects ratings of usefulness as much or more than attitudes about usefulness affected usage.

Ratings of the advantages of PCS also were very high, although participants thought some aspects of the technology were significantly more advantageous than others ($F [6,408] = 30.3$, $p < .001$). The two most highly rated advantages were being able to place or receive calls for help in personal emergencies, and being able to place or receive calls in family emergencies. The least highly rated advantage was the ability to have one phone and one number. In fact some participants wrote in the margin of their surveys that they considered the one-phone idea to be a disadvantage because it interfered with their preference for separating work and personal life. In particular, they did not want work calls at home and personal calls at work, which as the next section shows, did tend to happen when people used PCS phones and gave their PCS number to others. Ratings of advantages were a marginally significant predictor of usage ($F [7,60] = 2$, $p = .07$). However no single advantage significantly predicted usage. There were no group or level differences in ratings of usefulness or advantages, suggesting highly reliable and positive perceptions across all market segments reflected in this sample. Figures 7 and 8 show these data.

• Pouch	Carry pouch
• Size	Size of handset
• On	Power switch
• Ringer	Control of ringer volume
• Macro	Operation in macro cellular mode
• Micro	Operation in micro cellular mode
• Cdls	Operation in cordless mode
• Auto swtch	Auto switching between modes
• Forward	Call forwarding service
• Modes	Manual switching between modes
• Memory	Speed/memory dialing
• Display	Screen display
• Battery chk	Battery check
• Lock	Lock & unlock phone
• Sml batt	Small battery
• Lge batt	Large battery
• Car kit	Car phone/kit
• Voice mail	Voice mail
• Call block	Call blocking service

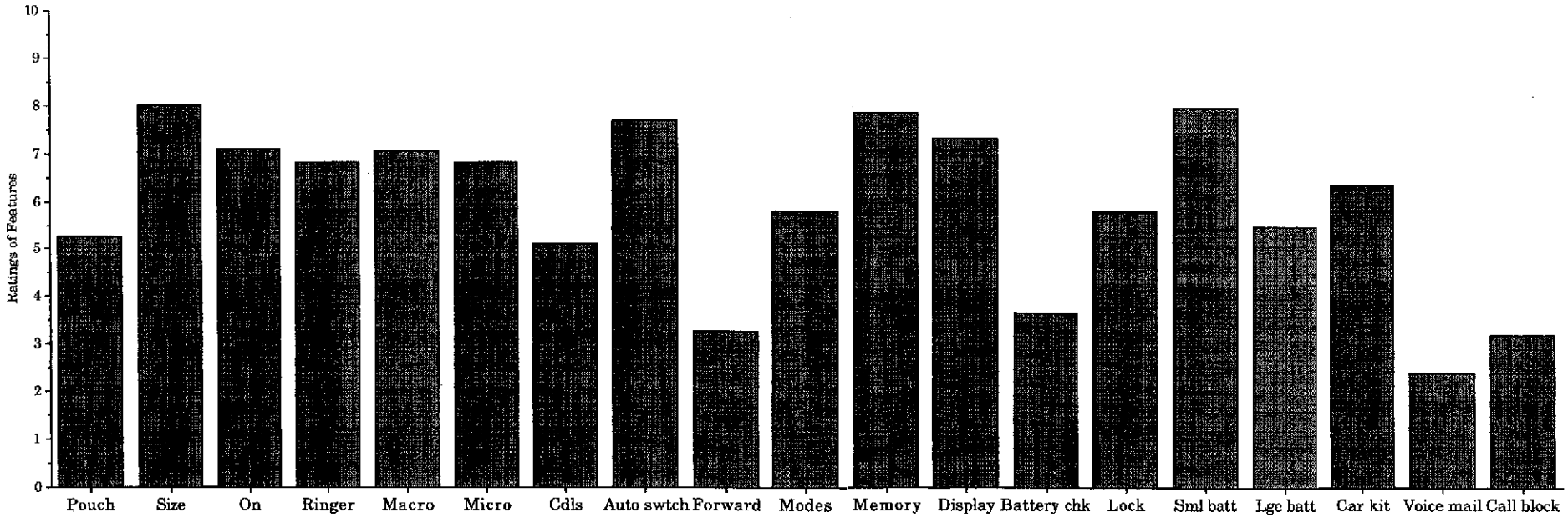


Figure 8. Advantages of PCS.

• Work away	Work while away from office
• Personal away	Personal business while not at home
• Deadtime	Fill 'dead time' with useful activity
• Call help	Call help in personal emergency
• Emergency	Reachable in family emergency
• One phone	One phone for all communications
• Control	Control over communications

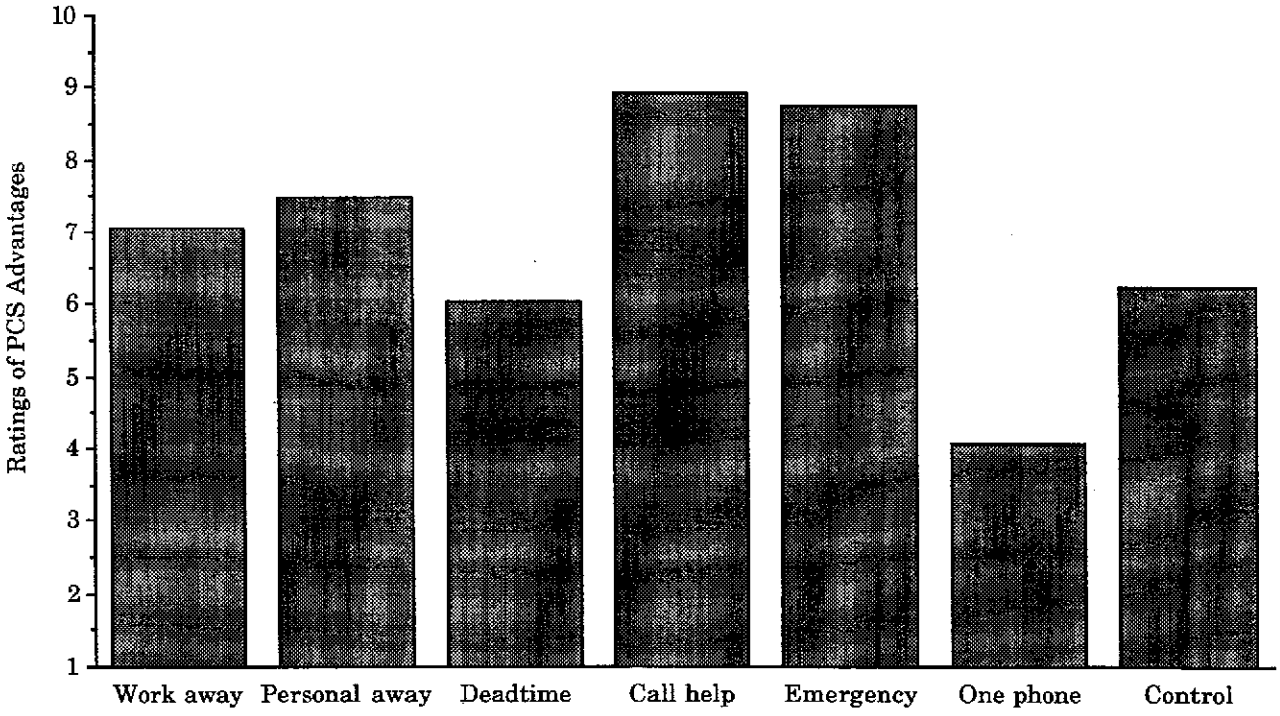
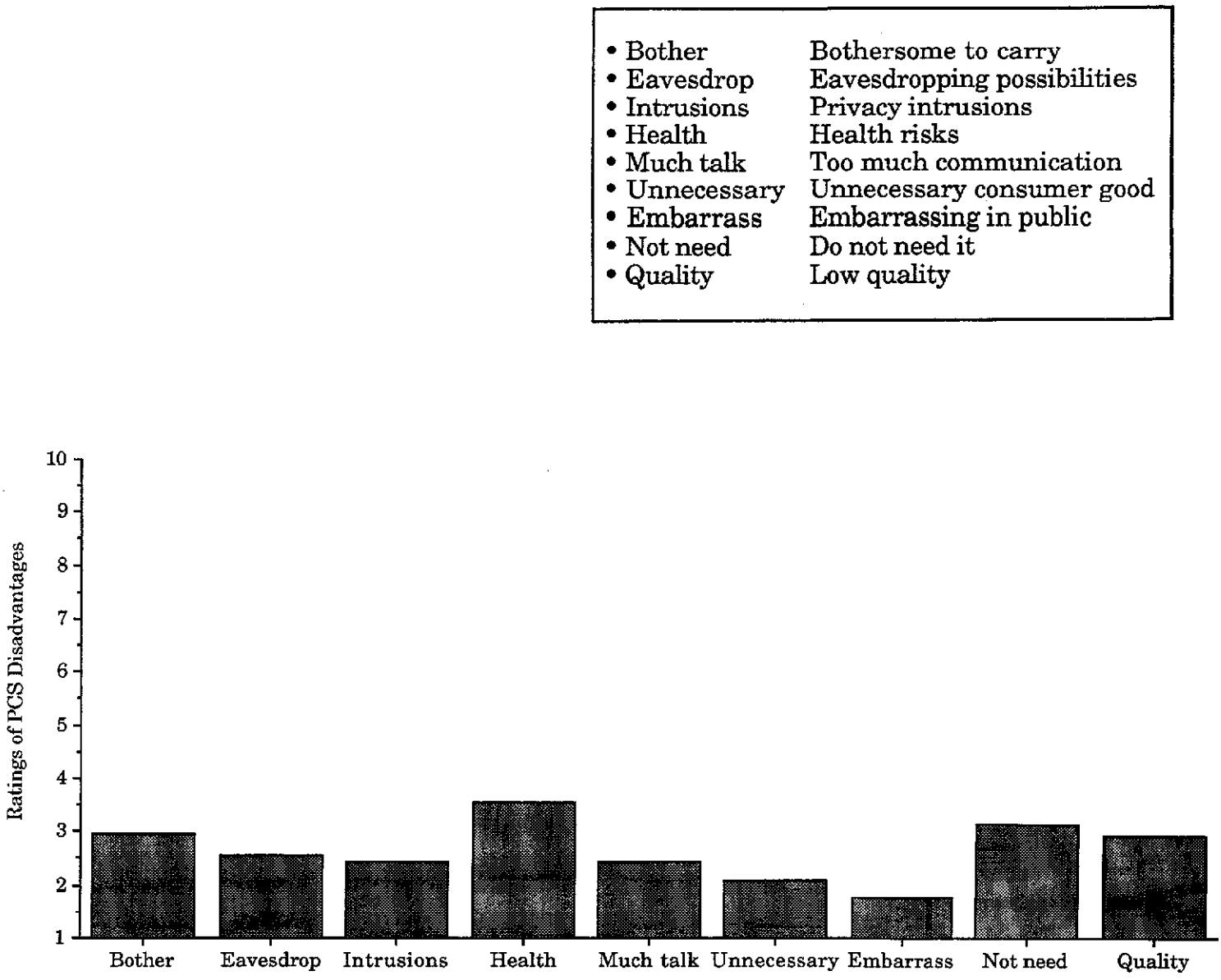


Figure 9. Disadvantages of PCS.



We also asked participants about the disadvantages of PCS (see Figure 9). Ratings of the disadvantages were significantly lower than ratings of advantages. The most serious disadvantage, according to these ratings, were possible negative health effects. This response no doubt stems from media reports, in February, 1993, about the possibility that people might get brain tumors from low-level radiation emanating from handsets. (The effects of low-level radiation are poorly understood, but the incidence of tumors by cellular users seems not to differ from chance levels.) It is probably not coincidental that all of the high disadvantage ratings on the "health" item were given by members of University Relations, whose jobs put them in constant contact with the press. As noted in the footnotes to Table 1, few participants took the health risk seriously enough to part with their PCS phones. The next most highly rated disadvantage was the perception that PCS phone wasn't really necessary. This turns out to be a critical rating. We did a regression analysis of how ratings of disadvantages affected usage of PCS. Ratings of disadvantages predicted usage significantly (model $F [9, 66] = 2.3$, $p = .03$). The disadvantages of most consequence for low usage were rating the PCS phone as unnecessary ($t = 3.2$, $p < .01$) and having "too much communication already" ($t = 1.9$, $p = .06$). We had thought high-level managers, especially, might say PCS had these disadvantages, but no particular group or level of management did so.

As the high ratings of advantages and low ratings of disadvantages suggest, participants were generally enthusiastic about their PCS phones. Participants evinced enthusiasm about their phones in many ways. For instance, we made an attempt to wean some participants from their PCS phones about halfway through the trial. We posted a message on email requesting that if any of the trial participants weren't making good use of their PCS phones, we would like them to volunteer to give up their PCS phones to be used for a special research project. Only 4 participants volunteered. In response to our request, we received messages of the following kinds:

"I am most definitely using my personal line phone. In fact, I love my personal line phone. I think the trial should continue for another year. I did not, however, install the car jack [sic]. So I can return all the automotive accessories to you, pronto. . ."

"I'm using this thing more than ever. . . ."

"My phone has become a permanent part of my anatomy. I can check with others in our group about available phones and get back to you. . ."

"I have come to rely on it more these days. It came in very handy when Telecom was moving and people were scattered for a time. I'd like to keep it. "

"I am using my personal phone and find it very useful!"

"If it would be possible, I would like to keep my phone especially when school starts. It has proved very valuable in tracking down students. If this is a problem, please email me."

"I use my phone all the time. . .The phone has been a great time saver and it's going to be very difficult to give it up when the time comes."

"Let me describe my phone usage patterns, then let you decide whether I'm the sort of user whom you want in the trial. . . .
-I carry it with me routinely to work and on trips out of town.
-I tend to use it as a cordless phone at home, especially when working away from our phones.
-I use it fairly often on trips, because I find it much more useful than trying to find or beg a phone.
-I use it in travel around town.
-I don't communicate regularly with anyone on campus.
-During the school year, I have occasionally made myself available to [secretary].
-At times, I have made myself available while on trips. . ."

"I use the Personal Line Phone. If there is any change I will contact you. . "

"I LOVE MY PHONE!!! Bell Atlantic will have to tie me down to get it back!!. . ."

Well, I am using it, especially on days where I have to be out of my office or off campus. . . if you are running short, though, I could go ahead and turn mine in . . ."

"I'm using it, and enjoying it. Sorry ---don't think you'll get one from me. Good luck."

Relationships with the PCS phone. In the pre-PCS interviews that followed diary keeping, we asked participants to characterize their "relationship" with their home and work telephones. Then, in the post-PCS interviews, we asked participants about their relationship with their PCS phone. The figures that follow show the results of these comparisons:

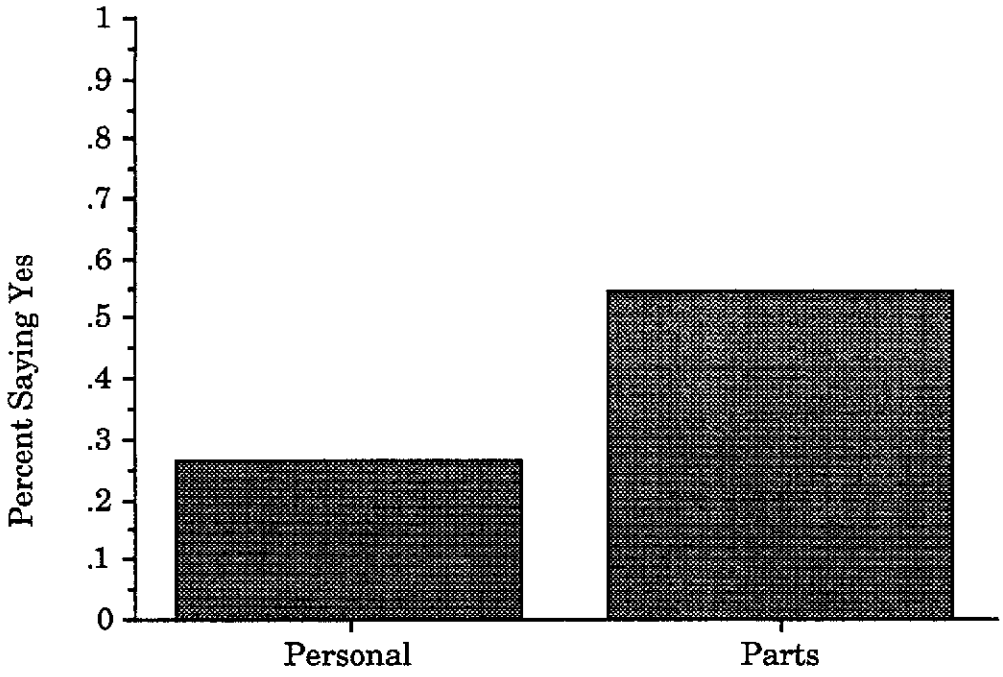


Figure 10a. Is your work phone a personal possession or just a bunch of mechanical and electronic parts?

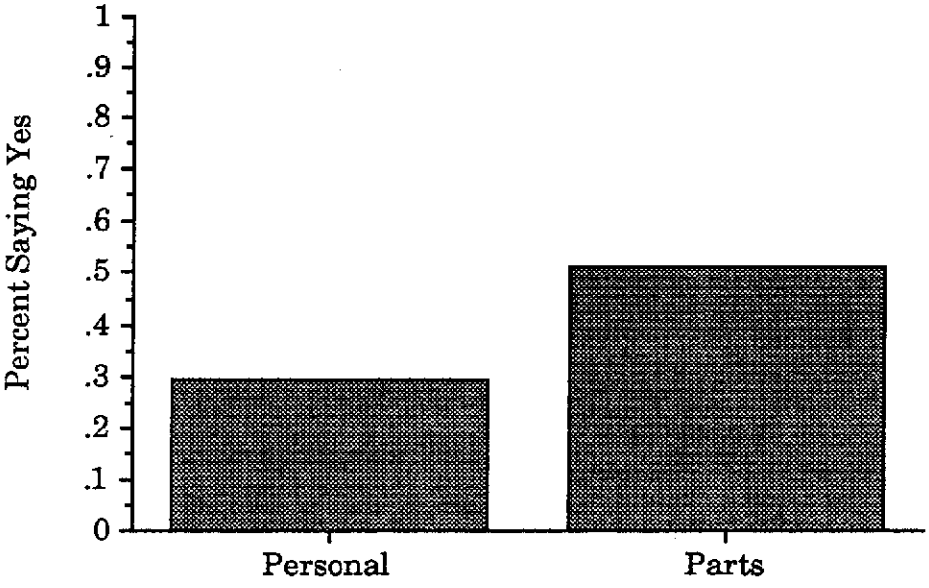


Figure 10b. Is your home phone a personal possession or just a bunch of mechanical and electronic parts?

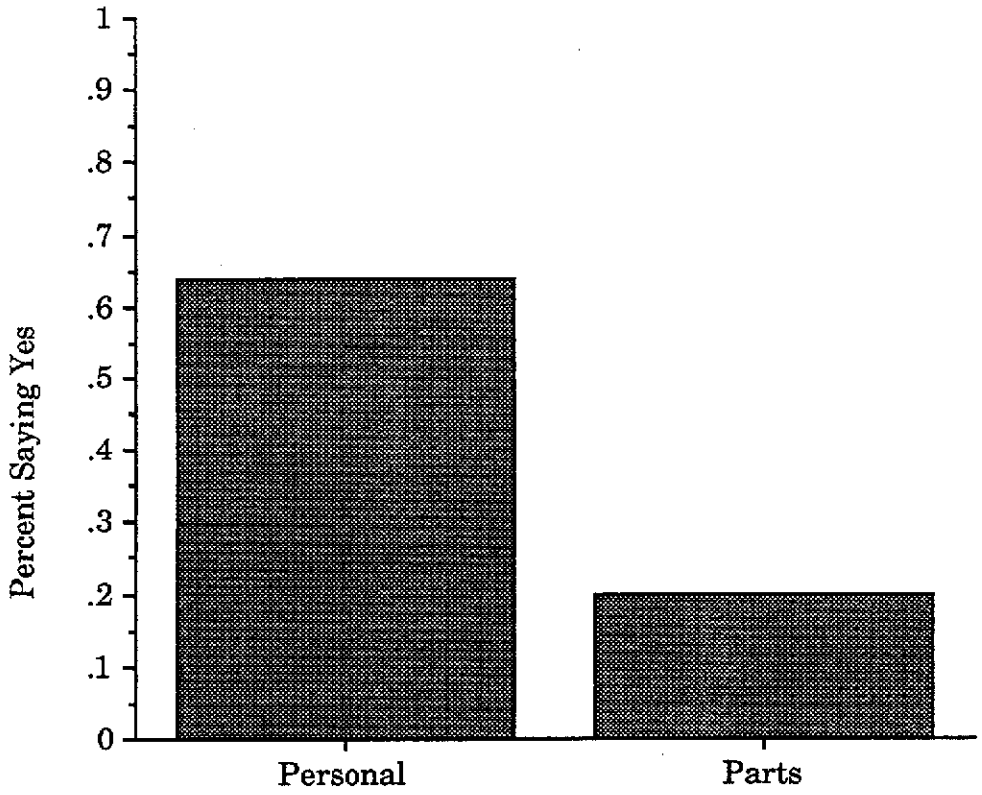


Figure 10c. Is your PCS phone a personal possession or just a bunch of mechanical and electronic parts?

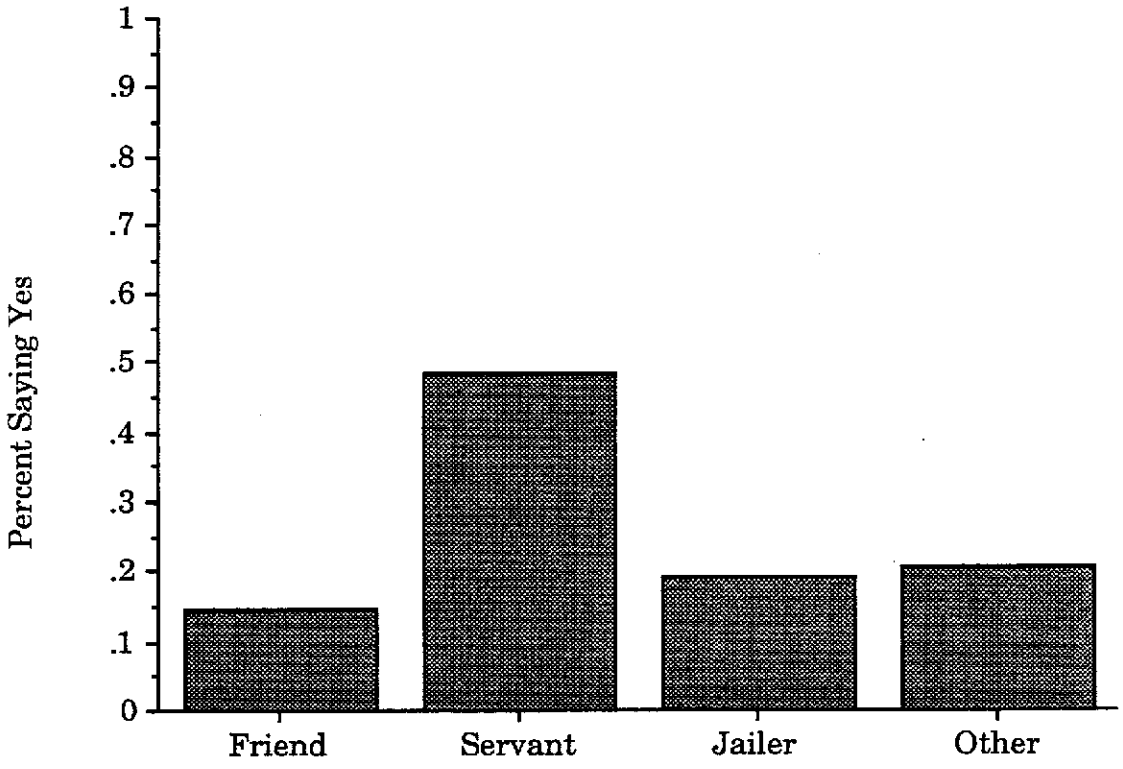


Figure 10d. Is your relationship with your work phone more like that of a friend, a servant, a jailer, or something else?

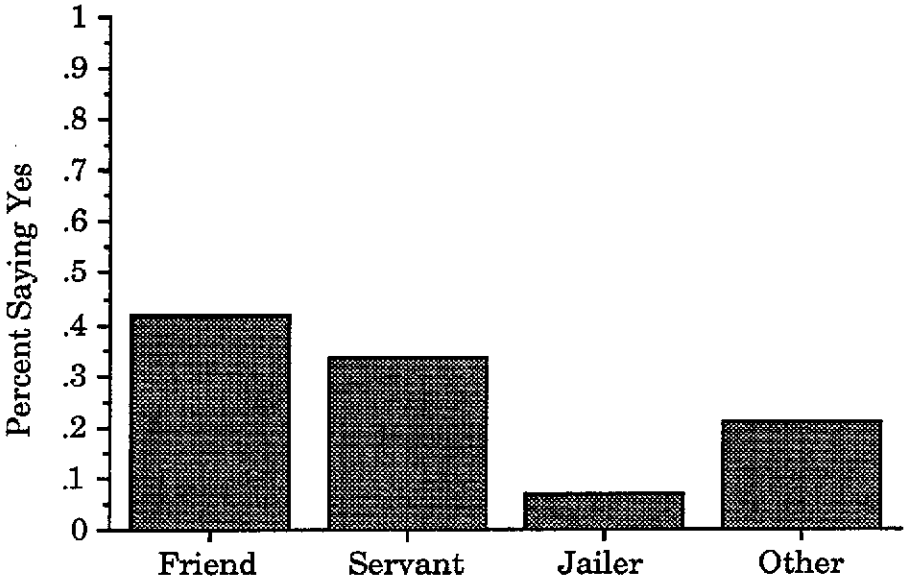


Figure 10e. Is your relationship with your home phone more like that of a friend, a servant, a jailer, or something else?

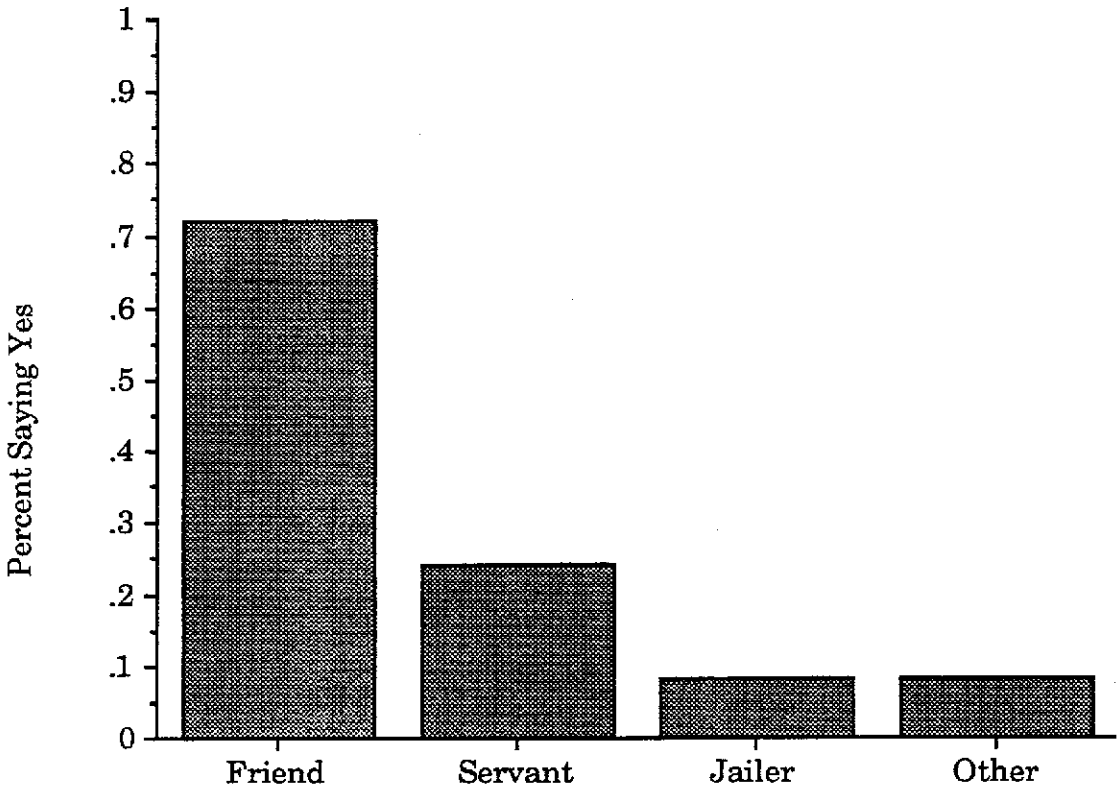


Figure 10f. Is your relationship with your PCS phone more like that of a friend, a servant, a jailer, or something else?

Clearly, participants developed a positive attachment to their PCS phones. Also, probably due to its small size and portability, they came to think about it more as a personal possession such as a Walkman or a wallet than an appliance or VCR. Would participants pay the hefty fee for the PCS phones? About 40% of them said they intended to subscribe to PCS service after the trial, a much smaller percentage than "loved" the phones. This pattern of response suggests considerable price sensitivity. For example, despite the very high usage of the PCS phones in the Drama group, and the fact that Drama staff were as enthusiastic about PCS advantages and as unwilling as others to quit the trial, few expected to have PCS in the future. Most Drama staff and graduate students in production do not have the income required for PCS, at the price it was being sold at the time they did the survey. (See Table 6 and Figure 9.)

Table 6. Wireless communication technology participants have now, and wireless technologies they intend to have in the future (N = 90).

	Mean	Std. Dev.
Cordless, Now	.51	.50
Cordless, Intend	.44	.50
Cellular, Now	.06	.23
Cellular, Intend	.06	.23
PCS, Now	.92	.27
PCS, Intend	.43	.69
Car phone, Now	.27	.44
Car phone, Intend	.37	.48

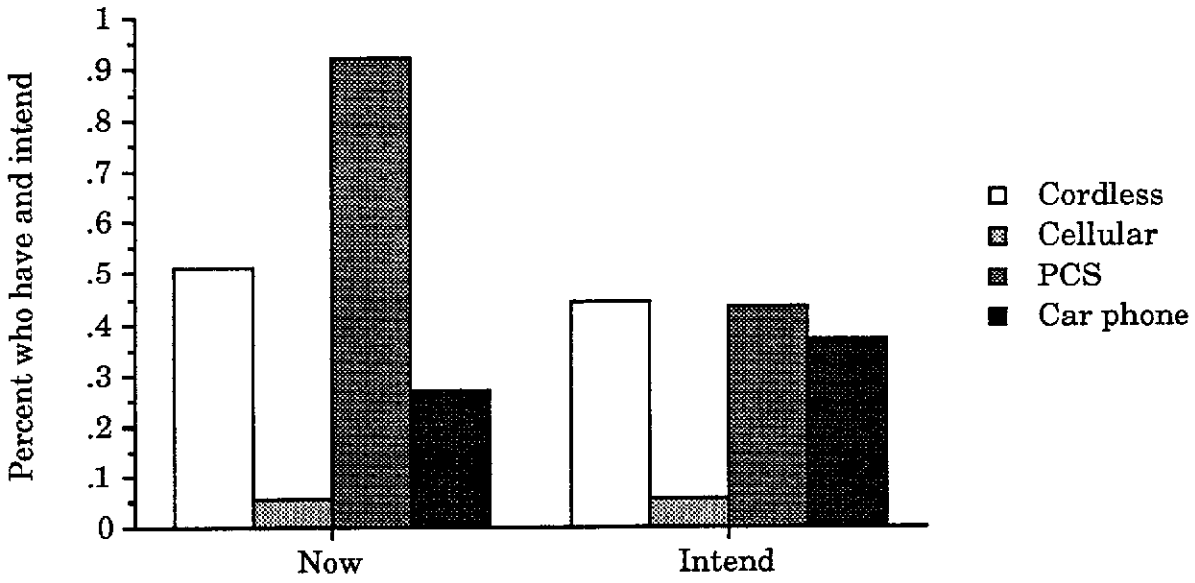


Figure 11a. Experience with wireless and intentions to have PCS and other wireless technologies (given prices as of 1993) .

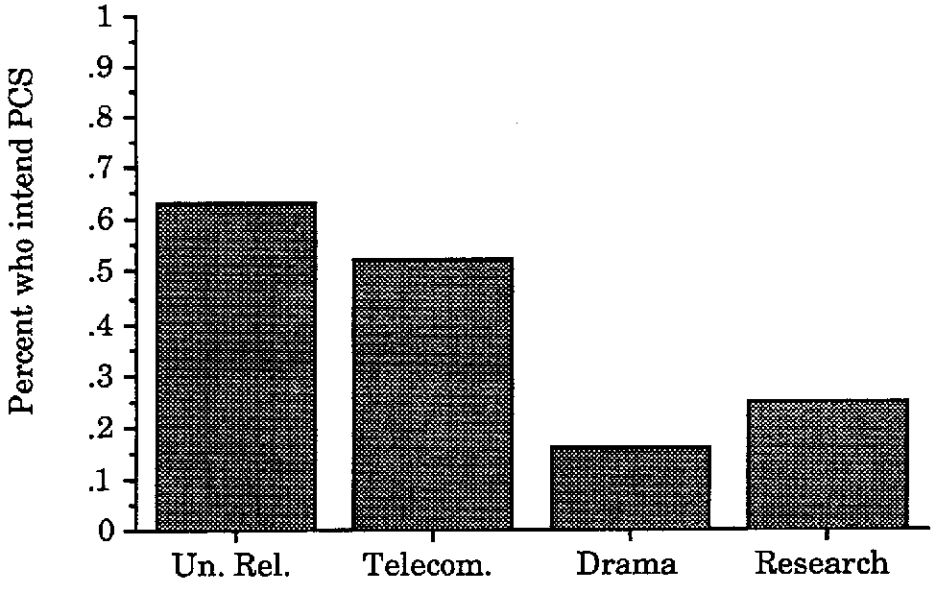


Figure 11b. Group differences in intentions to have PCS.

Privacy

A number of survey items were designed to explore how participants felt about privacy and whether they believed the PCS technology left them particularly vulnerable. At the outset, participants differentiated between two meanings of privacy. (This differentiation has been found in other research on privacy.) One meaning of privacy is that personal information is kept to oneself. Although participants did not want unauthorized groups to have access to information about them, most were not very concerned that such access would occur or that it would harm them. A second meaning of privacy is that one's private life is not subject to unwanted intrusion. Many people, including most of our trial participants, are concerned about intrusions.

Personal information. Touching on the first meaning of privacy, we gave respondents a list of sensitive topics they might want to discuss with another, such as discussion of one's personal health, gossip about a coworker, proprietary company information, and government secrets. We asked participants which topics they would not discuss using different communication technologies. Groups differed. Staff in University Relations (which deals with the press) checked many of the items, meaning there are many sensitive topics they would not want to discuss using a communication technology. Telecom staff checked fewer items, then Researchers. Participants in Drama checked few items, meaning they feel no qualms about talking about many sensitive topics using communication technology. In general, participants felt PCS phones were more insecure than wired phones but they felt no more insecure about PCS technology than about the U.S. postal service. The average number of topics participants would not talk about in a private face-to-face discussion was .6, for a home telephone it was 2, for email it was 5.6, for U.S. postal mail it was 3.9, and for the PCS phone it was 4.1 ($F [4,336] = 65$, $p < .001$).

Participants were not very worried about others eavesdropping on their PCS phone conversations, as may be seen in Table 7.

Table 7. How comfortable are you with your protection from eavesdropping? (10 pt scale, where 10 = most comfortable.)

Situation	Mean	Std. Dev.
Face to face in the woods	9.2	2.0
Home phone (wired)	9.0	1.9
US postal mail	8.5	2.1
Home phone (cordless)	8.1	3.3
Work phone (wired)	8.0	2.4
Work, face-to-face	7.8	2.6
PCS at home	7.3	3.1
PCS at work	6.9	3.0
Email	6.8	2.9

Most participants also were either not aware or not worried about others being able to locate them when they were using their PCS phones. A group of students did a special study of participants' responses after they were explicitly informed about the possibility that their locations would be discoverable if they used cellular phones, but participants still were not very worried about that.

Intrusion. The evidence from the surveys is that participants are even more concerned about intrusions than about the security of personal information about them. Of all the privacy invasions we studied, the most disturbing to most participants were intrusions they experienced on their wired telephones. When asked to rate various possible "nuisances," ranging from "people who just like to talk" to "people who want to sell you something" to "people who want information about you," the wired telephone ($\overline{X}$= 6.3) was rated as a significantly worse intrusion than either a computer network ($\overline{X}$= 4.9) or a cellular phone ($\overline{X}$= 5.5). The most intrusive incidents were people trying to sell something on a wired phone ($\overline{X}$= 8.9) and the least intrusive incidents were people using email to locate you ($\overline{X}$= 3.4). Work by Robert Kraut and his colleagues at Bellcore suggests also that people are more disturbed by intrusions than by others obtaining personal information about them. This attitude is somewhat perverse. Although intrusions are an annoyance, others' obtaining personal information about oneself can have serious long-term consequences such as denial

of insurance, poor credit rating, becoming a subject of gossip, and so forth. Our previous research on interactions with computer terminals and communication on computer networks suggests that people using computer-based communication technologies may have an illusion of much more privacy than they actually have. This illusion stems from using technology with few social context cues or visible reminders of the audience or the memory in the computer; possibly people have difficulty envisioning threats to privacy they do not experience or see directly.

• Talk	People who just like to talk
• Locate	People who want your location
• Sell	People who want to sell you something
• Info	People who want info about you
• Gos'p	People interested only in gossip
• Gain	People interested in personal gain (i.e. fraud)
• Extrt	People interested in extortion
• Govt	Government agencies (i.e. FBI)

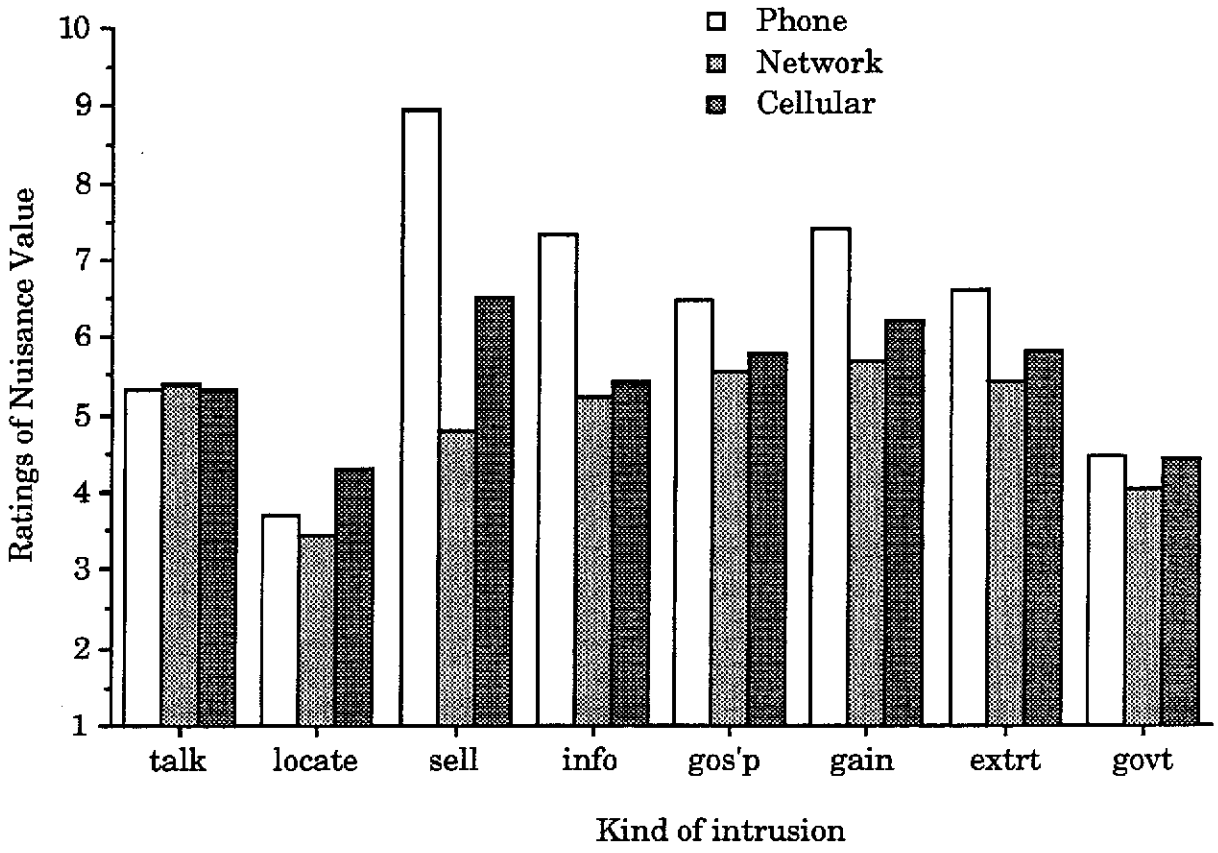


Figure 12. Ratings of intrusion.

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Future PCS

In a follow-up survey of trial participants, we asked them to evaluate future versions of PCS, based on their experience. We compared their responses to those of novices who had learned to use the phones and voice mail but did not have a PCS phone, and with experts—sales representatives who sell cellular telephones and services to the public. The data show that expertise is a strong determinant of people's desire for some features. For example, consider responses to a "control" question, which asked how much respondents valued voice mail, a feature currently available to cellular subscribers. The groups described in Figure 13 are Novices (graduate students from the learning study; see previous section), Low-Intermediates (trial participants who reported below-median expertise in using their PCS phones after 8 months), High-Intermediates (trial participants who reported above-median expertise in using their PCS phones after 8 months), and Experts (sales reps.). There is a significant relationship between expertise and ratings of voice mail ($F [3,122] = 6.2$, $p < 001$.)

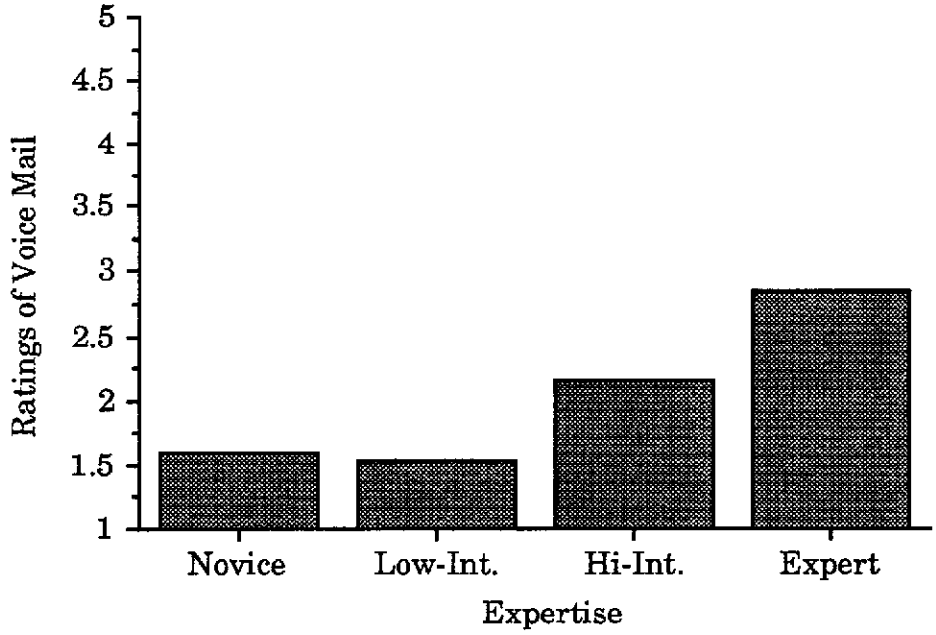

Figure 13. Ratings of voice mail: dollars people would pay per month for voice mail.

We then asked respondents to evaluate a series of features not currently available using a scale of 1-10, where 1 = not useful and 10 = extremely useful. These data are presented next.

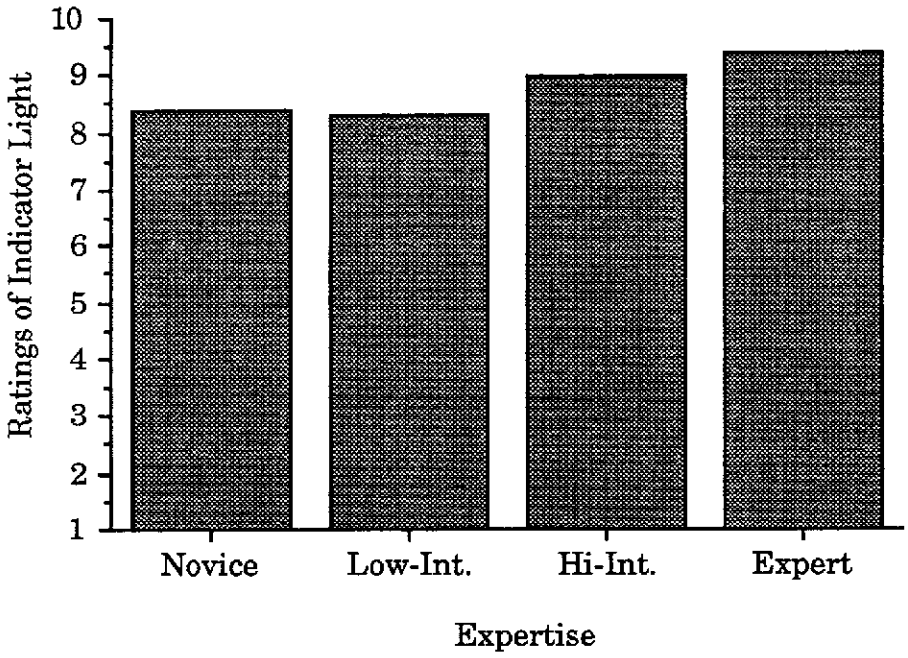

Figure 14a. Ratings of "an indicator light on your [PCS phone] that tells you when you have new messages waiting in your voice mail box." (Group differences are not significant.)

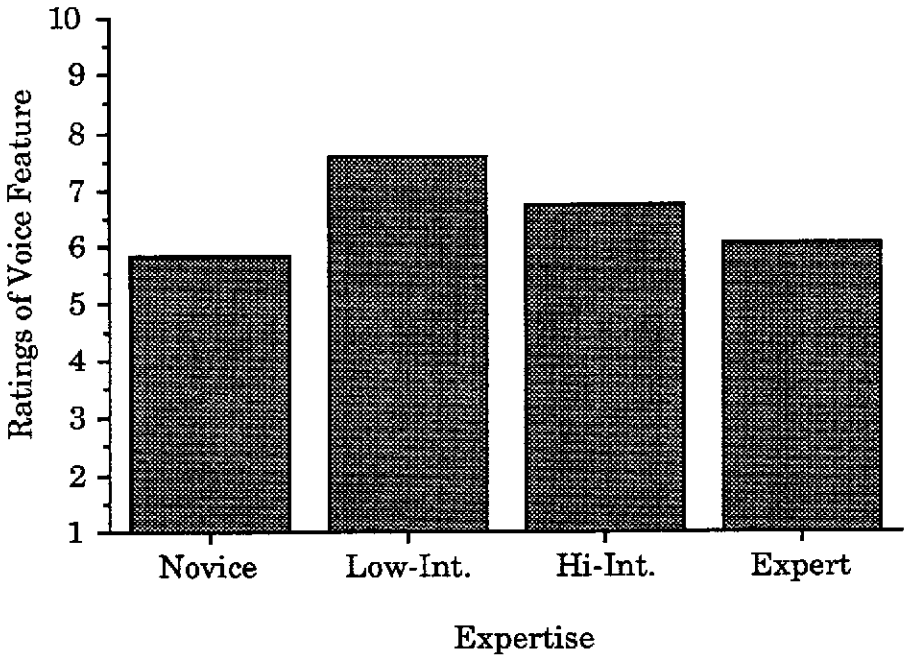

Figure 14b. Ratings of voice dialing that would "allow you to dial numbers by speaking the name of the person you wish to call." (Group differences are not significant.)

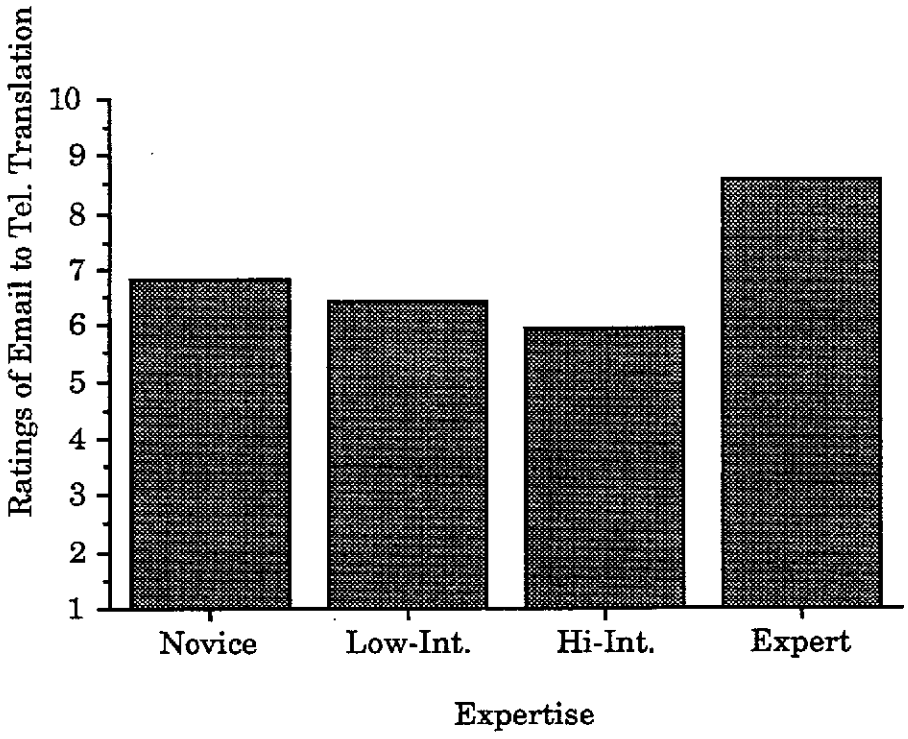

Figure 14c. Ratings of a translation device "that would allow you to listen to your email messages by telephone." (F [3,122] = 3.4, p = .02).

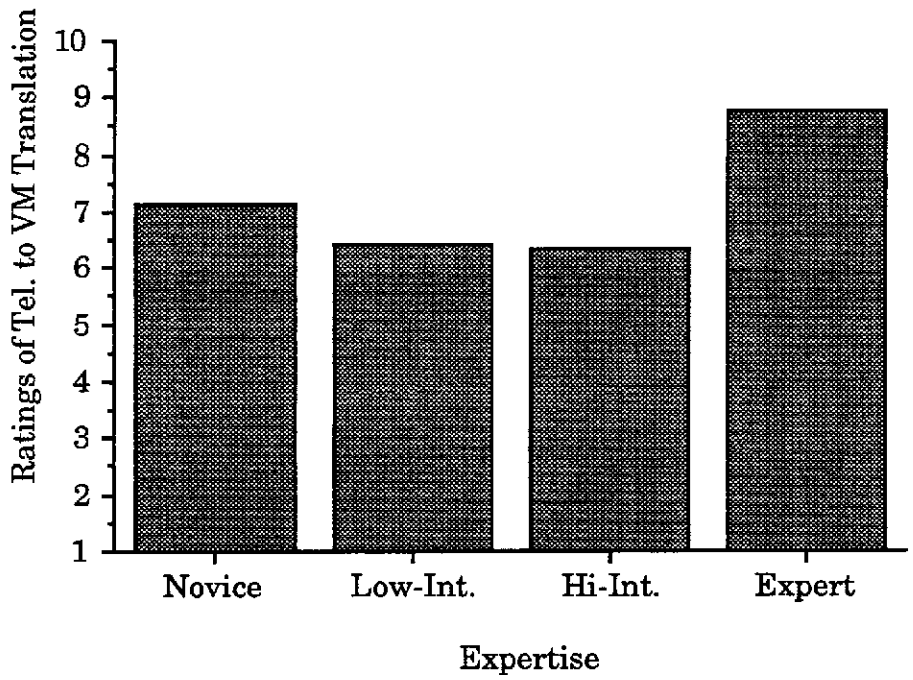

Figure 14d. Ratings of a translation device "that would allow you to leave email messages by telephone." ($F\ [3,122] = 3.4$, $p = .02$).

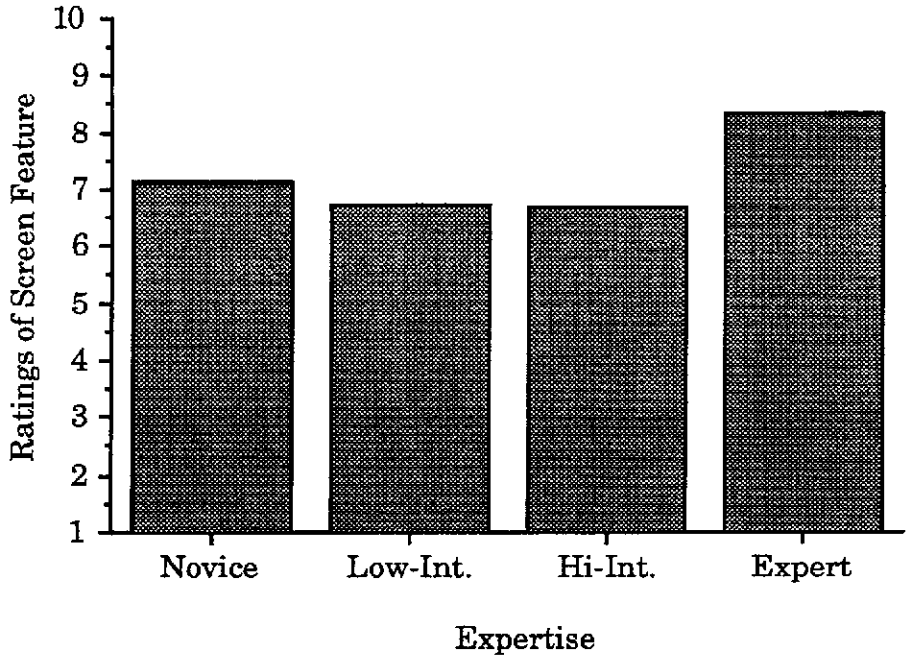

Figure 14e. Ratings of an automated screening system that "told you the number of the person calling and allowed you to either accept the call now or redirect it to voice mail." (Group differences are not significant.)

The data above suggest that people do rate additional features or services of PCS highly. However, the high ratings given by inexperienced novices, who do not own and have not used cellular phones, suggest that people tend to rate technology advances positively regardless of their actual experience and regardless of the specific nature of the feature or service. Ratings that varied with expertise are probably more believable, and therefore more indicative of future features or services that actual PCS users would value.

Summary

Across-the-board enthusiasm and high usage of the PCS technology suggest that wireless phones might easily be a universal consumer good, even indispensable to a minority, much like other communication technologies. However, participants' positive attitudes and intentions about PCS are very sensitive to the comparisons they make with wired phone services. That is, in the mental accounting people make of cellular or PCS, it is compared with wired phones, not with such other technologies as email, VCRs, or medical devices. In

this comparison, PCS prices come out very much behind, and PCS intentions were very sensitive to the current price structure for cellular technology. Consumers do not yet think of it as a necessary good, although our experience with trial participants indicates that these attitudes will change if consumers do try the technology. A number of our trial participants informally offered very negative remarks about the packaging of cellular subscriptions, which they feel is "elitist" and which would prevent most from affording PCS. If people were to subscribe to PCS at current prices of more than .30/minute and make 12 one minute calls per day, the cost of air time alone would be more than $100/month. Yet to make fewer than that would require actively trying not to make or receive calls. Participants compared having to do this with their ability to make unlimited local calls on wired lines, and did not like the result. Evidently, churning (turnover in the customer base) is a major industry problem; no doubt churning results from people making many calls and then discovering how much they have spent (Lange, 1993). As a result, they "quit" cellular entirely or try to restrict their calling, which drives them back to wired phones. We conclude people have an underlying preference for portable telephony but this preference will not be satisfied or acted upon in the current environment.

MOBILITY ACROSS WORKPLACE AND SOCIAL PLACE[10]

In every culture, the places people frequent predicts their social behavior and communications. The same person acts differently in a supermarket, in a bar, and in an office. The association of place with behavior is sometimes very specific. In the office, a secretary is likely to be typing on a desk computer, filing papers in a metal hanging-filing cabinet, answering a telephone, or perhaps, placing calls on the telephone. One does not ordinarily expect secretaries to do such things in bars or supermarkets, or even in hallways or meeting rooms of office buildings, or outside of office hours. Organizational theorists have proposed models in which communication is a primary activity correlated with the physical setting and its technology (Pfeffer, 1982; Steele, 1986; Rice, 1992). Constraints and opportunities for communication, and social norms regulating communication, influence what people do in different places. These same factors influence which places people choose to frequent. Particular places attract people with pre-existing preferences to behave in particular ways, and these choices will increase the observed association of place and behavior.

This study investigates how portable telephony may change the current practice of telephoning within offices and homes, and perhaps change people's other communication habits as well. For instance, if with a portable phone people feel free to leave their desks, more face-to-face communications might take place outside the office. There currently exists a strong tendency for people to have their work communications when they are physically situated in their office or workspace (such as a conference room). Likewise, people have most of their social communications at home. We investigated whether portable telephony would blur this distinction, that is, increase work communications at home and other social places and social communications at the office and other work locations. Researchers usually must infer from retrospective or cross-sectional evidence how people begin to use new technology. Because this study was conducted in the context of a trial of new technology, we were able to measure the communication behavior of groups in their workplace and other places before and after we gave them PCS technology. The trial is a "natural experiment" that allowed us

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[10]This study was conducted by Diana Gant and will be published in more detail in a separate paper.

to measure changes in patterns of communication across place that we would not have expected without the intervention of new technology.

The hypotheses of this study are related to three alternative arguments. First, an improvement in the opportunity to communicate does not necessarily change existing patterns of communication. Historical evidence on other technologies suggests that social behavior is very stable. Alternatively, improvements in the opportunity to communicate might increase communication in places where communication has been physically difficult. For instance, people with portable telephones might make more work calls in hallways of their office building and more personal calls in parks or in their backyards or automobiles. Existing habits of having work communications in workplaces and social communications at home and in other social places might not change, however. People would still talk with work colleagues around their workplace and with friends and family elsewhere. A third alternative is that new technology disrupts existing norms or rules of communication. If people have an underlying preference for flexibility and control in their communications, portable telephony could encourage people to do more social communication in office environments or more work communication in social environments or both. If portable telephony affords more flexible communications across place, then it could lead to a blurring of the distinction between workplace and social place (Jarratt and Coates, 1990).

Hypotheses

Since the use of PCS gives people an additional technology for communication within all behavior settings, it follows that people might increase their total communication across all locations. Accordingly, our first "baseline" hypothesis is:

Having the use of PCS phones will increase total communications across settings. (H1)

On the other hand, the office and home are already "high access" settings, that is, people currently have wired phones, and in some cases also fax machines, answering machines, and networked email or voice mail, which improves their opportunity to have asynchronous communications. In homes and offices people also are likely to be near other people. Hence it seems reasonable to expect that the addition of PCS phones in offices and homes will not add much real opportunity to people's existing opportunity send or receive communications. However, in settings where people previously had less direct access to others with whom they might want to communicate, and less access to communication technologies (i.e. hallways, restaurants, friend's homes, cars, and parks), having the use of PCS phones might significantly increase the opportunity to both send and receive communications. Further,

PCS phones permit people to do two previously incompatible activities at once. For instance, people can return calls and walk across campus at the same time. Hence our second hypothesis is:

Having the use of PCS phones will increase the proportion of communications people have in settings with low communication access. (H2)

Hypothesis 1 and 2 can both be true. Or, total communications might remain constant or increase at a rate slower than communications in low access locations. In either case, a substitution effect would have occurred. That is, PCS telephony, rather than (or, in addition to) increasing total communication, might lead people to substitute communications in low access settings for those in high access settings (presumably, using the PCS phone to place calls).

The introduction of PCS phones might affect the boundaries between work and social settings. If PCS phones are perceived as a general communication device like the wired telephone, then having PCS handsets around could blur existing social and work cues and encourage communication irrespective of place. Thus, more social communication might occur in work settings and more work communication might occur in social settings. Hence:

Having the use of PCS will increase the proportion of people's work communications in social settings and the proportion of people's social communications in work settings. (H3)

Method

This study was conducted using before-PCS and after-PCS diary data described in the first section of this report. The subjects of the study are described in Table 1. Section 1 of this report provides details of the method.

The general analysis strategy uses each person's diaries from before and after the PCS introduction. The unit of analysis is each communication and message. We examined communication and message attributes to determine how communication patterns changed. Chi square and regression models tested the significance of the relationships between communications before and after PCS, whether communications took place in high access or low access settings, whether they took place in social or work settings, and whether they were social or work in content. The term PostPCS in a regression model captures variation in how the relationships between message attributes changed from pre-PCS to post-PCS. A significant interaction between a PostPCS and the other variables suggests that the PCS technology changed patterns of communication.

Statistical analyses assume that each communication is an independent event. This would not be true if we included in the same analysis all sent and received communications reported in the diaries, because the same communication might be "sent" by one person and then recorded again as "received" by one or more others. To prevent such double counting, all analyses were conducted separately for sent and received communications.

Analyses of total communication (H1) compared pre-PCS with post PCS communications. Analyses of communication in high or low access settings (H2) required a code for high or low access. Setting access was coded as "high" if the respondent recorded the communication was sent (or received) in the office or home, and it was coded "low" if the respondent recorded the communication in other locations. The office and home were defined arbitrarily as providing high access because people generally have access to telephones and other people in those settings.

The variable, communication setting (H3), was coded as "work" if the respondent said the communication (or message) was sent (or received) in any workplace, including an office, campus building, or outside on campus. The setting was coded as "social" if the communication was sent (or received) at home, in a car, a public place (i.e. a restaurant), or in a private place (i.e. a friend's home).

The variable, communication topic (H 3), was coded as "work" if the communication or message contained any reference to work (e.g., meetings, clients). Communications that included both social conversations (e.g., greetings) and work-related topics were coded as work. Also, vague references to a topic were coded as work-related communications.

The topic variable was coded based on the description of the message topic as assessed by the researcher from pre-PCS diaries and self-reported by the participant at the post-diary interview at post-PCS data collection. To check the accuracy of the coding scheme, the self-reported social communications on the post-PCS diary were compared with researcher-coded social communications. The correlation coefficient between these two variables represents the proportion of pairs where the values of both variables agree. The correlation coefficient is 0.96; suggesting that the coding scheme accurately reflects participants' reports of work versus social communications.

Results

We hypothesized (H1) that the total number of communications would increase after people had the use of portable telephony—PCS technology. Table 8 summarizes the total number of

communications pre- and post-PCS, across locations and settings, for the entire sample. These data are presented separately for sent and received communications.

Table 8 shows that the total number of communications after the trial was apparently lower than the number reported before the trial. For the 58 people in the study, the total number of pre-PCS communications = 3002 and the total number of post-PCS communications = 2631; yielding a $\chi 2\ (57) = 450$, $p < .001$. Much if not all of the apparent drop, however, is due to a change in the comprehensiveness of participants' diaries before and after the trial started. (See discussion of response rates and reliability in section 1.) Pre-PCS, we were able to match senders and receivers for a majority (54.2%,) of "matchable" communications but post-PCS we matched only 41% of matchable communications. Hence we can infer that participants underreported their communications by nearly 60% when they kept diaries the second time. The drop in recorded communications from pre-PCS to post-PCS is less than the increase in underreporting, implying that if participants had been as comprehensive on the second diary, there would have been a slight increase in the number of communications.

Table 8. Change in number of communications from first to second diary.

	Number of Communications			
	Before PCS	After PCS	Chi-square (d.f.)	P-value
University Relations	1180	1101	89.85 (22)	0.000**
Computing Services	1467	1321	339.8 (24)	0.000**
Drama	355	299	19.56 (9)	0.0224*
Total	3002	2631	450 (57)	0.000**

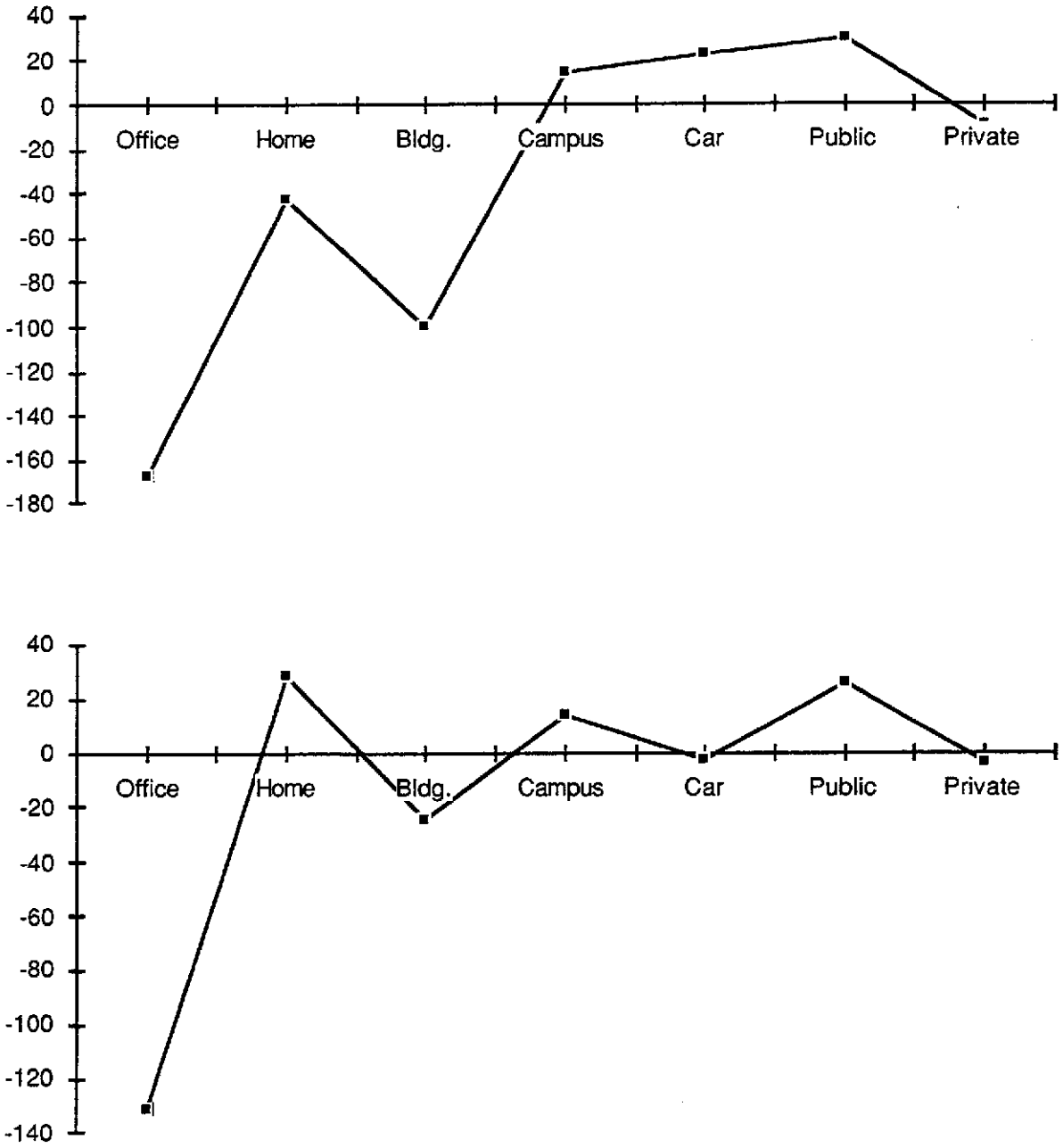

Figure 15. Change in number of sent communications (top figure) and received communications (bottom figure) from pre-PCS diary to post-PCS diary.

The second hypothesis posited that with the introduction of PCS, communications in low communication access settings would increase as a proportion of total communications. Figures 15 and 16, and Tables 9 and 10, summarize the number and proportion of the total number of communications pre- and post-PCS across behavior settings for the total sample. The communications are separated according to sent and received communications. Across all groups, communications in low access settings increased (but not significantly) after the introduction of PCS (sent: pre-PCS = 27.28%, post-PCS = 29.25%; received: pre-PCS = 11.88%, post-PCS = 13.19%). Considered separately, both the University Relations group and the Telecom groups showed a modest shift in the percentage of communications from high to low communication access settings. The University Relations staff sent more communications from low access settings (pre-PCS = 14.77%, post-PCS = 15.38%), but received more communications in high access settings (pre-PCS = 12.55%, post-PCS = 7.1%). The Telecom staff both sent and received more communications from low access settings (sent: pre-PCS = 39.09%, post-PCS = 41.24%; received: pre-PCS = 9.33%, post-PCS = 10.3%). Drama staff, however, showed a large shift in communications from high to low communication access settings (sent: pre-PCS = 34.06%, post-PCS = 54.26%; received: pre-PCS = 23.11%, post-PCS = 46.76%). Communications of the Drama staff moved away from the office and into campus buildings, including the theater and production shops. We think the larger change of behavior in the Drama department is a response both to its needs and to the absence of bureaucracy in that department.

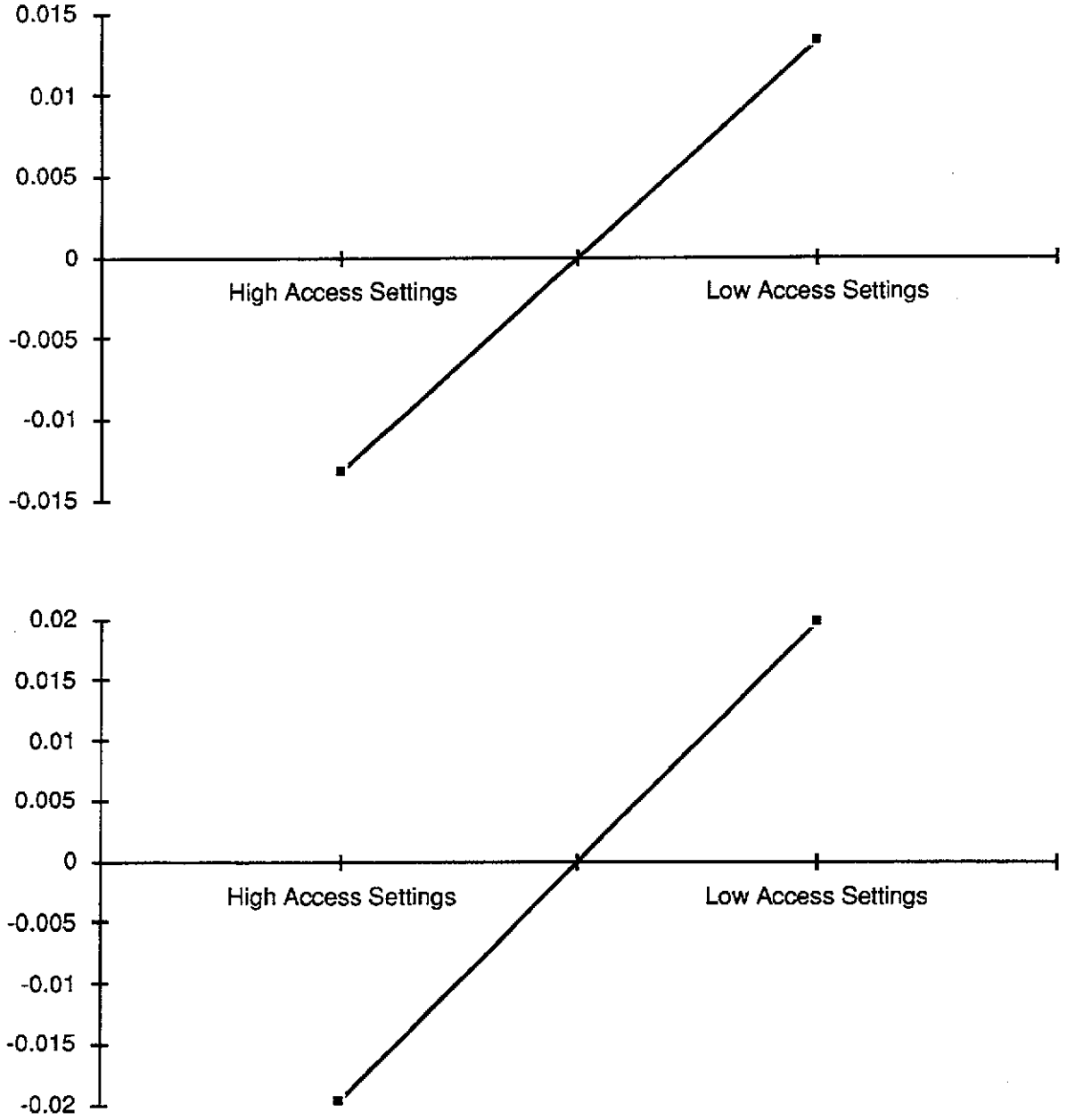

Figure 16. Percent change in the proportions of sent communications (upper graph) and received communications (lower graph) from high to low access settings, pre- to post-PCS.

Table 9.

SENT COMMUNICATIONS

	Behavior Setting							
	High Access to Others		Moderate or Low Access to Others					
	Work Setting	Social Setting	Work Setting		Social Setting			
Topic	Office	Home	Bldg.	Cam-pus	Car	Public	Pri-vate	Total
				Pre-PCS				
Work	55.0%	2.7%	18.7%	.6%	.1%	.8%	.2%	78.1%
Social	6.4%	8.6%	1.8%	.4%	1.4%	2.6%	.8%	21.9%
Total	61.5%	11.3%	20.4%	1%	1.5%	3.4%	1%	100%
				Post-PCS				
Work	53.5%	1.1%	13.8%	.9%	.7%	4.1%	0%	74.0%
Social	7.3%	9%	2.6%	1.5%	3.2%	2.6%	0%	26.0%
Total	60.7%	10.1%	16.4%	2.4%	3.8%	6.7%	0%	100%

continued next page

Table 10.

RECEIVED COMMUNICATIONS

	Behavior Setting							
	High Access to Others		Moderate or Low Access to Others					
	Work Setting	Social Setting	Work Setting		Social Setting			
Topic	Office	Home	Bldg.	Cam-pus	Car	Public	Pri-vate	Total
				Pre-PCS				
Work	77.1%	0.90%	8.4%	0.3%	0.5%	.1%	0.13%	87.4%
Social	6.5%	3.7%	0.8%	0.3%	0.8%	.6%	0.13%	12.7%
Total	83.6%	4.58%	9.16%	0.5%	1.2%	.7%	0.26%	100%
				Post-PCS				
Work	66.3%	2.5%	6.8%	0.8%	0.6%	1.3%	0%	78.3%
Social	13.8%	4.3%	1.2%	0.7%	0.6%	1.2%	0%	21.7%
Total	80.0%	6.8%	8.0%	1.5%	1.1%	2.5%	0%	100%

Hypothesis 3 was that the introduction of PCS would increase the proportion of people's work communications in social settings and the proportion of people's social communications in work settings. Figures 17a and 17b show changes in the location of communications in general as well as changes in the kinds of communication that people had in different settings before and after the trial. As can be seen in these figures (and derived from the table above), there is an effect supporting the hypothesis. The statistical analyses shown in Table 11 indicate that, across all groups and levels, there is a statistically significant model for received communications, but not for sent communications. More fine-tuned models (not shown in this report) show that for most groups and kinds of people, after the trial, there was more social communication in work settings and, to a lesser extent, there is more work communication in social settings.

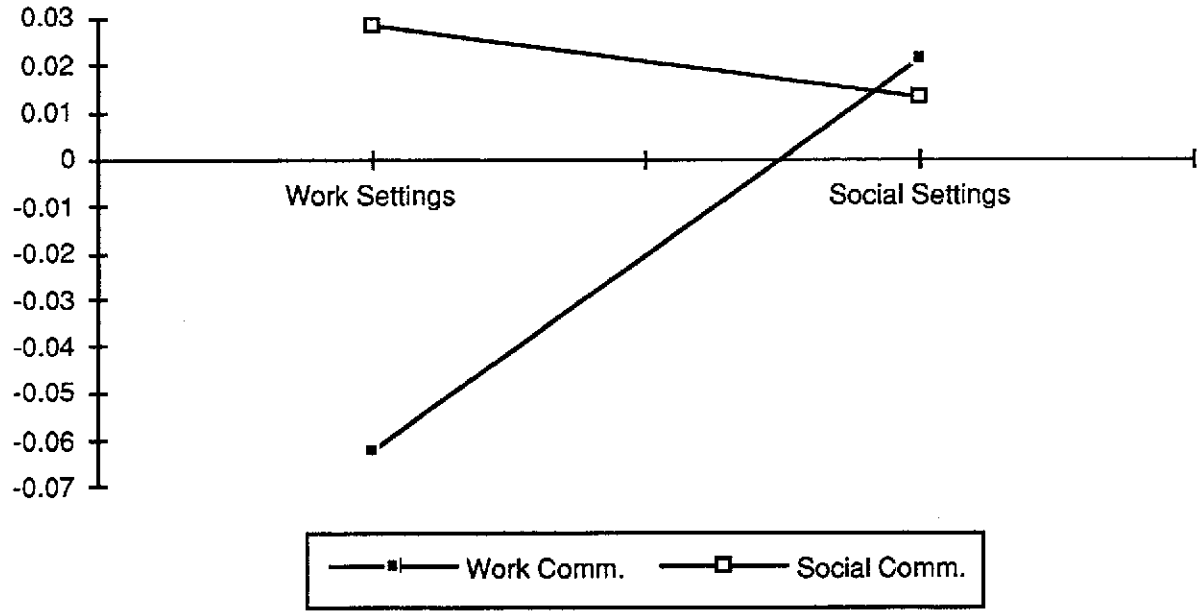

Figure 17a. Percent change in the proportion of sent work communications in social settings and social communications in work settings, pre- to post-PCS.

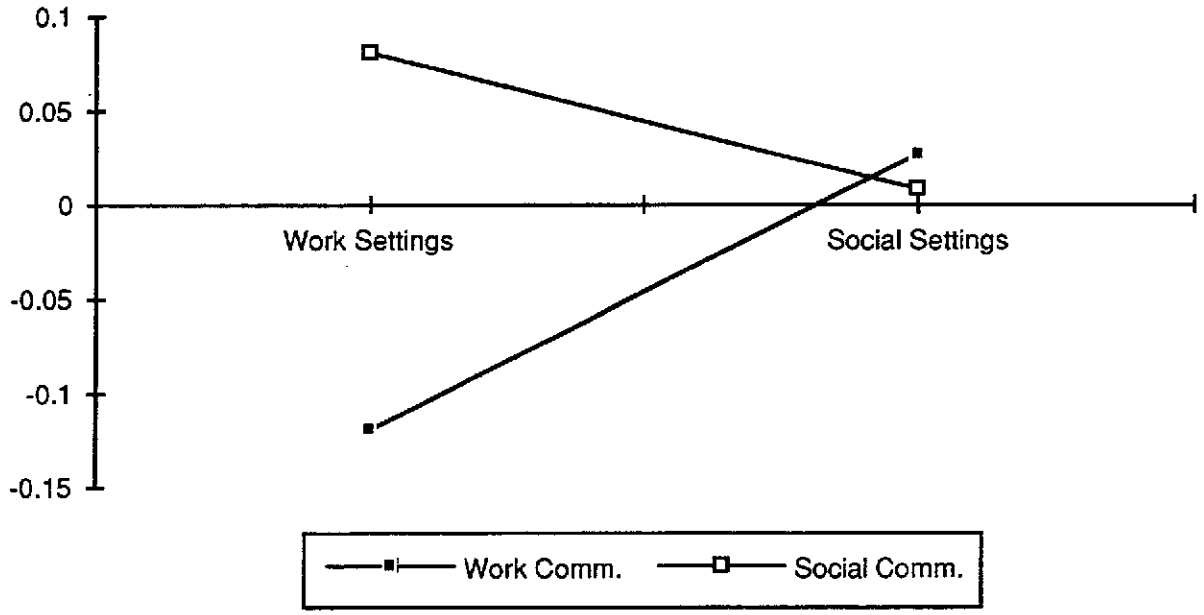

Figure 17b. Percent change in the proportion of received work communications in social settings and social communications in work settings, pre- to post-PCS.

Summary

The results of this analysis suggest that PCS or cellular portable telephony does have social implications. This study shows that use of the technology in work groups is associated with a blurring of the boundaries of workplace and social place. Further analyses (to be reported in a subsequent draft) will determine how particular communication technologies are related to this change. At this writing we have determined that although paper communication did not change from pre-PCS to post-PCS, social communication in work settings and work communications in social settings did increase for communications by wired telephone and face-to-face communications. These data suggest that people were not simply communicating different amounts with different people in the same places but were more mobile as well.

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