

**VALIDATING A COMPUTER ASSESSMENT OF HOUSING FOR OLDER ADULTS: AN APPLICATION OF DESIGN KNOWLEDGE TO PROMOTE INDEPENDENT LIVING**

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**Abstract**

*The gap between gerontological design research and interior design practice that can apply this knowledge is addressed. A validation study was conducted of the Elderly Resident Housing Assessment Program (ERHAP) to test the hypothesis that a computerized artificial intelligence system is a comprehensive and reliable home evaluation tool for identifying housing inadequacies among older residents. The following research questions were asked: (1) When does the expert panel identify the same inadequacies as the computer program? (2) When does the expert panel identify inadequacies the computer program misses? (3) When does the computer program identify inadequacies that the expert panel misses?*

**Introduction**

The consumer impact of safe and supportive independent living within the community for older adults is of high social priority. This is evident because helping older adults stay in their own home as long as possible has significant fiscal and policy implications for our American society. With estimates suggesting that annual nursing home expenditures are as much as ten times higher than home care expenditures, finding alternatives to institutionalization has become a popular rallying cry (Applebaum and Phillips, 1990). Social policies reflect this priority: the 1981 Omnibus Budget Reconciliation Act (OBRA), states receiving Section 2176 waivers allowing Medicaid reimbursement for case managed in-home care, 1980 OBRA liberalizing Medicare home health benefit and stimulated greater participation of proprietary home care agencies in the Medicare program, and Social Services Block Grant and Title III of the Older Americans Act increasing funds for in-home care.

With this growth of home care to assist individuals who choose to reside in their own home as long as possible, the quality of home care becomes more critical (Applebaum and Phillips, 1990). One component of assuring the quality of in-home care is the physical environment. The attention to the physical home environment is of particular interest to environmental gerontologists and designers and is the focus of this study. While there is a base of heuristic design knowledge that demonstrates how to provide safe and supportive home interiors, there is consternation regarding the application and utility of that knowledge base for those who most require assistance.

The gap between environmental research and practice is also recognized as the schism of knowledge and implementation or the detachment between expertise and application. This gap, schism, or detachment has been widely discussed in the environment and behavior field, workshops, and conferences, and easily readable publications are promoted to assuage the situation. Robert Sommer addressed the issue of "research utilization" in his keynote address at the Environmental Design Research Association and promoted reports describing research findings, articles in trade periodicals, direct consultation on design projects, and legal testimony. Furthermore, he suggested that the cooperative extension service model in agriculture be followed where as much time is devoted to dissemination, implementation, and evaluation of impact as to data collection and analysis (1990). It may also be argued that the best solution to closing the gap has more to do with a researcher's commitment to improving the quality of life for the user as a primary purpose and orientation than any other post-research marketing strategy.

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Designers write and collect design guidelines that are of use to those who are designing large, new housing complexes. Designers have numerous texts and checklists that are standard references. These design criteria can be computerized (Brent, Phillips, Brent, Gupta, and Ray-Degges, 1991; Brent and Phillips, 1990; Brent and Brent, 1987).

While computer technology may help the designer retrieve that knowledge so that it can be applied to new construction, the gap between expert and user is wide. For the older adults who are struggling to live in their own home, and not inclined to hire a designer/consultant to help them make their home more livable and safer, the impressive current gerontological design knowledge may as well be nonexistent. While more information on how to design for older populations can be stored in a data bank, that information is useless unless it can be translated and applied as specific recommendations in making a home more safe, functional, and comfortable.

It may further be argued that professional designers commonly experience contradictions in how they are paid and how to make the most difference in peoples' lives. Design professions are not structured to provide services for the masses who can not pay for specialized consultation. Furthermore, these masses are unaware of the "value added" benefit of design in their immediate home setting. Therefore, this market for interior design services is unrealized.

The significance of this study is that it contributes to solving the practical problem of independent living in housing older adults. The study builds on past research that addresses the housing problems of elderly Americans. For example, Struyk (1984/85) reports that the concept of adequate housing should include minimally acceptable physical standards such as plumbing facilities, that it be affordable, and that it include the ability of the persons to use the unit (p. 3). Struyk suggests that the need for some types of supportive services can be eliminated by various changes to the dwelling that can compensate for particular functional impairments--ranging from grab-bars to modifications for wheelchairs. He estimates the probable need for modifications--beyond those already occupied by some 700,000 elderly-headed households--is on the order of one million units. And, some 250,000 households within this group need special features because of their impairments (p. 10).

Reschovsky and Newman (1990) examined how well older frail households cope with the requirements of independent living and considered household operation activities, housing consumption adjustments, and health-related activities. Housing consumption adjustments were described as whether the use of rooms were changed or stopped, whether the dwelling had special modifications or features such as grab bars, handrails, or ramps, and whether the household had recently moved to the present residence within the past year. They reported that about 10 percent of the frail households lived in dwellings with at least some accommodating feature. Only 7.6 percent of frail households had moved to another residence in the past year and 26 percent had lived in their current dwelling for four years or less. And 3.4 percent of the frail elderly in the sample changed or stopped using a room in the past year (1990). From this evidence, it may be argued that there is a large gap between what environmental gerontologists understand will facilitate a supportive habitat and the actual application of this knowledge for those who would most benefit. The leading cause of death in the home for all ages is due to falls, with a reported 6,300 deaths (Allman, 1985). Perhaps the number of these fatalities could be reduced with environmental modifications.

The theoretical perspective used in this study is best described as a functional perspective of how older persons live or adapt to their home setting. It is exploratory research since there is little evidence that such an assessment is useful in identifying housing constraints.

The background assumption of this study is that environmental gerontology information can be computerized to generate a comprehensive computer assessment. Furthermore, it assumes that the identification of housing problems for residents will be useful in improving their residence.

### **Methods**

A comprehensive computerized program called the Elderly Resident Housing Assessment Program (ERHAP) was used to identify housing inadequacies (Brent and Brent, 1987).

The computer program systematically utilizes over 300 rules in the field of environmental gerontology when an assessment is conducted. Questions are organized by room to facilitate a room by room walk-through assessment. The program identifies potential housing problems that may be a hazard now or in the foreseeable future given the unique set of resident health and individual constraints. The Elderly Resident Housing Assessment Program (ERHAP) was developed using an expert system shell, which enables it to solve complex problems by using an explicit computer model of human reasoning. This provides the program with the capability of reaching identical conclusions that a human expert would reach when faced with a comparable problem. Figure 1 lists some of the questions in the environmental assessment that were asked of residents regarding their bathroom.

**Figure 1. Example of bathroom assessment.**

The resident has a lack of physical coordination and/or lack of physical strength in the upper extremities (upper body) and the bathroom has

1. a standard knob or handle
2. a "D" handle

The floor treatments of the living areas and the bathroom are

1. made of different surface treatments and as a result floor heights vary slightly
2. not made of different surface treatments and as a result the floor is flat and level

The resident is forgetful and the water in the dwelling is

1. too hot (greater than 120 degrees F)
2. of a controlled temperature (115 to 120 degrees F)

The resident is

1. uncomfortable with bathroom area lighting
2. comfortable with bathroom area lighting

The resident has

1. adequate light source directly over tub or shower
2. inadequate light source directly over the tub or shower

The resident's eyesight is fair or poor and light is

1. not pointed directly towards the mirror in the bathroom vanity area
2. pointed directly towards the mirror in the bathroom vanity area

The resident's eyesight is fair or poor and lighting in the vanity/lavatory area is

1. inadequate, shadows often appear on the residents' facial features
2. adequate, facial features are evenly illuminated

The resident has

1. a ceiling fan or vent in the bathroom
2. no ceiling fan or vent in the bathroom
3. an easily operable window

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ERHAP incorporates advanced computer technology to provide specific, individualized design recommendations to users. This dissemination model is only possible with the advancement of computer technology called artificial intelligence. That is, an expert system was developed to provide design knowledge during a home assessment conducted by a relative or health care provider in the home. Specific recommendations are made to improve the interior. The program was used by a community housing development agency conducting housing quality audits and also by University Extension for pre-retirement workshops. (For further descriptive information on the program's development and use, see: Brent, Phillips, Brent, Gupta, and Ray-Degges, 1991; Brent and Phillips, 1990; Brent and Brent, 1987.)

Authors of the program hypothesized that a computerized artificial intelligence system could be a comprehensive and reliable home evaluation tool for identifying housing inadequacies among older homeowners. To test these hypotheses, a validation study was conducted which addresses the following research questions:

1. When does the expert panel identify the same inadequacies as the computer program?
2. When does the expert panel identify inadequacies the computer program misses?
3. When does the computer program identify inadequacies that the expert panel misses?

Fifty persons sixty years of age or older were selected to participate in a study that examined housing inadequacies. The assessment focused on inadequacies in three areas -- safety, function, and comfort. All resided in the same Midwestern community of approximately 65,000 people. Most individuals participating in the study had household incomes between \$5,000 and \$9,999 (82 percent). Of the 50 cases sampled, 45 cases agreed to complete the assessment. Names of respondents were obtained from the local Housing Development Agency. Respondents were participating in a home repair program funded by the Community Development Commission and the local City Council. They were low income individuals qualifying for community services.

The project was interdisciplinary involving design and social science researchers with advanced degrees and experience in interior design, architecture, sociology, and computer science. The environmental design project also represented interagency cooperation of groups from private industry, community service, and the university to address the interior environmental problems of housing inadequacies for low income older adults.

Utilizing the computer program and a portable computer, assessments were conducted in residences by a designer trained in environmental gerontology. Each home assessment took approximately one hour and fifteen minutes to complete the interview protocol and identify inadequacies with a tour of the home. Photographs were also taken to document particular problems for further analysis. After analysis of the assessment, a report was written to the individual participant listing problems and recommendations for his/her home improvements. Participants were under no obligation to make changes. The assessment results could then serve as a "design program" for assistance from a social service agency.

Two nationally recognized design researchers familiar with environmental gerontology independently reviewed the photographs, demographics, health status, and floor plan sketches for each case to identify housing inadequacies. Each expert then documented environmental problems for each case. The housing inadequacies were then checked against those identified by the computer.

### Results and Discussion

The findings for this validation study are reported by the research questions addressed. The first question was: "*When does the expert panel identify the same inadequacies as the computer program?*" Table 1 shows the mean number of housing inadequacies by computer program and experts among forty-five homes. Complete expert and program agreement occurred 84 percent of the time.

Table 1. Housing inadequacies identified by experts and computer program.

	Mean # and %
Expert agreement and Expert/program agreement	228.9 (84%)
Expert agreement and Expert/program disagreement	33.4 (12%)
Expert disagreement and Expert/program disagreement	9.8 (4%)
Expert/program disagreement Total	272.1 (100%)

The second question addressed was: “*When does the expert panel identify inadequacies the computer program misses?*” There was a low level (1 percent) to which the expert panel identified problems that the computer did not (mean = 2). (See Table 2.)

Table 2. Expert agreement and expert/program disagreement.

	Mean # and %
Expert not identifying inadequacies and program identifying inadequacies	31.4 (12%)
Expert agreement identifying inadequacies and program not identifying inadequacies	2.0 (1%)
Total expert agreement and expert/program disagreement	33.4 (12%)

The recommendations that were made by experts, that the computer did not catch, related to three different types of problems. The most common inadequacies required a subjective judgement call in situations having a relative safety threshold. For example, distance of flammable items from a burner or heater, distance of electrical appliances and lighting from water, distance of items from a ceiling fan, mechanical operation of a door, uneven floor surfaces and floor vents which cause one to stumble, holes and tears in the floor covering, foliage blocking exterior entrance, interior plants located where watering would be difficult, and the excessive amount of clutter impairing safety. Experts were strong in their subjective evaluation of identifying a problem. Experts were able to adjust the “threshold” of what was considered problematic while the computer worked within the system of what was labeled problematic. In some homes where there were few life safety problems, experts were able to identify more function and comfort concerns.

In addition, some inadequacies were identified only when seen in the full functional context of a space such as the refrigerator door opening from the side that would make the kitchen most efficient. Other comments included an inefficient floor plan that required one to walk through the bedroom to get to the bathroom, range location near a corridor, and too large of a house for a forgetful person. Expert designers can take specific situations and subjectively make a larger generalized recommendation. There is a limit to which a range of possible situations can be included in the computer program for comparable recommendations.

Another explanation is that some inadequacies were identified that would be subtle non-critical issues that a trained designer would perceive but not a priority concern for the computer program. For example, the designers would identify quality of lighting and figure-ground relationships of objects.

The third research question addressed was: “*When does the computer program identify inadequacies that the expert panel misses?*” The mean number of housing inadequacies that the program found and the experts did not find was 31.4. (12%).(See Table 2.) The computer program appeared to be more consistently thorough than the experts. While experts were asked to identify inadequacies and make recommendations like the computer program, experts were inconsistent about reporting both inadequacies and recommendations. Often, the experts would identify the inadequacies but would not make appropriate, although seemingly obvious, recommendations. The program is also convincing because it is descriptive and easily confirmed from data and positive observations.

The computer program easily focuses on both small and large hazards because of the structure of its programming. Perhaps because of the limitation of the procedure of experts reviewing photographs, or perhaps because of the difficulty of focusing on both small and large problems, some inadequacies were not routinely identified by experts. For example, it was difficult for the expert panel to determine from photographs if ground fault interrupters were available.

In examining the homes of older adults, features categorized as safety inadequacies such as throw rugs or electrical cords across the traffic path, were found more frequently than function or comfort problems. It was difficult, however, to separate inadequacies in

terms of safety, function, and comfort. It was recognized that safety inadequacies contributed to individual capacities to function in their home and contributed to their overall comfort as well. Thus, as the study progressed, the lines of distinction between safety, function, and comfort were less important in identifying housing problems. For example, when kitchen cabinets were assessed as being too high to use, the concern was for both safety and function. Similarly, when a step stool was needed to reach kitchen cabinets, it was both a safety concern and a function concern because step stools are difficult to use.

The reliability of the computer program is approximately the same as the reliability of experts compared with each other as measured by percent agreement (See Table 3). Some examples found in five or more cases by both experts and not included in the program are:

Kitchen

- Range too close to doorway, tight between counter and side of range...both could cause accident with pot handles or open flame of burner and loose clothing
- Refrigerator door opens wrong direction

Bathroom

- No place to sit in bathroom
- Heater does not provide even heat
- No counter space near sink in bathroom

Bedroom

- Dresser drawer in bedroom too low

Living room

- Heater does not provide even heat
- Floor vent could catch shoe (tripper)

Table 3. Summary report and coding of expert and program findings.

Expert A	Expert B	Program	Code	Mean #
no (0)	no (0)	no (0)	9	228.0
no (0)	no (0)	yes (1)	1	31.4
no (0)	yes (1)	no (0)	2	2.7
no (0)	yes (1)	yes (1)	3	.6
yes (1)	no (0)	no (0)	4	4.9
yes (1)	no (0)	yes (1)	5	1.6
yes (1)	yes (1)	no (0)	6	2.0
yes (1)	yes (1)	yes (1)	7	.9
Total				272.1

Table 4 gives the high level of the computer program's validation success. That is, the expert and program agreement (84 percent) is combined with the unique success of the program in identifying inadequacies that the experts did not find (12 percent) to total 96 percent.

Table 4. Summary of program validation percent.

Expert and program agreement	84%
Program identifying inadequacies that experts did not find	12%
Total validation percent	96%

This validation study enables the research team to identify areas where design experts found housing inadequacies that the program did not and improve the program. Because the expert system is cumulative, the knowledge system can be built to become a more powerful system. This cumulative character of the program is in contrast to humans who age, forget, move away, or die..

### Implications

The unique contribution of this study, which distinguishes it from earlier research, focuses on closing the research/ practice gap. Commonly, there is a contradiction between academic research and making a practical difference in the lives of many people requiring environmental modifications. With a computer program that is widely available, it is unnecessary for a client to request the professional services of a designer. The computerized protocol, it may be argued, does not directly compete with the professional designer but aids in the design programming stage of the design process. A bridge is made between several disciplines to identify housing constraints and more accurately identify constraints to the health, safety, and welfare of older adults. The more comprehensive this list of housing problems and general recommendations is, the better the designers can complete the later stages of their work.

Implications for future research include replication where site visits are made by an expert panel. Also, replication could determine if there is "any value" for distinguishing inadequacies in terms of safety, function and comfort. In addition to further testing, results of this validation study suggest that making this program available to existing service providers is warranted. A commercial version of this program is being marketed as "Home Safe Home."<sup>1</sup>

The program seeks to advance the knowledge base from heuristic to empirically tested knowledge. The long term benefit of this type of research is that there is a more refined knowledge base guiding the practices of design professionals and demonstrating an impact in the lives of people in society. The benefit of this research will ultimately be realized for the masses with practical application for older adult service providers.

<sup>1</sup> Footnote: Marketed by the Idea Works, Inc., 100 W. Briarwood, Columbia, Mo. 65203.

### References

- Allman, W. F. (1985). We have nothing to fear. *Science*, 6(8), 39.
- Applebaum, R. & Phillips, P. (1990). Assuring the quality of in-home care: The "other" challenge for long-term care. *The Gerontologist*, 30(4), 444-450.
- Brent, R. S., Phillips, R. G., Brent, E. E., Gupta, M. K. & Ray-Degges, S. (1991). Older adults residing in their own home: Prioritizing housing inadequacies. *Housing and Society*, 18(1), 23-33.
- Brent, R. S. & Phillips, R. G. (1990). Communicating housing design knowledge for older adults using electronic technology. *The Candle*, 71(2), 5-10.
- Brent, E. E. & Brent, R. S. (1987). ERHAP: An artificial intelligence expert system for assessing the housing of elderly residents. *Housing and Society*, 14(3), 215-230.
- Reschovsky, J. D. & Newman, S. J. (1990). Adaptations for independent living by older frail households. *The Gerontologist*, 30(4), 543-552.
- Sommer, R. (1990). Research on utilization: Did anyone use it? Where did we lose it? *Proceedings of the Environmental Design Research Association Annual Conference*. University of Illinois at Urbana-Champaign, April 6-9.
- Struyk, R. (1984/85). Housing-related needs of elderly Americans and possible federal responses. *Journal of Housing for the Elderly*, 2(4), 3-26.

