TOWARDS ROOM ACOUSTICS FOR AN ELDERLY POPULATION

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ABSTRACT

A qualitative social survey has been conducted on a group of 207 elderly people with a hearing loss. The aim of the study was to determine the extent to which acoustic problems in the built environment affect this subject group. The project was thought necessary because most areas of the built environment are designed using an assumption of normal hearing. The work was conducted as part of the EPSRC EQUAL programme to extend the quality of life for disabled and elderly users of the built environment. It was found that the speech communication of elderly people was significantly affected by the presence of background talkers in a reverberant environment. However, some routine social interactions can tolerate poor speech communication. Considerable evidence of subjects adapting their behaviour to acoustic problems was found. For example, a large number of subjects experienced poor reception with hearing aids. This prompted them to use the aid selectively. Also, poor sound insulation in domestic dwellings gave a strong disincentive for some subjects to use their television sets at a comfortable listening level.

1. INTRODUCTION

The built environment is largely designed for the able-bodied [1]. Though there are no doubt cultural reasons for this, it is also true that designers have little data available to them on the needs of various disabled groups or on the ways in which these groups use the built environment. One such group consists of elderly people with a hearing loss. It is a large section of the population – the average hearing loss for speech increases by 5 to 8 dB per decade of age [2]. Most of the readers of this paper will become a member of it at some point. However, most buildings seem to be designed for users with normal hearing.

It is known that inappropriate room acoustics can affect the listening experience of those with age-related hearing loss. For example, older adults experience more difficulty understanding reverberated speech than do younger individuals [3]. Elderly individuals are also greatly affected by background noise; for example, a signal-to-noise boost of more than 10 dB was needed to improve speech discrimination in noise for a group of elderly listeners [4]. Technological responses to hearing impairment have to date concentrated on augmenting the receiver using hearing aids. While these can offer considerable benefits, they work best in a non-reverberant environment with low background noise levels [5]. However, many enclosed spaces, particularly public or semi-public ones, do not fit this description well. Comparatively little attention has been paid to modification of the acoustics of rooms where the hearing-impaired may experience problems. The only study to address this problem directly [6] predicted that reverberation times should be reduced to improve the speech-reception threshold of elderly listeners. However, the effects of doing so were not directly measured.

Acoustic designers of rooms therefore have little data available to them when they try to consider the needs of the hearing-impaired. (There may be something of a vicious circle here: because there is little data disseminated, designers may not think to design for hearing loss and so may not

demand data from the research community.) The design criteria used for building acoustics suffer from being largely based on experimental work with individuals with good hearing. For example, it is rare to see a psychoacoustic study in building acoustics that does not as a starting point to the investigation reject all subjects with poor hearing as determined by pure tone audiometry.

The long-term aim of the work reported here is to provide technological and design solutions to improve acoustics for the hearing-impaired. It is intended that the solutions would work for both users and non-users of hearing aids. If the built environment is improved so that the signals reaching the listener are improved, then the listener's auditory system and any hearing aid have less work to do to extract information. But before this work can be carried out, it is important to determine what problems the hearing-impaired face and so establish the priorities for further investigation. This paper reports on an initial study that sought to identify these problems.

The project aimed to answer the following questions:
1. To what extent are elderly individuals with a hearing loss affected by acoustic problems in the built environment?
2. What problems are perceived, in what environments and what activities are interfered with?
3. Can a multi-disciplinary research approach offer advantages in this kind of study?

The rest of the paper is structured as follows: first, the qualitative research methods used are discussed, because these may not be familiar to readers of this paper. Next, the results are discussed using examples of the data, in the form of textual quotations. Finally, some conclusions are drawn for acoustic design and for future research in this area.

2. METHOD

The choice of research method was crucial to the outcomes of this study. The project sought to explore the perception of acoustic problems experienced by elderly people with a hearing loss. It was decided that this would be best achieved by allowing the respondents to express these problems in their own language and in a naturalistic social context. This desire oriented the study away from quantitative methods and towards qualitative ones.

The project consisted of six stages: identifying the sample, surveying the whole sample with a brief questionnaire, researching a sub-sample with a diary to establish patterns of behaviour, exploring specific issues using semi-structured interviews with individuals drawn from a sub-sample, investigating specific issues using focus groups drawn from a sub-sample and data analysis. The earlier, simpler stages funnelled through into more detailed and specific investigations. The relationship between respondent groups at each stage is indicated by the flow chart in Figure 1. The number of participants in each stage is indicated on this figure. Each data collection technique was piloted on a small group of respondents. The patterning of respondent behaviour using diaries followed by exploration of trends and hypotheses in focus groups was thought to be an efficient and novel methodology that would provide significant data. A brief explanation of the stages in Figure 1 follows.

The sample for this project was drawn from organisations for the elderly, rather than those focussing on hearing loss. This was because hearing loss can be an emotive issue for people and so not all individuals with presbycusis will readily identify as having a hearing loss. This method provided a sample with a range of (self-reported) hearing loss, so problems apparently caused by hearing losses could be set in context.

With the assistance of the collaborating elderly people’s organisations, a total sample of 250 individuals was identified in the urban areas of Manchester and Salford cities. All the respondents were given assurances of confidentiality and anonymity.

A short questionnaire was used to extract brief socio-economic data, a basic hearing history from the respondents and to identify respondents willing to participate in the more detailed stages of the project. The questionnaire provided 127 respondents for the diary survey. The diary took the form of a log of the participant's activity kept for a week. The intention was to assess patterns in respondents' behaviour and lifestyle. It was hoped that the diaries would furnish data on areas of the built environment that are frequented and those that are avoided

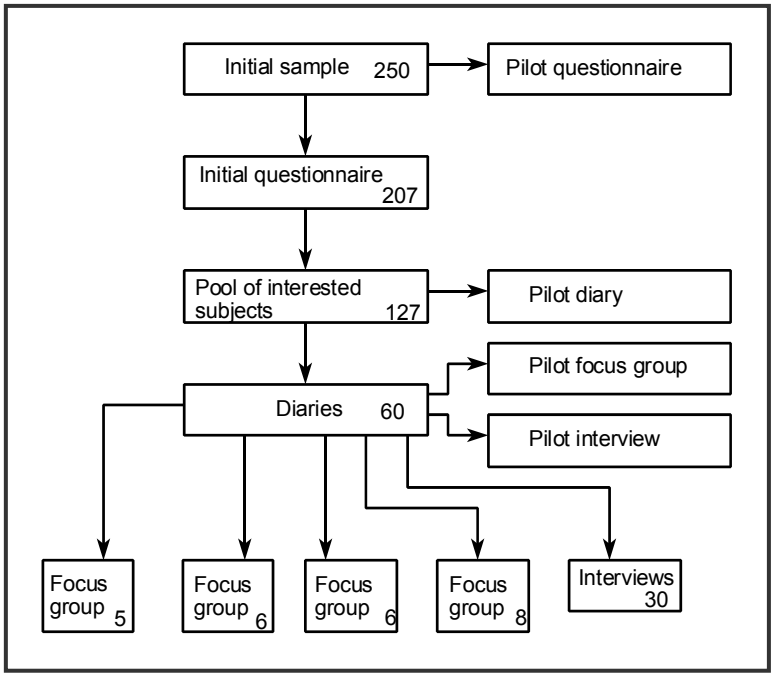

Figure 1. Flow diagram of respondent groups at each stage of data collection.

In the design stage of the project, it was thought that each respondent should complete the diary for two one-week periods, at different times of the year. This would allow a test of whether behaviour varies according to the time of year. However, due to the slow rate of diary return, this proved impractical. Instead, 88 diaries were dispatched during March and April and a second group of 41 were sent out during June and July. 41 of the first group were returned and 19 of the second group.

Once the diaries had been analysed to provide a basic context for the respondents and their habits, more detail was sought on some of the observed behaviour patterns. Picking individuals who seemed typical of a particular group or behaviour pattern and conducting a semi-structured interview with them obtained this data. (A semi-structured interview is one in which the interviewer begins the interview with a prepared set of questions, but allows the dialogue to move away from a fixed sequence to elicit information and by the use of probes such as "Why do you think this is?")

To give further insight into the importance that respondents place on hearing-related problems, four focus groups were held. A facilitator encouraged the participants to talk amongst each other as in normal conversation, with occasional prompts or questions. This technique is intended to reveal how elderly people talk about acoustic problems in a natural way with each other, rather than in direct response to a question from an interviewer.

3. RESULTS AND DISCUSSION

All except the questionnaire data in this study was qualitative. This data is textual, either short remarks or long conversations (sometimes with several participants). It was analysed by coding transcripts, a method well established in social science [7]. The codes were all words or short phrases used to tag short sections of the data. The coding is repeated several times so that the codes can be refined, thus revealing patterns in the data.

3.1 Demographic Data

Tables 1 to 3 summarise some basic demographic data from the initial questionnaires. The project did not aim for a stratified sample, and so over and under-representations of sections of the elderly population are to be expected. The aim was to identify the type and range of problems that elderly people suffered from rather than the exact percentages for those with defined difficulties.

Table 1. Gender of respondents.

	Frequency	%
Male	50	24.2
Female	157	75.8
Total	207	100

Table 2. Type of home.

	Frequency	%
Detached	12	5.8
Semi	27	13.0
Terrace	9	4.3
Flat	39	18.8
Sheltered housing	120	58.0
Total	207	100

Table 3. Age of respondents.

	Frequency	% (excluding missing data)
Up to 55	3	1.5
56-60	10	4.9
61-65	19	9.3
66-70	25	12.2
71-75	38	18.5
76-80	41	20.0
81-85	43	21.0
86-90	14	6.8
91+	12	5.9
Total	205	100

3.2 Patterns And Themes From Diaries

The main characteristic of the diary data was that most respondents led a life centred on routine. They tended to do the same things at the same times on certain days. Thus most patterns existed on an individual level. Each individual's pattern was specific to them. Contrary to our initial hypothesis, individuals did not seem to vary their behaviour patterns significantly at different times of the year.

Some common themes did emerge from the diaries. Respondents tended not to go out in the evenings unless it was a special occasion - for example, a wedding. Many seemed to avoid group situations. The utility of the diary depended on how detailed it was – some returned diaries were very basic and did not provide any real data. This is an inevitable drawback of asking respondents to complete the diary unsupervised.

3.3 Acoustic Problems Perceived

Four main areas of acoustic problems and respondents' response to them were identified from the interview and focus group transcripts. These are explored below.

3.3.1 Background Noise Interferes With Conversation

Many of the older people described having particular problems when socialising in groups where there are voices in the background which prevent effective hearing. This was anticipated, following several laboratory studies in which elderly respondents were found to have difficulty in understanding speech in reverberation [3], in background noise [4] and in background speech – the "cocktail party effect" [8]. Such problems are perhaps more significant for elderly people than for other groups because of the central role occupied by conversation in their lives [9]. The present

results confirm that background speech problems occur routinely in the lives of the respondents. To take two examples of many:

> Usually when there are other people talking it crosses with what somebody is trying to tell me. I can hear noise, but I can't always tell what it is. *Female, 84*

> I think it's because there are too many voices at once. I can concentrate on one person and one voice, but if there are a few then it's distracting and I can't really hear any of them. *Female, 81*

These problems were very significant to many respondents. As well as the direct effect - a loss of ability to communicate, several respondents worry what others – especially strangers - think of them:

> I keep saying 'I'm sorry, I can't hear you' and I can see them going tut…it's very difficult because you've got them talking and in the next booth there's other folk talking and then you've got the hum of the folk waiting their turn at the back…it's very very difficult that. *Female, 80*

It is not unusual to find selective use of the hearing aid in this type of situation. Those who have a problem with background voices find ways of adapting:

> When you go in people don't realise. They're all talking at once and you just don't hear a thing so you're glad then to turn it off. *Female, 81*

Speech communication problems were almost universal among the respondents in this study. In some interesting cases, however, there was evidence that when a social interaction is completely routine, poor speech communication is tolerated. The following conversation comes from a focus group whose participants had attended the same lecture course for several years:

1 I frequently miss what D says, the punchline, he'll say a lot and then the last little bit of the joke I miss. *Female, 82*
2 But is that because there's other noise impinging on what he's saying? *Female, age undisclosed*
1 Not necessarily, he seems to lower his voice somehow.
3 Yes, I think so, I think really he should speak louder. *Male, 72*

It seems that these people had tolerated poor speech communication for years perhaps because attending the lecture had become a routine, but significant event: important social interaction took place that did not depend on hearing what the lecturer said.

3.3.2 Behaviour Change And Individual Adaptation

Respondents reported many different strategies for managing hearing problems. In some cases, crowded spaces are avoided. Some respondents use their hearing aids selectively (to avoid background noise or reverberant sound), while others lip read. Some elderly people rely on verbal strategies, such as asking someone to repeat themselves, while others rely on a particular person to indicate what has not been heard:

> When my husband was alive it was a much lesser problem because whenever we were in company and somebody had said something I hadn't caught he immediately knew and used to repeat it to me…so he was a big help to me. *Female, 73*

Most respondents use a range of adaptive behaviours like these. Above all, it seems that respondents would prefer to take part in the activity and not be able to hear rather than avoid the situation altogether. It is as if the process of the conversation is more important than hearing every word, which is perhaps why they report pretending they understand or guessing what has been said, yet still enjoying the activity itself.

> Just hope for the best. Hope it goes away eventually. When it's very bad like as I said on that boat, I switched it off but you just say to people you know I'm sorry I didn't catch that. Have to begin again and hope that it doesn't matter too much. *Female, 75*

3.3.3 Specific Environments

Relatively few respondents mention specific environments, especially as a perceived cause of their problem. It appears that the biggest difficulties arise in large rooms, although this may be as much due to the presence of background talkers as to the acoustics of that particular space:

> It's usually big rooms like the lounge, you know. As I say I'm great when I'm talking to just the odd one or two near me – no trouble. It's usually big areas or as I say in that pub that time. Sometimes in the club. *Female, 84*

Several people commented that they have noticed particular difficulties when using transport:

> I think on a bus I have difficulty. Well I think the sound of the engine. Yes I do have difficulty hearing on a bus. I always get somebody to sit this side. *Male, 66*

Churches seem to cause a particular problem, although the respondents did not necessarily put this down to their own hearing but sometimes to the person preaching:

> I can never hear the sermon properly but really should go right to the front and I don't. But then again it's because our parish priest doesn't speak clearly and I don't want to say 'please put that microphone in front of your mouth'…He has got a beard and I'm sure it goes in his beard, his voice. *Female, 73*

Thus far, it seems that there is some evidence that inappropriate room acoustics is causing or exacerbating hearing problems in the respondent group. Very many are aware of speech communication problems. However, few of these attribute their difficulties to room acoustics. It seems likely, though, that many of the speech communication problems could be helped by reducing reverberant background sound levels with appropriate room acoustic design. Though the environment is more difficult, this also applies to vehicle interiors.

3.3.4 Poor Sound Insulation Inhibits Television Use

Several respondents referred to difficulty when listening to reproduced sound, especially that of the television. Many reported problems centred on the signal itself. Some, however, specifically identified limited dynamic range caused by their own inhibition to increase the sound level:

> I'm very aware, living in a flat, that the noise is going to go up or down as the case may be and annoy people…I find quite often that I have [the television] reasonably low – as low as I can stand it because I think you ought to think about other people in here. *Female, 68*

It is possible that elderly people may feel a greater sense of social responsibility than younger groups in society so they would be more likely to feel inhibited in this way. Thus, poor sound insulation can be a problem for those with a hearing loss as well as for those with none.

3.4 Reflections On The Methodology

One of the objectives of this project was to test the novel methodology of diaries funnelling into qualitative interviews and focus groups. Advantages and disadvantages can be identified when the techniques used here are compared with the acousticians' more usual quantitative questionnaire or laboratory psychoacoustic test. Most positively, the qualitative techniques allow respondents to describe their experiences in their own language and in their own environment. Very little is assumed by the researcher other than that the respondent may have a view to express. In this respect, qualitative methodology seems well suited to the kind of exploratory project described here. It is suggested that other areas of human response to sound could benefit from this approach.

However, in gaining the benefits of more reliable data, the researcher has to give up some control over the variables. For instance, it is not usually possible or desirable to constrain the discussion of a focus group to one dimension of the problem while ignoring all the others. While this makes analysis potentially more difficult, it contributes to the ensuring the validity of the data by allowing a natural discourse. It also allows the respondents to reveal important data that was not anticipated by the researcher (for example, the problem of poor sound insulation discussed above).

One significant outcome is that using the three different techniques of diaries, interviews and focus groups helped to validate the results. The three methods each have different strengths and provided data with different emphases. Diaries are an efficient way to obtain initial information on behaviour patterns for a sizeable group of respondents. The interviews allowed the researcher to probe the responses of an individual respondent and follow a line of thought to its conclusion. Focus groups provide a way for the researcher to observe and record natural interaction between respondents and they often stimulate the group to arrive at a consensus view which would not necessarily be expressed by any of the respondents in an individual interview.

4. CONCLUSIONS

This paper has reported the results of a qualitative survey of elderly people to reveal acoustic difficulties that the elderly have in the built environment. Many of the 207 elderly respondents in this study were found to have experienced acoustic problems in the built environment. The most common problem reported was poor speech communication, in two-way conversation, in small groups and as a member of an audience. The respondents tended to focus on their own hearing loss rather than on how particular acoustic conditions exacerbate a communication difficulty, but their responses revealed background speech, reverberant conditions and background noise to be the main causes. Of the specific environments mentioned by respondents, churches were a common source of problems. The elderly people in this study used a range of strategies to adapt to their hearing difficulties, though when the communication problems are so great as to be insurmountable they would often take part in social activities anyway. It seems likely that the effects of poor speech communication could be reduced by more appropriate room acoustic design in the built environment.

An unexpected finding was that poor sound insulation can affect people with a hearing loss. This happens when they feel inhibited about using a television loudly enough to disturb a neighbour. This finding should be taken into account in the design of housing for elderly people. Because background noise can severely degrade the hearing performance of those with a hearing loss, it would seem that higher standards of sound insulation may be appropriate than for those with

normal hearing. Building regulations and design criteria need to be reviewed to identify whether they are appropriate when designing for all.

The utility of a novel qualitative methodology involving diaries, interviews and focus groups has been successfully tested. This was found to be an efficient way to capture naturalistic responses from the respondents. In particular, the use of three methods rather than relying solely on interviews was found to provide different views of the data and to give confidence in its validity. It is suggested that the application of such techniques could be extended to studies in other areas of acoustics.

The next step in this project will be to attempt to quantify the necessary improvements in the acoustic design of the built environment. It seems likely that it should be possible to thereby improve an important part of the lives of a large and growing group in the population.

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