SIMULATED REVERBERATION AND HEARING AIDS

Izel M. Taylor, Ph.D. and Robyn M. Cox, Ph.D.

The University of Memphis and The Department of Veterans Affairs, Memphis, TN.

Presented at the American Academy of Audiology National Convention, Salt Lake City, UT, 1996

Introduction

Understanding speech in noisy situations is usually the main objective of people who decide to obtain amplification from a hearing aid. However, one of the major complaints from hearing aid users is that they can not understand speech in reverberant environments (ex. churches, auditoriums). Yet, to this date there is no clinical protocol that employs reverberation as a parameter during hearing aid fittings. It is believed that if hearing aid candidates are exposed to this type of distortion, it may allow for the development of more valid expectations about the hearing aid and its performance in a reverberant environment. This study explored the need to include reverberation as a parameter into hearing aid fittings. Specifically, it examined whether speech intelligibility errors of elderly listeners differ under different reverberation conditions, talkers, and speech features.

The research questions were:

1. Is the pattern of speech errors produced in one reverberation condition reproduced in another reverberation condition or is the pattern the same regardless or reverberation condition?
2. Are patterns of talker intelligibility observed in one reverberation condition maintained in other reverberation conditions?
3. In a given reverberant environment, are the speech errors generated by a person listening to one talker different from the errors produced while listening to another talker or is the pattern the same regardless of talker?

Methods

Speech Materials: A modified version of the Speech Pattern Contrast Test (SPAC) was used to quantify speech intelligibility (Boothroyd, 1985). This test yields a total of eights speech features:

VHT: Vowel Height
VPL: Vowel Placement
ICV: Initial Consonant Voicing
ICC: Initial Consonant Continunace
FCV: Final Consonant Voicing
FCC: Final Consonant Continuance
ICP: Initial Consonant Place
FCP: Final Consonant Place

Talkers: Six talkers, 3 males and 3 females, generated the master recordings of the SPAC test.

Subjects: 14 "normally" hearing elderly subjects (65-75 yrs) were selected for the study. These subjects had thresholds that can be expected to be exceeded by 10% of otologically normal groups of males and females of the same ages (ISO 7029, 1984). Therefore, the definition of "normal-hearing" indicates thresholds that are typical for this population. Figure 1 displays a composite audiogram for the elderly listeners.

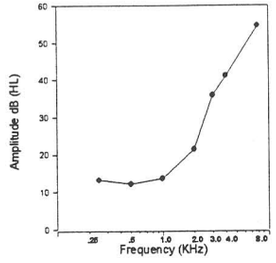

Figure 1.
Composite audiogram for elderly listeners.

Reverberation Conditions: Reverberation was simulated with the use of a Yamaha, 2-channel electronic reverberator.

Rev. Cond.	RT60	Rev. emphasis	Delay of early reflection	Delay of late reflections
NR	.01	-	-	-
SRH	0.8s	High Frequencies	15ms	30ms
SRL	0.8s	Low Frequencies	15ms	30ms
BRH	1.6s	High Frequencies	20ms	40ms
BRL	1.6s	Low Frequencies	20ms	40ms

NR: No Reverberation
SRH: Small Room High
SRL: Small Room Low
BRH: Big Room High
BRL: Big Room Low

Results

1. Is the pattern of errors produced in one reverberation condition different from another reverberation condition or is the pattern of errors the same regardless of the details of the reverberation condition? Figure 2 displays intelligibility scores for seven features for all listening conditions.

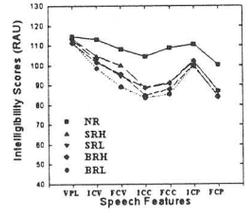

Figure 2.
Intelligibility scores for seven features for each condition.

A significant difference was found between the pattern of errors for the NR condition and the simulated reverberation conditions.

The pattern of errors among the simulated reverberation conditions were only slightly different.

2. Are patterns of talker intelligibility observed in one reverberation condition maintained in other reverberation conditions? Figure 3 displays mean feature scores for all reverberation conditions for an individual talker.

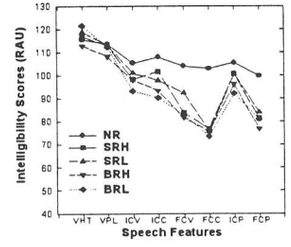

Figure 3.
Mean feature scores for 5 reverberation conditions.

For a given talker, significant differences were found between the scores for the NR condition and the scores for the 4 simulated reverberant conditions. However, no significant differences were found between the scores among the 4 simulated reverberant conditions.

3. Are the speech errors produced by a person listening to one talker different from the errors produced while listening to another talker or is the pattern of speech features the same regardless of talker? Figure 4 displays mean feature scores collapsed across the 4 simulated reverberation conditions.

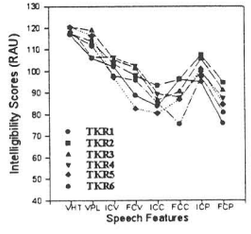

Figure 4.
Mean feature scores collapsed across 4 reverberation conditions, excluding the NR cond.

Different talkers produced different patterns of speech feature scores, even when reverberation conditions were collapsed.

Conclusions

1. Speech intelligibility in the NR condition was significantly better and had a different pattern than that of the four simulated reverberation conditions.
2. One cannot predict the effect of reverberation on speech intelligibility by testing speech intelligibility in non-reverberant environments. However, one could predict intelligibility performance in reverberation based on a different reverberation condition.
3. Different talkers produced different patterns of speech feature scores. However, for a given talker, intelligibility remained the same for the four simulated reverberant conditions.

Selection of talker:

The findings of this study suggested that it would not be possible to predict the pattern of feature scores of one talker from the scores of a different talker.

What are the options?
1. Test multiple talkers?
2. Choose a talker with "average" speech characteristics?
3. Choose a talker typical for the particular region?

Clinical implication

The clinical implication of this study is that hearing aid dispensers are not able to validly assess the speech understanding in real reverberant environments based on speech tests in sound treated rooms with minimal reverberation. Since within talker intelligibility remained constant across the 4 simulated reverberation conditions, the results also imply that the inclusion of some kind of reverberation during the hearing aid testing, would allow assessment of this ability. The particular parameters of the reverberation condition do not seem so critical.

HARL
Hearing Aid Research Lab.